The contribution of Integrated Polytechnic Regional College (IPRC) Musanze in creating valuable uses to tomato crop farm-leftovers

A case of Tomato Farmers in Nkotsi Sector/Musanze District/Rwanda

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(A case of Tomato Farmers in Nkotsi Sector/Musanze District/Rwanda)

Research submitted to Van Hall Larenstein University of Applied Sciences in partial fulfilment of the requirements for the master's degree in Agricultural Production Chain Management-Specialization in Horticulture Chains

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Dedication

To my lovely wife UMWIZA Bernadette, my daughter NSHUTINZIZA Belle Marie Albine, and my son IZERE U. Ailbe, my brothers and sisters and the whole close family, I dedicate this achievement.

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List of Acronyms

$: US Dollar
APEFE: Association pour Promotion de l'Education et de la Formation à l'Etranger
CAP: Community-Academic Partnership
CBI: Centre for Promotion Imports
CIAT: International Center for Tropical Agriculture
CO_2: Carbon Dioxide
COVID 19: Coronavirus Disease 2019
Cu: Copper
FAO: Food and Agriculture Organization
Fe: Iron
FFS: Farm Field School
GAP: Good Agricultural Practices
Ha: Hectare
IGES: Institute for Global Environmental Strategies
IIRR: International Institute of Rural Reconstruction
IPRC: Integrated Polytechnic Regional College
KIT: Royal Tropical Institute
LSU: Louisiana State University
MIFOTRA: Ministry of Public Service and Labour
MINAGRI: Ministry of Agriculture and Animal Husbandry
Mn: Manganese
N_2O: Nitrous Oxide
NAEB: National Agriculture Export Development Board
NIRDA: National Industrial Research for Development Agency
RAB: Rwanda Agriculture Board
RBC: Rwanda Biomedical Centre
RDB: Rwanda Development Board
RP: Rwanda Polytechnic
SEAD: Strengthening Education for Agriculture Development
SPSS: Statistical Package for Social Sciences
SWOT: Strength, Weakness, Opportunity, and Threat
T: Ton
TVET: Technical and Vocational Education Training
UK: United Kingdom
UN: United Nations
USA: United States of America
VC: Value Chain
VCD: Value Chain Development
Zn: Zinc

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Abstract

The horticultural farming development cannot be achieved without the involvement of various shareholders including the training and research institutions. The absence of collaboration between tomato farmers and TVET higher learning institution weakens farmer's development and does not disclose the capabilities of the college. The purpose of this study is to identify potential value addition activities to tomato crop farm-leftovers and investigate their existing end-uses to suggest a collaboration model between tomato farmers in Nkotsi Sector and IPRC Musanze to tailor-make solutions to tomato farming challenges and associated issues.

The quantitative and qualitative methods were used to get data from respondents and key informants. The online surveys were done for randomly selected 34 tomato farmers and purposively selected 13 TVET trainers. The in-depth online interviews were also done for purposively selected 6 key informants from public and private institutions closely involved in horticulture development in Rwanda. The data were electronically gathered, presented, analysed, and discussed before designing a new farmer-academia collaboration model, concluding and recommending further activities.

The analysis of tomato farmers' responses confirmed that the tomato crop stems are the main type of tomato crop farm-leftovers found on the farm, leaves and roots are also present in minor quantities. Those farm-leftovers are mainly used for compost making, some remain unused at farm level, and few are used for feeding animals. For whatever destination, the farm-leftovers do not generate any cash to farmers, and unfortunately, 91% of farmers are not aware of their negative effects. All respondents know the IPRC Musanze, and 59% of them recognise its community outreach activities, however, 97% of farmers do not have any previous collaboration with the college even though they show willingness for future collaboration. 62% of TVET trainers revealed that there are no advanced tomatoes farming activities present in the area, and that crop farm-leftovers have negative effects even though they are mostly used for compost making. The trainers suggest technical training and joint research and innovation activities as the main activities suitable for the proposed collaborations between farmers and the college. All informants stressed that compost is the only product manufactured from tomato crop farm-leftovers that they knew. Their curiosity and requests emphasise on further research about processing crop-based products from tomato crop farm-leftovers which could generate additional income to tomato farmers. The farmers' appreciation of a new collaboration will depend on their involvement and the discussion about the opportunities and benefits of the cooperation, and a piloting phase is required for trial and test of its feasibility.

Based on the study results, a collaboration model is designed as a new way of working to boost tomato farming as well as improving the quality of TVET training. The stable relations, trust, shared problem, resources, planned activities and their execution are some of the elements of the proposed model. Therefore, the collaboration between tomato farmers and TVET School is possible and should be mainly based on technical training, joint problem-solving initiatives, applied research, and the provision and farming of improved seeds.

Keywords: Tomato crop, farm-leftovers, valuable uses, TVET, collaboration

CHAPTER ONE: INTRODUCTION

The present document is all about the thesis report carried out on a tomato farmer's case in the Musanze District/ Nkotsi sector in Rwanda. The research outcomes will help the Integrated Polytechnic Regional College (IPRC) Musanze to enhance the quality of the practical training and increase the applied and innovative researches that respond to the farmers' challenges starting with the valorization of tomato crop farm-leftovers for farming business development. Most of the Rwandan population is in a rural area and depends mainly on agriculture farming activities. Given its predominant role in the Rwandan economy, agriculture is the main driver for sustainable growth and poverty reduction, the reason why its development is a point of concern for Rwandan leaders. Horticulture farming, one strong subsector in Rwandan agriculture, is mostly focused on in terms of sector development. Thus, Rwanda intends to create a more diversified horticultural primary product, value-added products for local consumption, and even for export market opportunities. The tomato, one of the horticultural crops, is mostly targeted regarding this perspective and its development is considered as a key contribution to farmer's poverty reduction and food security, and it must be entirely valorised.

1.1 Research Background

The world counts 7.3 billion people and the number may reach 9.9 billion by 2050 (UN, 2019). That number is directly linked to the global unprecedented increased demand for food from 59% to 98% by 2050. The feed and fuel demand will also increase probably due to underutilization of agricultural and horticultural production by-products (Junker-Frohn, et al., 2019). Global sustainability requires a lot of effort in different domains and one of the key challenges to be addressed relate to agriculture and its entire affiliated subsectors. According to LSU AgCenter, 2018, horticulture is "science and art involved in the cultivation, propagation, processing, and marketing of ornamental plants, flowers, vegetables, fruits, and nuts". Tomato in Rwanda is considered as one of the horticultural crops highly produced and gradually consumed, but its primary production is seasonal, and the crop is highly perishable (Mukantwali et al., 2018).

The tomato crop has a very high social importance and the active farmers raise their economy directly or indirectly through the involvement of its cultivation (Singh et al., 2019). The tomato is a horticultural crop, during its production especially in postharvest activities, produces a huge number of discarded/unvalued residues at farm level, trashes at the fresh market as well as rubbish at processing units. Among them, about 33 kg of leaf and stem biomass per 100 kg of harvested tomatoes accrue during and at the end of the growing period (Junker-Frohn, et al., 2019). Although stem biomass contributes to about 70% of the residual green biomass after harvesting, each tomato plant generates about 0.75 kg of leaf biomass, resulting in about 15t ha^{-1} (Junker-Frohn et al., 2019). The large quantities of discarded plant biomass from primary production are either used for biofuel production, composted, or are discarded with costs (Junker-Frohn et al., 2019).

Although it is a simple crop residue disposal method, burning has an excessively negative impact on the agri-ecosystem as it produces a lot of small particles in the environment and causes air pollution as well as disturbance of soil physical, chemical and biological components that affect also microflora and microfauna life (Pratap Singh and Prabha, 2018). Therefore, the valorization of crop-residues is an imperative action to improve soil structure, crop productivity, and protect the environment. The recommended use of improved harvesting methods, postharvest handling technologies to be adopted by farmers are possible in Rwanda and other Sub-Saharan African countries, but still, there is a need for value addition of the tomato crop leftovers/residues at farms location (Crump, 2016).

Furthermore, all initiatives targeting the upgrading of farmers' activities require the skilled and well-trained technical workforce. The hand-on competences are mainly obtained through Technical and Vocational Education Training (TVET) schools having various domains of specialization (agriculture, irrigation, construction, hospitality, Information Technology, etc). In Rwanda TVET schools at a higher learning level are known as Integrated Polytechnic Regional Colleges (IPRCs) and are governed through Rwanda Polytechnic (RP). The RP is a higher learning technical institutions umbrella that was established by law N° 22/2017 of

30/05/2017 determining its mission, powers, organization, and functioning. The Law established RP as Higher Learning Institution, an organ with legal personality and enjoys administrative, teaching, research, and financial autonomy and it is managed following relevant laws. The RP has eight (8) colleges where the action of teaching-learning and research happens.

According to MIFOTRA (2017), the main mandate of RP is to address the issues and problems of Rwandan communities, especially youth unemployment and limited labour opportunities, partly caused by a lack of relevant labour technical skills. The adopted way forward for RP is creating a strong partnership with different stakeholders to address the labour market requirements. Therefore, RP through its affiliated IPRCs wants to graduate a highly skilled and well-trained workforce and link them to current and future societal needs. Rwanda is rapidly transforming into a competitive knowledge-based economy that requires new ways of teaching and learning accompanied by applied research to address community challenges. The main mandate of IPRCs is to train the practical workforce ready to make changes in the Rwandan community and provide creative and innovative solutions to societal problems through applied research. Additionally, IPRCs are mandated to be engaged in community outreach services (skills transfer, research, innovation, community works, etc...) to support, contribute, and solve the developmental problems within the surrounding community.

1.2 Problem statement and problem owners

1.2.1 Problem statement

Rwanda has a strong agriculture competitive base founded on its natural environment elements such as good climate, abundant rainfall, high fertile soils, and enough labour force that are used to produce quality and competitive horticultural products (RDB, 2020). This encouraging farming environment helps farmers to produce reasonable quantities of tomatoes throughout the year (Kitinoja et al, 2019). The tomatoes' primary production generates a high amount of crop farm-leftovers which are not yet profitably used and when improperly managed they become a source of environmental issues such as air pollution, crop diseases, and contribute to climate change issues. On the other hand, IPRC Musanze, a well-equipped and capacitated TVET higher learning institution is not generally contributing enough to local farming challenges via its offered technical courses like Agriculture and Food Processing course which is trending nowadays. Therefore, there is a knowledge gap about the non-existence of a formal problem-solving collaboration between tomato farmers in the Nkotsi Sector and IPRC Musanze to jointly address tomato farming challenges (e.g. farm-leftovers valorization). This is one of the starting points to develop a tomato farming business coupled with enhancement and application of the practical training and applied research from the college. The problem weakens farmer’s development and does not disclose IPRC Musanze capabilities. There is no conducted and published research regarding the farmer-academia collaboration model in Musanze District, therefore, the importance of this research undertaken in the above-mentioned area.

1.2.2 Problem Owners

The problem owners are both small scale tomato farmers in Musanze District / Nkotsi Sector and IPRC Musanze as one of the colleges of Rwanda Polytechnic that is offering agricultural-related TVET courses in all levels (basic to Advanced Diploma levels).

1.3 Research Objectives

The overall objective of the present research is to identify potential value addition activities to tomato crop farm-leftovers and investigate the current farm leftovers uses, to suggest collaboration model between tomato farmers in Nkotsi Sector and IPRC Musanze as a channel of solutions provision on tomato farming challenges and associated issues. The collaboration will disclose IPRC Musanze capabilities and create awareness on tomato farming opportunities in Nkotsi Sector. The specific objectives for this research are:

- To conduct critical literature about the tomato crop value addition and identify gaps for research in developing tomato crop-based products;
- To estimate the amount of tomato crop leftovers and identify their current uses in Nkotsi Sector;
- To propose a collaboration model between tomato farmers in the Nkotsi sector and IPRC Musanze to find out monetary benefits opportunities to tomato crop farm-leftovers.

1.4 Main research questions and sub-questions

This research study has two main research questions and three sub-questions for each as mentioned below.

Main question 1:

What are the estimated amounts and current uses of tomato crop farm- leftovers in Nkotsi sector?

Sub questions:

1.1 What type and how much quantity of tomato crop farm-leftovers from Nkotsi Sector?
1.2 What are the final destinations of farm-leftovers along the tomato value chain in Nkotsi sector?
1.3 What are the monetary benefits from tomato crop farm-leftovers in Nkotsi Sector?

Main question 2:

What are the potential value addition processes that can be applied to tomato crop farm-leftovers?

Sub questions:

2.2 What are the value-added activities to transform tomato crop farm-leftovers into other products?
2.3 What are the technical requirements to create valuable products from tomato crop farm-leftovers?
2.4 What could be the joint value addition activities between tomato farmers and IPRC Musanze?

CHAPTER TWO: REVIEW OF LITERATURES

In the agriculture crop production sector, the actors in that domain expect to get better quality of the primary intended products that could relatively generate money to them. Usually, during the whole process of crop production, there are also other unintended organic materials produced which are commonly known as crop residues. The latter name has a negative connotation of being useless because they are not the primary products for the farming business, therefore they are destroyed, improperly managed or remain unused at farm location. Interestingly, those unintended produced organic materials can be beneficial or detrimental to farmers activities and affect the agricultural value chain as well as to the general community.

2.1 Value Chain description

The chain of values is explained as a tree with various branches and each of them representing an end-product (KIT, Mali and IIRR, 2010). As the name states, within a value chain, various actors are involved. The key actors directly involved in the chain are known as primary actors (e.g.: input suppliers, farmers, transporters, processors, wholesalers, consumers). The other indirect actors are known as chain supporters (e.g.: policy-making agency, financial institutions, quality standard). Generally, the term "value chain" is defined differently depending on the context it is used for. In the agricultural sector, the value chain (VC) is a set of activities and actors that work together to bring a basic agricultural product from primary production in the field until it gets to its final step of being used or consumed, where at each stage value is added to it (Madhovi, 2020).

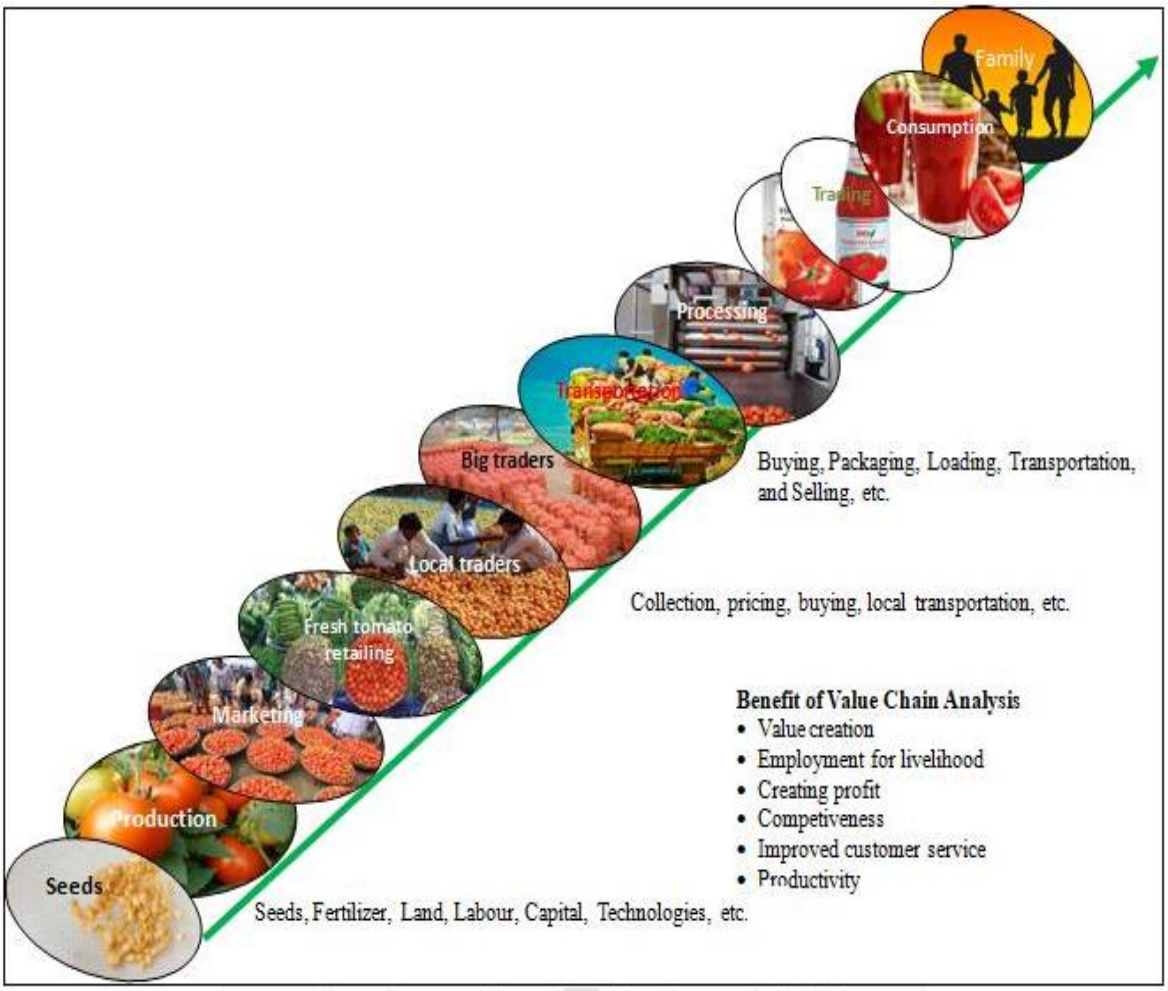
One of the wings of the value chain is named "support environment" composed of value chain stakeholders (both public and private) that provide support services. The latter may include services offered by training and research development institutions, services from agricultural extension offices, innovative opportunities from agribusiness establishments dealing with Agricultural Value Chains (Foundation of Abomey–Calavi University, 2018). The categories of universities and research institutes are the middle level of interaction between the agricultural sector and educational scientific institution (CBI, 2015). This interaction results in the provision of support services that help to solve certain agriculture technical problems (i.e.: improvement of varieties, formulation and trial of new fertilizer, biological control, optimal production technique, innovation in postharvest handling, etc.).

The chain activities are not always static along the way of the crop production; consequently, the Value Chain Development (VCD) terminology is familiar in the discussion of the crop production chains. According to Donovan et al., 2015, VCD is explained as the discovery of unfamiliar options to enrich opportunities for smallholder chain actors' participation in the establishment of new linkages between them and favourable markets. This enhancement also is based on the description of the context whereby the VC is to be developed. Some VCD approaches do not target only the production and marketing of a new product, some focus on the design of new intervention and interaction among chain actors, while others can only deal with the development of a new value chain that links smallholders to national or export markets. Whatever the adopted approach, it is influenced by the political, legal, and business environment where the value chain is implemented (Donovan et al., 2015).

2.1.1 Tomato value chain

Tomato is ranked the second worldwide fresh and processed crop after potato. Epi Heuvelink (2018) classifies tomatoes in the family *of Solanaceae*, with the genus of *Solanum* in the section of *Lycopersicon*. The Solanaceae family is large and contains more other vegetable crops like aubergine (Solanum melongena), chilli and bell peppers (Capsicum spp.), potato (Solanum tuberosum), tamarillo or tree tomato (Solanum betaceum), tobacco (Nicotiana tabacum), and tomatillo (Physalis ixocarpa). Sarma (2019) explains the tomato value chain as the addition of values to the tomato product as it moves from input suppliers as the first step and goes through producers and finally to consumers. From stage to stage throughout the value chain, the product is modified by chain actors and the incurred transaction cost reflects the form of value-added and generally its appearance and economic facet change from one stage to another depending on the effort made.

Figure 1: Sequential tomato value addition activities



Source: Sarma (2019)

The production of tomatoes starts with the supply of various inputs needed like seed, fertilizer, pesticide, and others. After the supply of all the input, the second function is the production/ farming that is followed by harvesting, collection, and transportation, processing as well as trading before the end-use and or consumption of the final product. Along the whole tomato value chain, various actors perform different functions as the product moves from one step to another, and the product value increases depending on effort exercised by chain actors. Along the way, there are always residues/leftovers at each step of the VC. In most of the times after obtaining the primarily intended product on a given VC stage, the remaining is useless (Karim and Biswas, 2016).

2.2 Tomato production in Rwanda

Tomato is considered as a crop with the highest value, ranked the second largest vegetable highly produced and consumed in Rwanda (Mukantwali et al., 2018). Tomatoes are domestically marketed as well as sold in bordering countries of Rwanda as fresh fruit and its processed form. Tomato is an essential crop for Rwandan, and it is classified as both food and cash crop and its productivity in Rwanda increased at 300% in 2008 and 2010 (Mwongera et al., 2019).

2.2.1 Production areas

The tomato crop is cultivated in most districts in Rwanda because it is farmed in 11 districts out of 30 districts of the countries. According to Fortune of Africa (2013), tomatoes in Rwanda are mostly grown in the following districts: Bugesera District; Rwamagana District; Kayonza District; Rusizi District; Nyagatare District; Gatsibo District; Burera District; Musanze District; Nyanza District; Nyamasheke District; and Huye District. The total tomatoes production in Rwanda for the last five years (2014-2018) is 548 042 tons on a total harvested area of 49 452 ha. The interesting observation is that the harvested areas have been increasing for the first four years and decreasing for the fifth year while the total of tomatoes produced has been increasing for the first three years and decreasing in the fourth and the fifth year. The statistics show on average 11 tons of tomatoes produced from one hectare (FAO, 2019).

2.2.2 Tomato production seasons in Rwanda

The tomato crop farming lasts five months from planting to final harvesting (Basset-Mens et al., 2019). The tomato production can be carried out in the open field or protected farm (Greenhouse) during three separate seasons namely season A (September, October, November, December, and January); season B (January, February, March, April., and May) and season C (May, June, July, August, and September). Season C is usually done in Marchland or the greenhouse with irrigation because it is a dry period in Rwanda.

Table 1: Tomato production seasonality in Rwamagana District (Rwanda)

Season/Month		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Season A										■	■	■	■	■		
Season B	■	■	■	■	■	■										
Season C						■	■	■	■	■						

Source: Basset-Mens et al., 2019

2.2.3 Tomato Production challenges in Rwanda

Despite the reasonable tomatoes production in Rwanda, this horticultural sub-sector faces several challenges. Mukantwali et al., (2018) show through the Commodity Systems Assessment Methodology report that farmers face postharvest losses on average 21% of their crop during harvesting, 11.5% of tomatoes are lost the collection point, 10% of tomatoes are lost at the wholesaling level while 13.6% of tomatoes are culled out and discarded at the retailing places. The subsequent post-harvest losses are connected to over mature tomatoes, improper postharvest handling activities, poor quality containers which create rough transportation. These postharvest challenges consequently result in tomato prices fluctuations at the local market thus affecting farmer's profitability as well as farming development (Mwongera et al., 2019).

Apart from postharvest losses, generally, players in horticulture sector face other challenges in their farming business to note: competition between locally processed and imported tomato products; lack of skills in modern farming; pests and diseases affecting tomato production; incapacity of local value addition to produced tomatoes, and the gap in market knowledge (Fortune of Africa, 2013).

2.3 Agricultural crop leftovers

Along the way, in the agricultural value chain, some materials are either intentionally or not discarded. The unintentionally agricultural materials produced at the farm are considered as waste because they are not primarily intended products. UN (2016) defines agricultural waste as any materials that are not primarily produced for the market and are the results of production, conversion, consumption, and most of the time are discarded. These agricultural leftovers may result from harvesting and post-harvesting activities such as modification of raw materials, transformation into other products, the end products consumption, and other human activities. Those remaining materials are taken as useless and discarded but in reality; they are biological materials that can be recycled, valorized, and reused for other purposes as well as generating additional income to farmers. Agricultural crop wastes/leftovers are generally divided into pre-harvest wastes, harvesting time wastes, and post-harvest wastes (Ari Aprianto, Dryanto, and Sanim, 2016).

The pre-harvest agricultural wastes are generated from nursery operations and maintenance of immature plantations that are usually in the form of generative and vegetative parts of crops that have fallen (leaves and twigs) but it can also be the discarded material. The post-harvest residues include those from the transfer activities from the field to storage facilities, and transportation before being sold to a processing factory (Ari Aprianto, Dryanto, and Sanim, 2016). The management of agriculture wastes to prevent their negative impact on the environment requires stakeholder's collaboration. The joint efforts from concerned players may solve the problem of the knowledge gap across organizations and it requires extending the capability of partners to accomplish a continuous improvement through problem-solving innovations (Handayati, Simatupang and Perdana, 2015). According to Fritsch et al., (2017) the global major concerns nowadays are the huge amount of agricultural and food wastes that need sustainable solutions in creating profitable utilization as well as reducing the environmental burden.

2.3.1 Products made from crop farm-leftovers

Various agricultural leftovers possess potential uses and can be valorized through diversified technologies and contribute to monetary benefits to farmers and environmental advantages to the whole society. Trung Hai and Anh Tuyet (2010) describe the advantage of the decomposed agricultural materials as not only providing indispensable nutrients for plant growth and development but also their important role in soil characteristics, particularly its water holding capacity, contribution to sustainable agriculture, and clean and safe environment. The post-harvest agricultural materials contain organic macronutrients (hydrocarbons, proteins, lipids) and microelements (Mn, Zn, Cu, and Fe) that could be also the raw material for further high valued products like enzymes (Tabrika et al., 2019). There is a current trending concept known as the economic values of post-harvest agricultural materials describes as a process of 3Rs: Reduce, Recycle and Reuse to convert the agricultural waste stream into valuable biomaterials for a circular economy (Trung Hai and Anh Tuyet, 2010). This conversion process involves several steps: waste separation (sorting), processing facilities setting up, market development for value-added products, and finally the organization of all connected marketing logistics.

a. Compost

The most familiar product generated from decaying organic materials is called compost and contains essential nutrients for crop production (Van der Wurff et al., 2018). This organic product is obtained through an aerobic process whereby microorganism activities transform the organic materials into a stable and hummus-like product called Compost (Pergola et al., 2020). The proper use of compost is indispensable in agriculture because too low application leads to nutrient deficiency in the soil but again too high application causes changes in soil composition (nitrate leaching and phosphorus runoff). The processing of organic wastes into compost with the circularity approach was successfully implemented as a business model in Ghana. The collected organic wastes from markets were transported to a composting facility, and after processing activities the compost was sold to farmers by unemployed young people who welcomed that opportunity to

earn a small income. This concept may be replicated across many African countries as a sustainable approach for agriculture development (Bianchi et al., 2020).

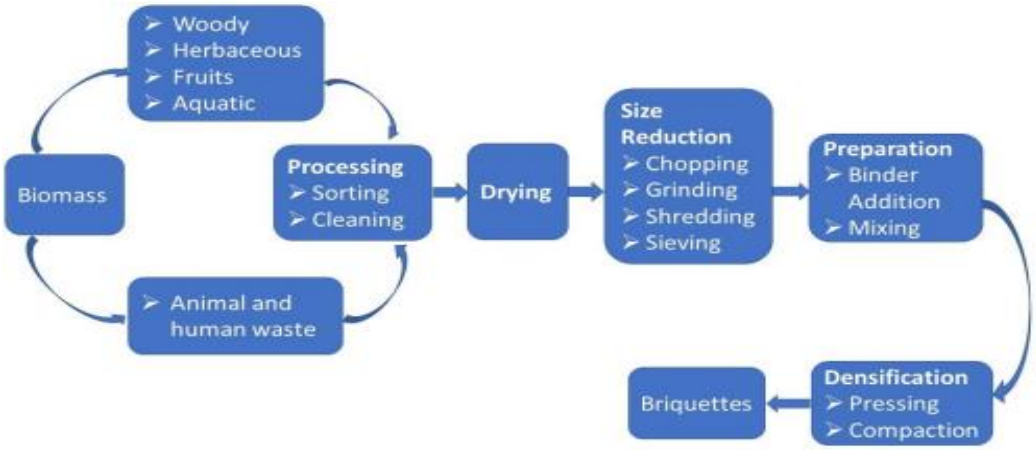
b. Animal feed

Currently, human food is mainly produced from plant and animal sources. Farm crop residues have been used for ruminant feeding as an alternative use to avoid burning or composting them. The land reserved for crop production is not expanding while the crop farm-residues are produced without additional input (land, water). This creates an opportunity for crop farm-residues nutrient to serve for animal feeding purposes (Madhu Mohini, 2015). Due to the chemical composition, crop farm-residues have to be treated before being given to animals. Several physical (chopping), Chemical (soaking in Alkali), biological (Karnal process) treatments have been tried by both researchers and farmers with the aim of deconstruction of lignocelluloses components to ease the digestion by animals. Nevertheless, further 'food-feed crops research' is crucial to moderate future global animal feed demand without human food scarcity (Madhu Mohini, 2015).

c. Briquette

The term "*briquette"* is derived from the French word "brique" meaning brick. It is known as a compressed block of coal dust or other combustible biomass material used as fuel and starts a fire. Agricultural wastes produce biomass briquettes. These crop-based energy generation materials are divided into two types: crop residue briquette and agro-industrial briquette. According to Kpalo et al., (2020), the crop residue briquettes are produced from any crop farm-leftovers (leaves, twigs, roots …) while agro-industrial briquette is manufactured from processing industry waste (cassava peel, bagasse, coconut shell…).

Figure 2: Briquette manufacturing process



Source: Kpalo et al., 2020

The briquettes are biomaterials utilized in rural and urban places for both domestic and industrial heating application and energy production (gasification). They are used as an affordable alternative source to replace firewood, charcoal, or other solid fuels (Kpalo et al., 2020).

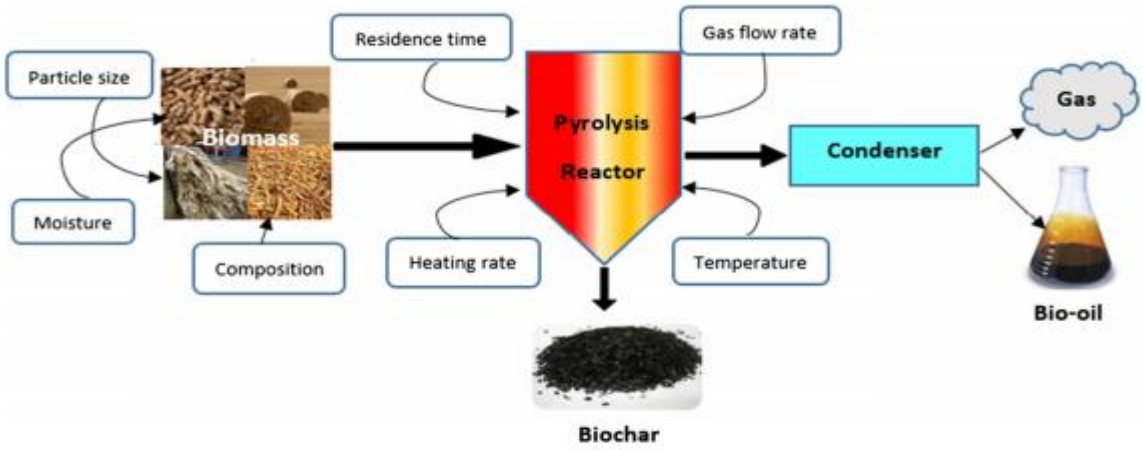
d. Biochar

The crop organic material consists of three main components lignin, cellulose, and hemicellulose. At elevated temperature, those materials are broken down in simple compounds and this process is known as thermochemical depolymerisation reactions. The thermochemical decomposition *"pyrolysis"* of biomass,

generally, takes place in an oxygen-free environment within a temperature range of 300–500 °C to produce the char (Sakhiya, Anand and Kaushal, 2020). This bio decomposition process converts low-energy-density biomass into a high-density liquid product called *"bio-oil",* medium caloric value gas called *"synthesis gas",* and high-density solid product called *"biochar".*

After its production, biochar must be activated before its application for various purposes. The activation here means a technique applied physically or chemically to biochar to improve its physical characteristics (i.e. specific surface area) and absorption capacity (Sakhiya, Anand and Kaushal, 2020). The activated biochar serves multiple purposes like soil amendment in agriculture, absorbent of contaminant and pollutant in aqueous solutions; it can be used also as catalysts of chemical reactions, fuel alternative, used as an additive, used in the construction sector.

Figure 3: Biochar manufacturing process



Source: Sakhiya, Anand and Kaushal, 2020

e. Bio-Based packaging materials

Majority of packaging materials are made from plastic materials which are not biodegraded and become a source of environmental pollution. Nowadays, as the technology is advancing some alternative natural packaging material is manufactured and cellulose, a polysaccharide, is one of the most used biopolymers as raw material. Cellulose is a polymer originating from the plant material and is made of β-D-glucose subunits. Naturally, cellulose is not good raw material for packaging material due to its very low water solubility (Reichert et al., 2020). However, plasticizing, surface modification, coating, and blending are used to modify the natural condition of cellulose and become water-soluble. Thus, modified cellulose with the addition of plasticizers serves a raw material for film formation as one type of bio-based packaging material.

2.4 Technical and Vocational Education Training in Agriculture

Generally, the global economy generated from various domains of production involves two-thirds of the workforce (technicians, specialists) to perform technical activities. These skilled people are trained by experienced teachers and trainers from various domains of Vocational Education helpful for Human Resources Development (Grollmann & Rauner, 2007). Considering the importance of vocational training for economic success, especially its link with the agricultural value chain, it is noticeable that in many countries, TVET education is not directly and fully involved in the agriculture development and consequently failure to achieve the professional and social collaboration between agriculture players and TVET institutions.

2.4.1 IPRC Musanze Description

One of the eight colleges of Rwanda Polytechnic named IPRC Musanze is located and operating in the Northern Province of Rwanda in Musanze District, Nkotsi Sector, Bikara Cell, and Barizo Village. IPRC-Musanze, is a public TVET higher learning institution, offering practical training, applied research, and participation in community outreach activities to contribute to the social welfare of its neighbouring community. IPRC Musanze has five teaching academic departments namely: Agriculture and Food Processing Department, Irrigation and Water Engineering Department, Hospitality Management department, Civil Engineering department, and Electrical and Electronics Engineering department. The aim of the Agriculture and Food Processing Department at IPRC Musanze is to contribute to Rwandan agriculture transformation from the subsistence to a modern and income-oriented agriculture with the overall mission of improving people's lives. This is mainly done through academic training, applied research, and community outreach initiatives (IPRC Musanze, 2020).

The college offers also short courses of three months, four months, six months, or one year in the following trades: Carpentry, Culinary Arts, Electrical Domestic Installation, Food and Beverage Service, Food Processing, Front Office, Housekeeping Operations, Masonry, Plumbing and Welding. In a wide perspective, the IPRC Musanze mandate is not only training but also the involvement in community outreach services and solution-based applied research. Since its establishment in 2015, IPRC Musanze has various achievements by which in collaboration with local leaders, the college built a house valued to 16 million Rwandan Francs for vulnerable survivor orphans of the 1994 genocide against Tutsi.

IPRC Musanze staff and students participated in many community outreaches like donating Health insurance to poor and vulnerable citizens, giving cows to families for malnutrition prevention and contributing to the social economy, providing small start-up capital for some entrepreneurs with limited capacity. IPRC Musanze has 76 academic teaching staff whereby 15% of them are females while 85% are males. Majority of academic staff are bachelor's degree holders with five years' experience which are basic requirements for teaching at IPRC College. IPRC Musanze staff benefit from existing collaboration with different partners (SEAD Project, Jinhua Polytechnic, Technoserve, APEFE) in terms of short course training as one of a staff motivational channel. Besides, the college has the staff capacity building strategy whereby two teaching staff from any department are allowed for further studies (master or PhD studies) related to their field of specialization.

Figure 4: Master Plan of IPRC Musanze facilities

Source: IPRC Musanze Management

2.5 Farmer-Academia relationships

In the horticulture (e.g.: tomato) value chain, functions are performed by blended actors with different but complementary activities. One of the keys involved actors in any value chain environment is known as chain supporters such as academic training and research institutions among others. From experience, academic training and research activities are observed as a one-way initiative designed by academicians and researchers with minimal or without input from beneficiaries, whereby even the implementation of interventions or programs are done without any strong involvement of beneficiaries (Drahota et al., 2016). This approach results in a weak collaboration between academics and community stakeholders as a source of failure to translate university-based findings into “real-world” settings.

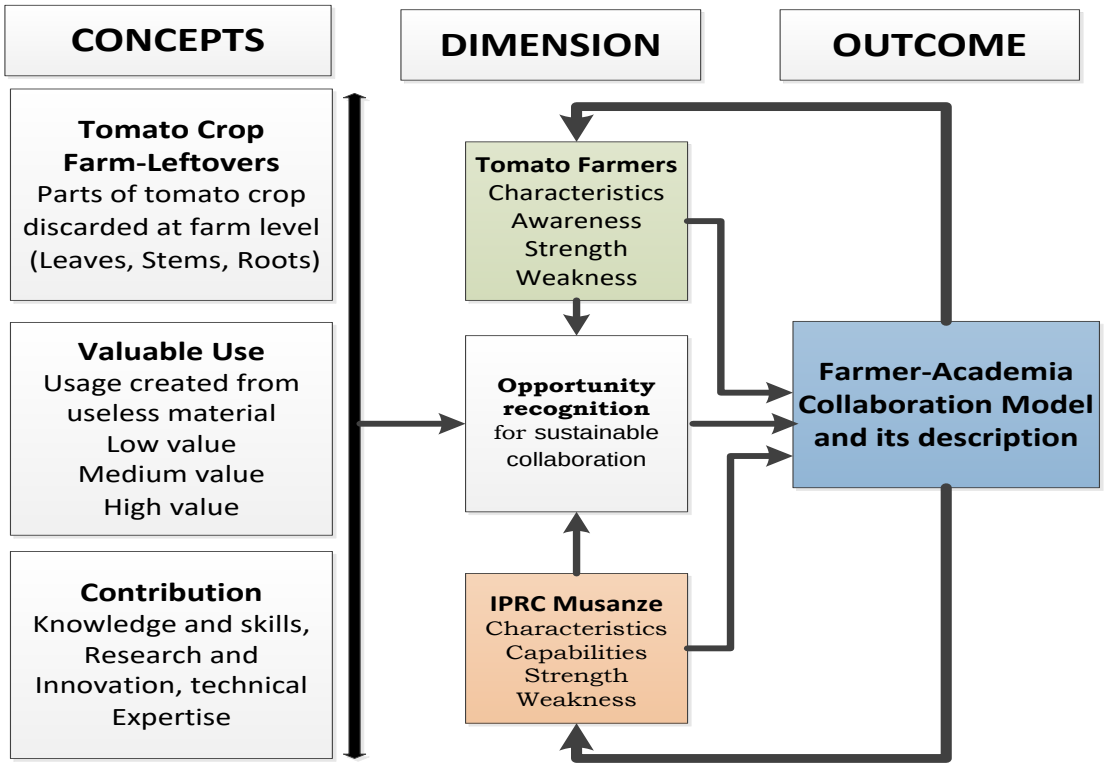
The crucial concept of community-academic partnerships (CAPs) life is based on innovations or applied initiatives that involve all players on the ground (trainers, researchers and beneficiaries) because it is beyond an academic environment and touches the community where it should make an impact on their ways of doing. The successful partnerships between academia and community may improve communication and cooperation between both parties and result in realistic ways of working that fill the gap of translation of academic research findings into community real-life practice (Drahota et al., 2016).

The overall goal of any partnership involving agricultural farmers is farming profitability improvement and one way to achieve this is to make use of the agricultural wastes as utilizable as possible because they are natural biological resources not just refused and discarded. Sabiiti (2011) suggests the setup that can tie together farmers with their potential of agricultural wastes as raw material from their farming activities and other institutions with technical capabilities (skills, knowledge, facilities) to create economic values out of the agricultural residues. This is the reason why a partnership within value chain actors is needed for better future performance for the benefit of all. Scientific knowledge that does not make the required contribution seriously hinders university-industry collaboration. If the universities are not creating knowledge and skills and disseminate it to solve industry problems, the industry will remain ignorant and reluctant to apply the new technologies discovered by the universities (Sannö et al., 2019).

2.6 Conceptual Framework

From the reviewed literature, key concepts have been identified as the base of the current research project and they are described in figure 5.

Figure 5: Conceptual framework



Source: Researcher's design (2020)

2.7 Operationalization

Tomato crop leftover in this study is considered as any part of tomato crop generated mainly at the farm level before or after harvesting the primarily intended product (i.e. Tomato fruits). Those parts (e.g. stems, roots, leaves) and any other are unintentionally produced and considered as useless or discarded material.

Valuable use is a beneficial and monetary use of biological materials naturally considered as useless/unvalued/discarded. Those organic materials serve in the production of other needed products of ***Low-value use*** (e.g.: animal feed, mulching, compost, source of fire for cooking); ***Medium value use*** (e.g.: briquettes, biochar); ***High-value use*** (e.g.: paper, packaging materials, enzymes)

Contribution in the current research context means any tangible, technical and practical support connected to TVET institutions' mandate to improve the knowledge, skills, and well-being of the farmers. This should include applied research and innovation, knowledge and skills transfer initiatives, and provision of technical expertise to communities.

CHAPTER THREE: RESEARCH METHODOLOGY

This chapter clarifies the research area, research strategy for data collection, processing, and analysis. The research findings incorporated qualitative and quantitative methods. It encompassed primary and secondary data sources whereby, primary data were obtained through the online surveys (semi-structured questionnaires) and online interviews. The secondary data were collected from the desk study (book, journal, reports, and internet search).

3.1 Description of the research area

The research was carried out in Rwanda, a landlocked country, bordered with four different countries (Uganda in North, Burundi in South, and Tanzania in the East and DRC in the West). Administratively, Rwanda has four different Provinces and the City of Kigali and each province has different Districts named in local language "Uturere". Every District again is subdivided into several Sectors (i.e. Imirenge) and each sector has several Cells (i.e Utugari) while each cell has several Villages (i.e. Imidugudu) which are the last decentralized local administration entity. The study was performed in Northern Province, Musanze District, and Nkotsi Sector. The Nkotsi Sector is in the South part of the Musanze District. Nkotsi sector is bordered by Muko Sector, Rwaza Sector, Kimonyi Sector, and Busogo Sector (Akinyemi, 2017). The Musanze district was chosen because it is among the top five districts producing tomatoes in Rwanda.

The research study was conducted during COVID 19 pandemic period and Rwanda is one of the affected countries. On 4th June 2020, Rwanda was counting 410 cases, 280 recovered, and 128 are active cases (RBC, 2020). Most of the cases were reported in the City of the Kigali and less than 10 cases in Northern Province where the current research was conducted. The cases continued increasing day to day but fortunately, due to strong prevention and combating strategies in place the pandemic was controlled and it did not kill many people and on 4th June 2020 only 5 people were reported dead due to COVID 19. The strict Rwandan regulations to combat the pandemic helped a lot with the data collection exercise for the study because it went as planned by the researcher.

Figure 6: Map of Rwanda

Figure 7: Map of Musanze District

Sources: (City population, 2020)

3.2 Research Strategy

The research studied a case of tomato farmers in the Musanze District /Nkotsi Sector whereby both quantitative and qualitative approaches were used to get data from respondents and key informants. The online semi-structured questionnaire (see Appendix 6) was given to tomato farmers and a different online semi-structured questionnaire (see Appendix 7) was given TVET trainers from IPRC Musanze whereas the online semi-structured interviews (see Appendices 8; 9; 10; 11; 12) were also done for various key informants from public and private institutions in close connection with horticulture sector development. The collected data from different sources were presented, analysed, and discussed before making conclusions and recommendations for further research works. The data were gathered electronically (online) via the internet because of COVID 19 Pandemic and the main researcher was not able to physically be present on the field. They were two researcher assistants hired to help the main researcher in terms of fieldwork and connected activities.

3.2.1 Desk Study

The research started with a desk study that provided suitable previous literature linked to the research questions. The main reason for the desk study was to collect secondary data which are useful to explain theories and concepts related to the tomato value chain, tomato farm-leftovers, and the possible valuable uses as well as describing the contribution of TVET institutions in the agricultural value chain development as sketched in the conceptual framework (figure 5). The outcomes of the desk study (secondary data) were reported in chapter two the current report.

3.2.2 Sample size

A total number of fifty-four was the sample size including thirty-four (34) individual tomato farmers (see Appendix 13) operating in Nkotsi sector, thirteen (13) TVET trainers (see Appendix 14) from the Agriculture and Food Processing department at IPRC Musanze, and eight (6) key informants (see Appendix 15) from different public and private institutions closely involved in horticulture subsector (table 2).

Table 2: Categories of respondents and key informants

SN	Respondents / Informants Function	Cell / Institution	Numbers
1	Tomato Farmers	Bikara Cell	**7**
2	Tomato Farmers	Gashinga Cell	**7**
3	Tomato Farmers	Ruyumba Cell	**7**
4	Tomato Farmers	Rugeshi Cell	**7**
5	Tomato Farmers	Mubago Cell	**6**
6	TVET Trainers in Agriculture and Food Processing Department	IPRC Musanze	**13**
7	Sector Agronomist	Nkotsi Sector	**1**
10	Deputy Principal in charge of Academic and Training	IPRC Musanze	**1**
11	Research Technician	Rwanda Agriculture Board (RAB)	**1**
12	Farm Manager	Sunripe Farm	**1**
13	Farm Quality Assurance Officer	Sunripe Farm	**1**
14	Field Agronomist	Holland Greentech	**1**
	TOTAL		***54***

Source: Researcher's design (2020)

The studied case was tomato farmers in Musanze District in Nkotsi Sector. The population was purposively chosen because it is a high tomato producing area in Musanze District, and it is also the IPRC Musanze location. The thirty-five (35) respondents were randomly sampled from five cells of Nkotsi sector whereby seven (7) tomato farmers from each cell were representative of remaining farmers and a total of thirty-four (34) responded to the online semi-structured questionnaire about their farming experiences while one respondent missed out. All thirteen (13) TVET trainers in the Agriculture and Food Processing Department at IPRC Musanze were purposively given online semi-structured questionnaires and provided their insights about the tomato farming based on their experience and expertise in the domain. A total of six (6) key informants were purposefully chosen from public and private institutions and provided additional information from their remarkable involvement and experience in horticulture sector development.

3.2.3 Field Works

After having strong supportive literature, the research was conducted on the field to get the primary data for the research. All activities were coordinated via an online platform created by the main researcher, and two assistant researchers were in support of the field works in terms of contacting local leaders, respondents, and key informants for the smooth data collection task. As the main researcher was not able to be physically on the field, he collaborated closely with two assistant researchers who are experienced colleagues (trainers) from the back-home institution. The assistant researchers performed daily fieldwork activities and handled different unplanned issues that happened during the data collection process, in an online consultation with the main researcher.

I. Data Collection from tomato farmers

The online semi-structured questionnaire was designed through Microsoft forms and piloted one week before data collection exercise to check for relevance of the questions and some adjustments were done. The primary data were collected from tomato farmers about their tomato farming experience in the Nkotsi Sector through online semi-structured questionnaires. The assistant researchers made appointments for farmers of different cells in the facilitation of Sector Agronomist. In real data collection activity, the farmers were supported by assistant researchers on the ground either at the cell's local administrative office or nearby their tomato farms and some clarification on questionnaires was provided whenever needed. The completed questionnaires were electronically sent to the main researcher who was also monitoring digitally every step of the data collection. Figure 8 shows some pictures of tomato farmers and assistant researchers during data collection activities in Nkotsi Sector.

Figure 8: Tomato farmers and assistant researchers during data collection activities

Source: Research data collection (2020)

II. Data collection from TVET trainers at IPRC Musanze

The TVET trainers at IPRC Musanze in the Agriculture and Food Processing Department responded to a specific online semi-structured questionnaire designed using Microsoft form. The online semi-structured questionnaire was piloted one week before on five academic staff and after some adjustments, the final version was sent by the main researcher to TVET trainers from the mentioned department. The responses from TVET trainers were electronically submitted to the main researcher who received them immediately via Microsoft forms.

III. Data collection from key informants

For the sake of triangulation, additional information was gathered from key informants selected from Musanze District/Nkotsi sector, IPRC Musanze, RAB, Sunripe Farm, and Holland Greentech. The online semi-structured interview checklists were designed and tested by the main researcher before interviewing key informants. The interview appointments were made two weeks in advance and the online communication links were submitted to key informants two days before the day of the interview. The various online communication tools were used namely: Zoom meeting, Skype calls, WhatsApp calling, phone calls, and the conversation were recorded and used during processing and analysis activities.

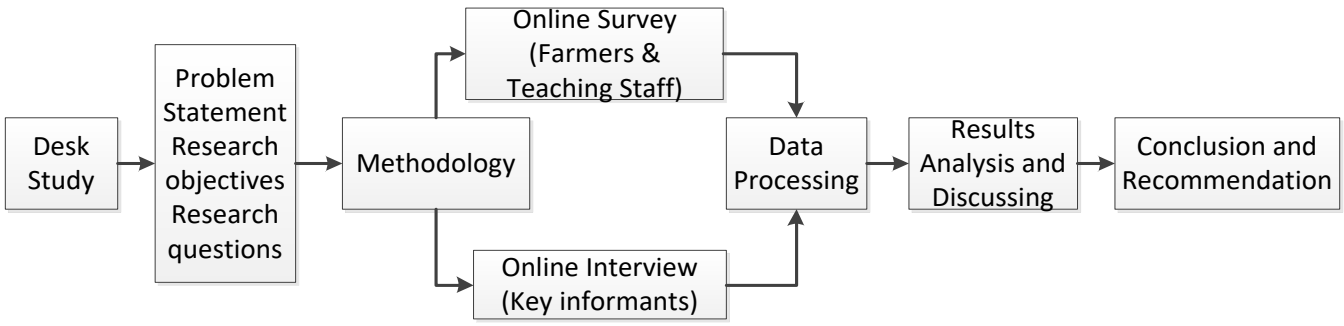
3.2.4 Data Processing and Data Analysis

All data collected using different data collection tools above described were recorded and processed via computer system immediately from the field. The Quantitative data (numbers provided in questionnaires or those converted after data collection) were processed by the main researcher via Excel spreadsheets and after transferred to IBM SPSS version 25 for analysis. On the other hand; the qualitative data mainly from online recorded interviews and some from online questionnaires open responses were transcribed in a word document, categorized, analysed, and summarized before presenting and interpreting them with support of secondary data generated from reviewed literature.

3.2.5 Research framework

The research framework comprises desk study that leads to problem statement and research objectives, fieldwork for data collection (i.e. online survey and online interviews), data processing, analysis of the results and discussion, conclusion, and recommendations (see figure 9).

Figure 9: A research framework



Source: Researcher's Design (2020)

3.2.6 Research limitations

Limitations of the study were all about getting precise interview appointments for some key informants. They were missing due to unplanned assigned tasks by their superiors on the day of the interview and two were not responding to any communication. The weak internet connection disturbed some online interviews and the researcher was obliged to postpone some interviews to other days which affected the data collection schedule. However, collected data from available different sources of information were adequate for the study as the researcher tried to get required information as much as possible.

Table 3: Summary of Research Methodology

Main Research Question 1: ***What are the estimated amount and current uses of tomato crop farm-leftovers in Nkotsi sector?***			
Research Sub Questions	**Research Method**	**Tools for Data Collection**	**Indicators / Findings**
1.1 What type and how much quantity of tomato crop farm-leftovers in Nkotsi sector?	Desk Study Method; Quantitative Method; Qualitative Method;	Online search engines; Online semi Structured Questionnaire (farmers); Online semi-structured interview (key informant)	Summary Scholarly published paper, official documents, and books; Types of leftovers and estimated Quantities; Interview Records; Interview Transcripts.
1.2 What are the final destinations of farm-leftovers along the tomato value chain in Nkotsi sector?	Desk Study Method; Quantitative Method; Qualitative Method	Online search engines; Online semi Structured Questionnaires farmers); Online semi-structured Interview (key informant)	Summary Scholarly published paper, official document, and book; Interview Records, Interview Transcripts,
1.3 What are the monetary benefits of tomato crop farm-leftovers in Nkotsi Sector?	Desk Study Method; Quantitative Method; Qualitative Method	Online search engines; Online semi-structured Questionnaire (farmers); Online semi-structured Interview (key informant)	Summary Scholarly published paper, official document, and book; crop leftover value; Interview Records,
Main research Question 2 ***What are the potential value addition processes that can be applied to tomato crop farm-leftovers?***			
Research Sub Questions	**Research Method**	**Tools for Data Collection**	**Indicators / Findings**
2.1 What are the value-added activities to transform tomato crop farm-leftovers into other products?	Desk Study Method; Qualitative Method	Online search engines; Online semi Structured Questionnaire (Teaching Staff); Online interviews (key informants)	Summary Scholarly Published Papers; Interview Records, Interview Transcripts,
2.2 What are the technical requirements to create valuable products from tomato crop farm-leftovers?	Desk Study Method; Qualitative Method	Search Engines; Online semi Structured Questionnaire (Teaching staff); Online Interview (key informants)	Summary Scholarly Published Papers; Interview Records, Interview Transcripts
2.3What should be sustainable tomato value addition linkages between IPRC Musanze and tomato farmers?	Desk Study Method; Qualitative Method	Online search Engines; Online semi-structured questionnaire (Teaching staff); Online interview (Key informants)	Summary Scholarly Published Papers; Interview Records, Interview Transcripts,

Source: Researcher's design (2020)

CHAPTER FOUR: RESULTS ANALYSIS

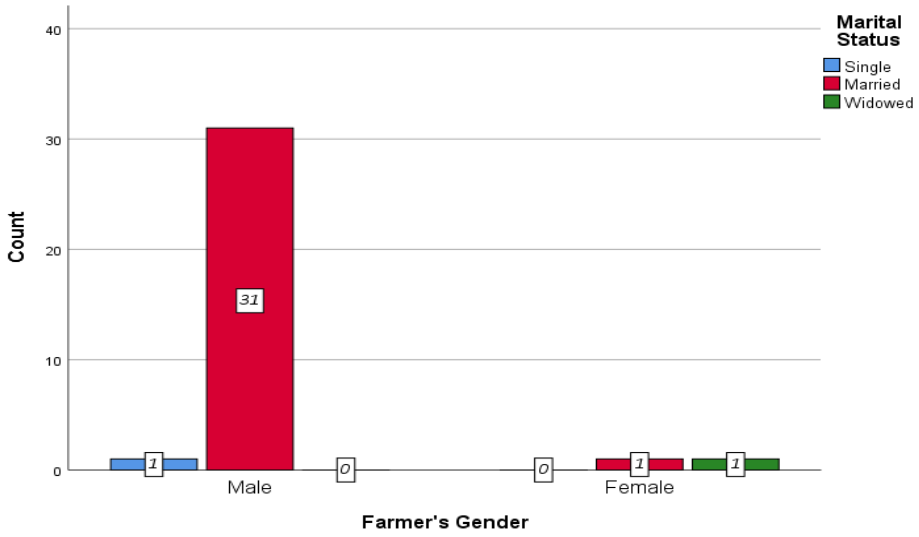
This chapter contains information from the research field works and it summarises the online survey results and online interview results. The results are presented in three parts; part one contains results from farmers' online survey with details on the respondents' characteristics, their farming experiences, and their awareness and willingness; while part two highlights information provided by TVET trainers through an online survey and includes the respondents' descriptions, respondents perception about tomato farming in Nkotsi Sector, farming areas of improvement, support and collaboration with IPRC Musanze; part three contains the information provided by key informants through the online interviews.

4.1 Results from farmers' online Survey

4.1.1 Characteristics of respondents

The total numbers of respondents (N=34) of individual tomato farmers responded to the online semi structured questionnaires. Figure 10 shows farmers' gender and the marital status where 31 are married male, 1 single male, 1 married female and 1 widowed female.

Figure 10: Farmers Gender and their marital status



Source: Farmers' survey (2020)

Table 4 highlights the tomato farmers' age range. 26% of the respondents are between 50-60 years old, 18% of respondents are between 20-29 years old.

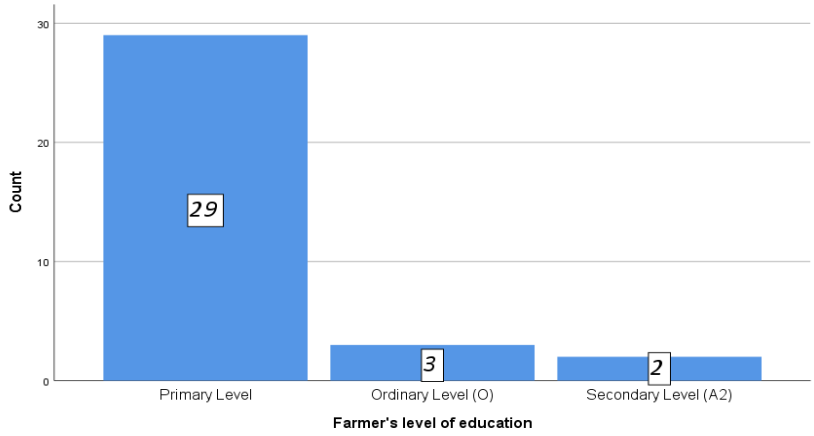
Table 4: Age range of tomato farmers in Nkotsi sector

Tomato farmers age range				
20 - 29	**30 - 39**	**40-49**	**50-60**	**Total**
6	9	10	9	**34**
18%	26%	29%	26%	**100%**

Source: Farmers' survey (2020)

Figure 11 shows the farmer's level of education by which 29 out of 34 respondents have a primary level of education.

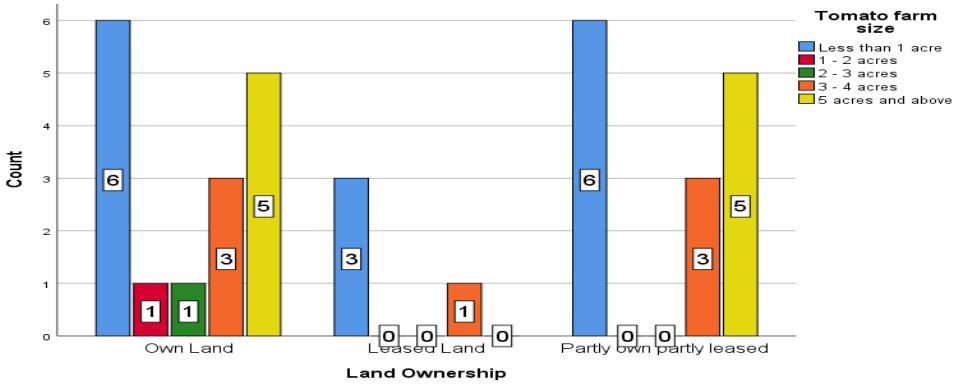
Figure 11: Farmers' Level of education in Nkotsi Sector



Source: Farmers' survey (2020)

The farm ownership is classified into three classes: own land; leased land, and partly own leased. 6 respondents out of 34 own their land with less than 1-acre (0.4 ha) farm size. Other details are in figure 12.

Figure 12: Tomato farm size and land ownership in Nkotsi Sector



Source: Farmers' survey (2020)

Table 5 shows the average land size of 2.88 acres (i.e. 1,15 ha) calculated for 34 respondents of farmers' survey.

Table 5: Average size of tomato farms in Nkotsi Sector

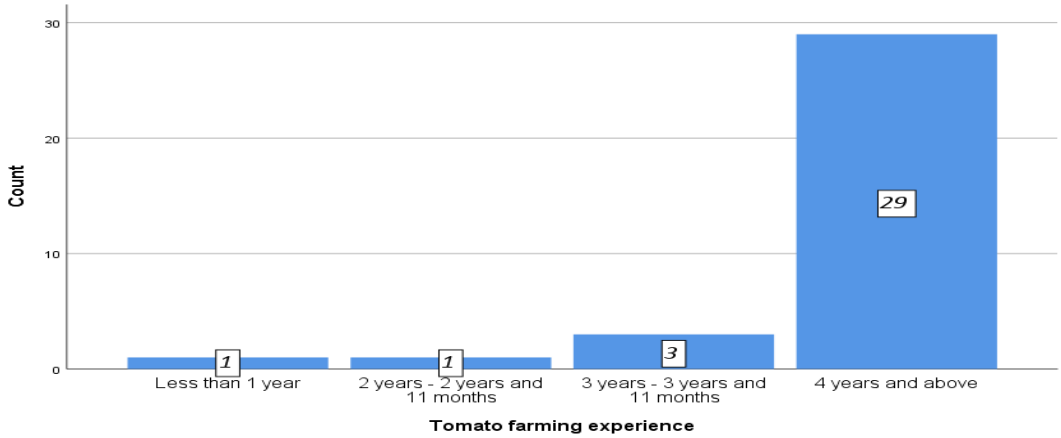
	N	Minimum	Maximum	Mean	Std. Deviation
Tomato farm size	34	1	5	2.88	1.805
Valid N (listwise)	34				

Source: Farmers' survey (2020)

4.1.2 Tomato farming experiences in Nkotsi Sector

Figure 13 summarizes the tomato farming experience in Nkotsi sector whereby 29 out of 34 respondents have more than 4 years of tomato farming experience.

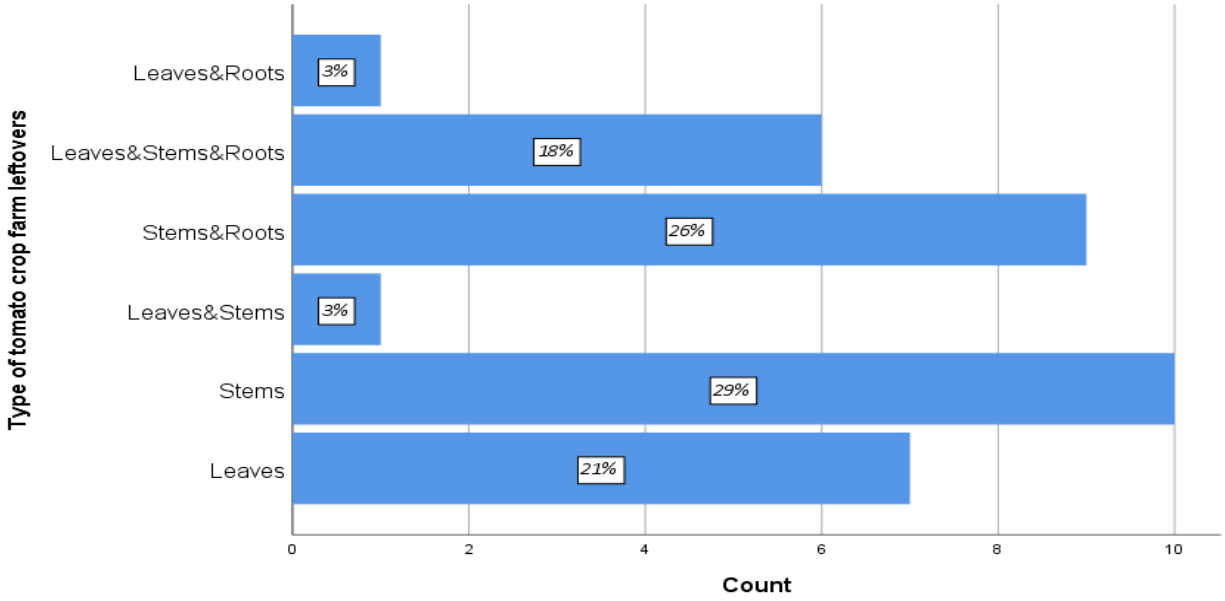
Figure 13: Tomato farming experiences in Nkotsi Sector



Source: Farmers' survey (2020)

Figure 14 illustrates the type of tomato crop farm-leftovers found in Nkotsi Sector tomato farms. 29% of respondents confirmed that the tomato stems are the most leftovers in their tomato farms. Table 6 shows the minimum and maximum estimated quantity of tomato crop farm-leftovers generated in a year in Nkotsi sector as shown by farmers' survey.

Figure 14: Types of tomato crop farm-leftovers in Nkotsi Sector



Source: Farmers' survey (2020)

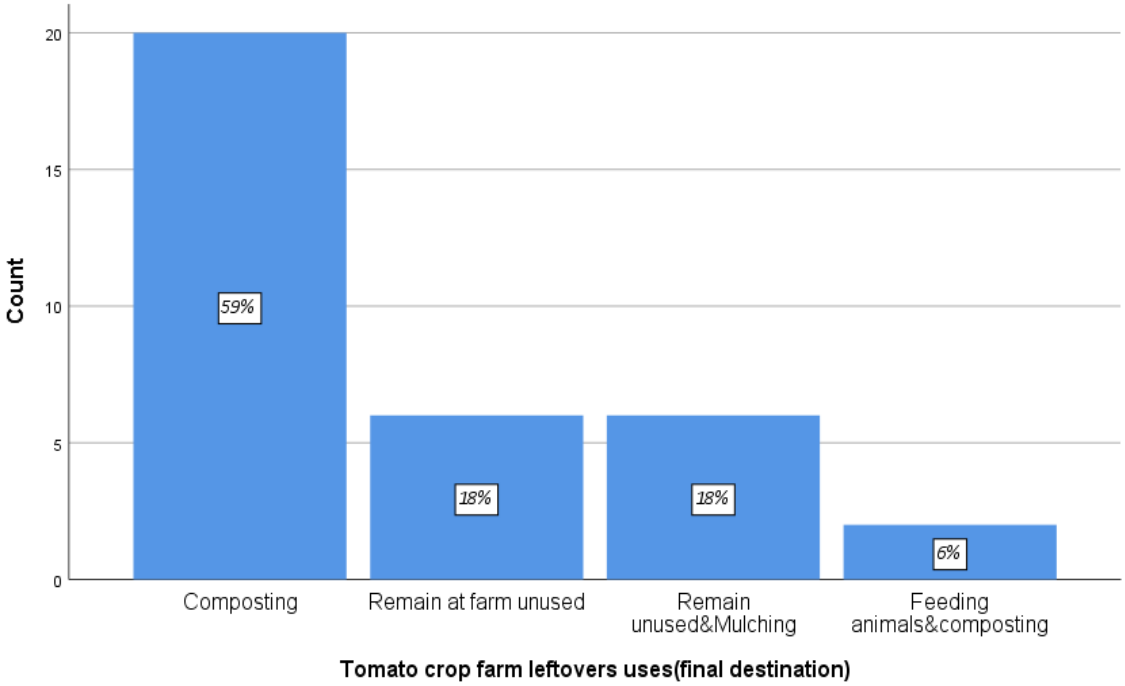
Table 6: Tomato crop farm-leftovers per year in Nkotsi Sector

	N	Minimum	Maximum	Mean	Std. Deviation
Estimates of tomato crop farm leftovers/year in kg	34	30	1600	323.82	378.330

Source: Farmers' survey (2020)

The 59% of respondents said that the generated tomato crop farm-leftovers are used for compost making, while only 18% of respondents said that the generated farm-leftovers remains unused at farm level, 18% respondents said that the tomato crop farm-leftovers remain unused and sometimes used as mulching, and 6% respondents use tomato crop farm-leftovers for feeding animals and making compost and no one mentioned burning practice of farm-leftovers (figure 15).

Figure 15: Tomato crop farm-leftovers final destinations



Source: Farmers' survey (2020)

4.1.3 Tomato Farmers awareness and willingness

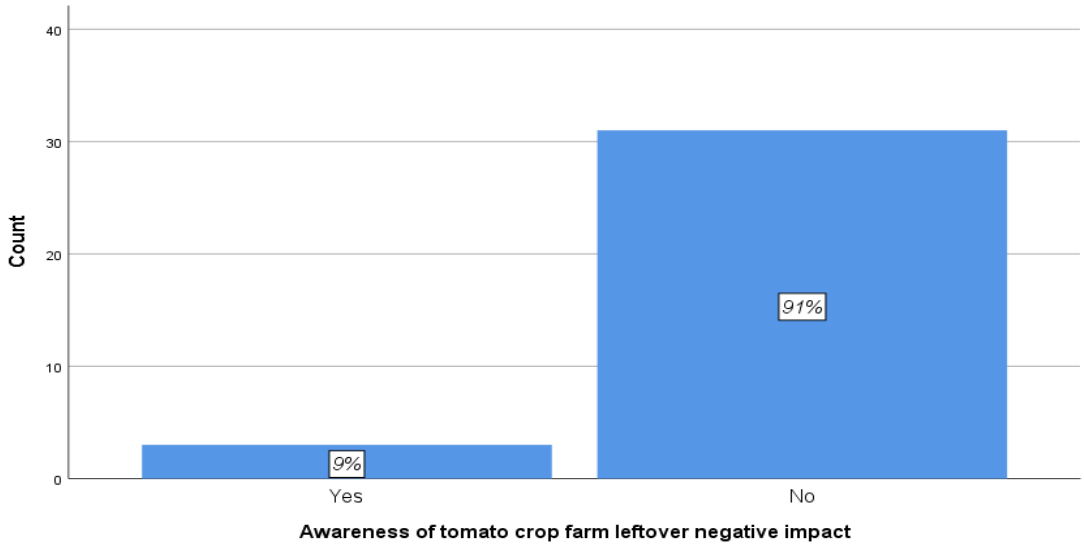
Apart from some positive impact of tomato crop farm-leftovers above highlighted by respondents, 100 % of respondents said that they do not gain any monetary benefit (cash) while using the tomato crop farm leftovers for different purposes (figure 16).

Figure 16: Tomato crop farm-leftovers monetary benefits

Source: Farmers' survey (2020)

Also, the farmers' survey responses showed that 91% of respondents are not aware of the negative impact of farm crop leftovers on their farming practices and the environment (figure 17).

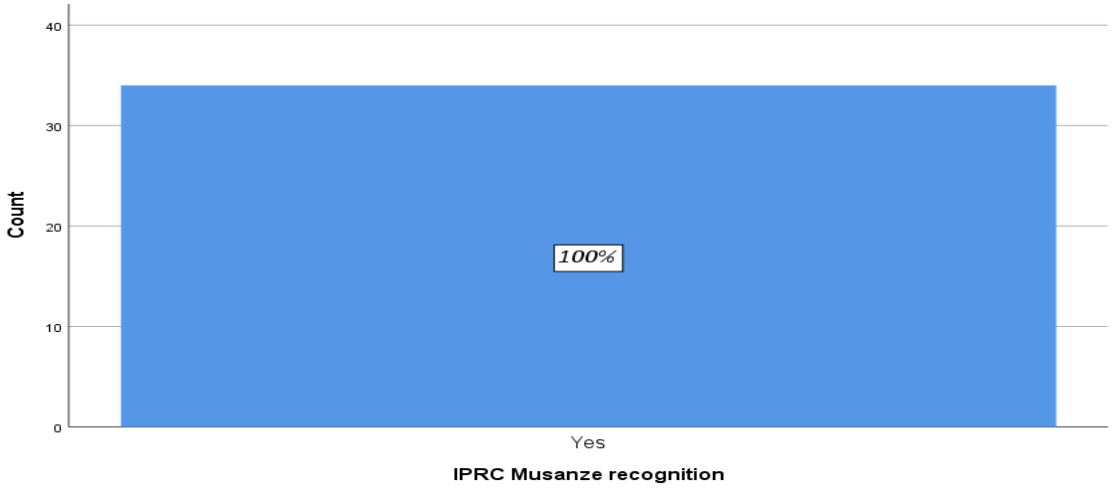
Figure 17: Awareness of tomato crop farm leftover negative effect



Source: Farmers' survey (2020)

100% of the respondents said that they know IPRC Musanze in different views (figure 18). 47% of respondents know IPRC Musanze as a university, while 41% of respondents recognize IPRC Musanze as a vocational Higher learning School, and 12% of respondents know IPRC Musanze as both a university and a vocational higher learning institution.

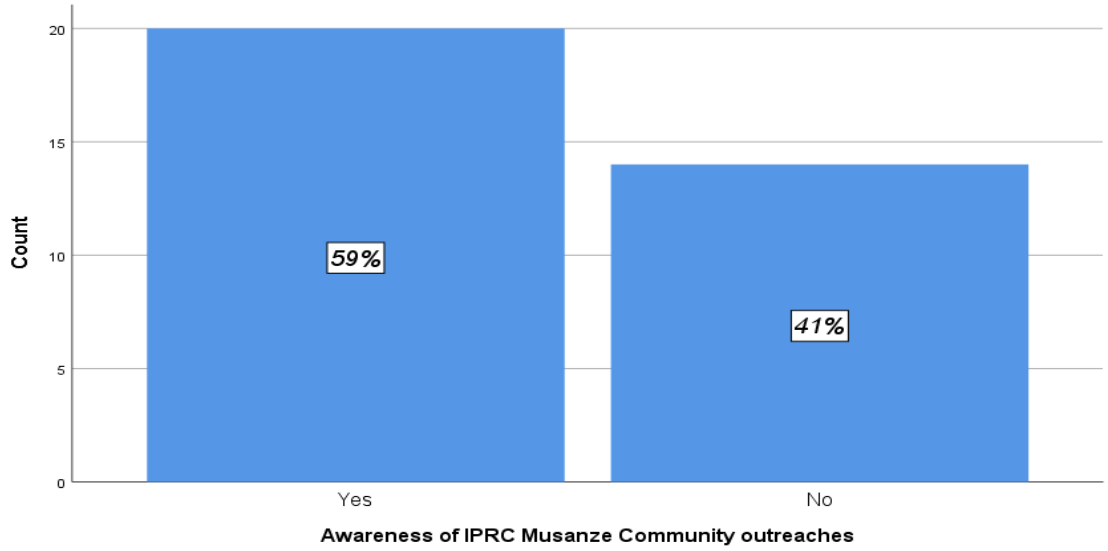
Figure 18: IPRC Musanze recognition



Source: Farmers' survey (2020)

Figure 19 shows that 59% of the respondents confirmed that they know the IPRC Musanze community outreach activities done to its surrounding communities.

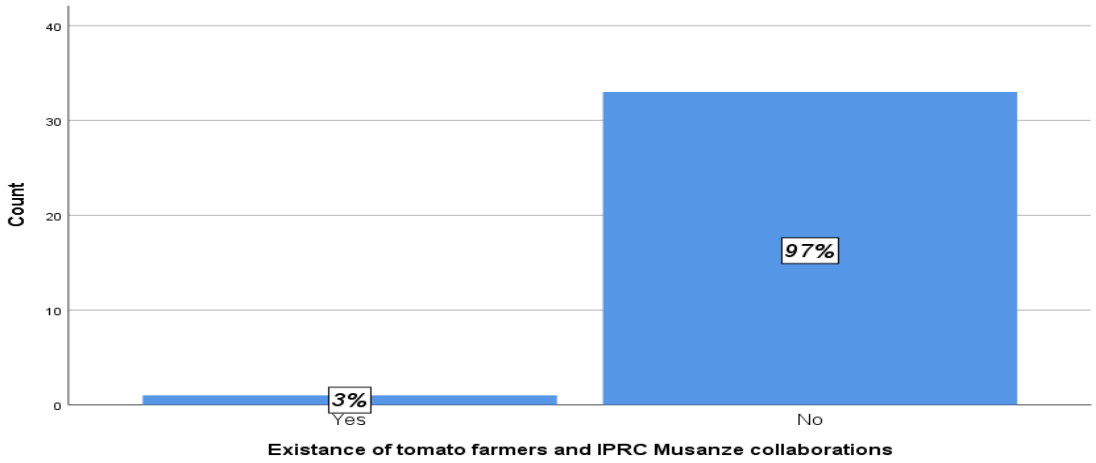
Figure 19: Awareness of IPRC Musanze community outreaches



Source: Farmers' survey (2020)

The farmer's survey revealed that 97% of the respondents have no previous collaboration with IPRC Musanze (figure 20).

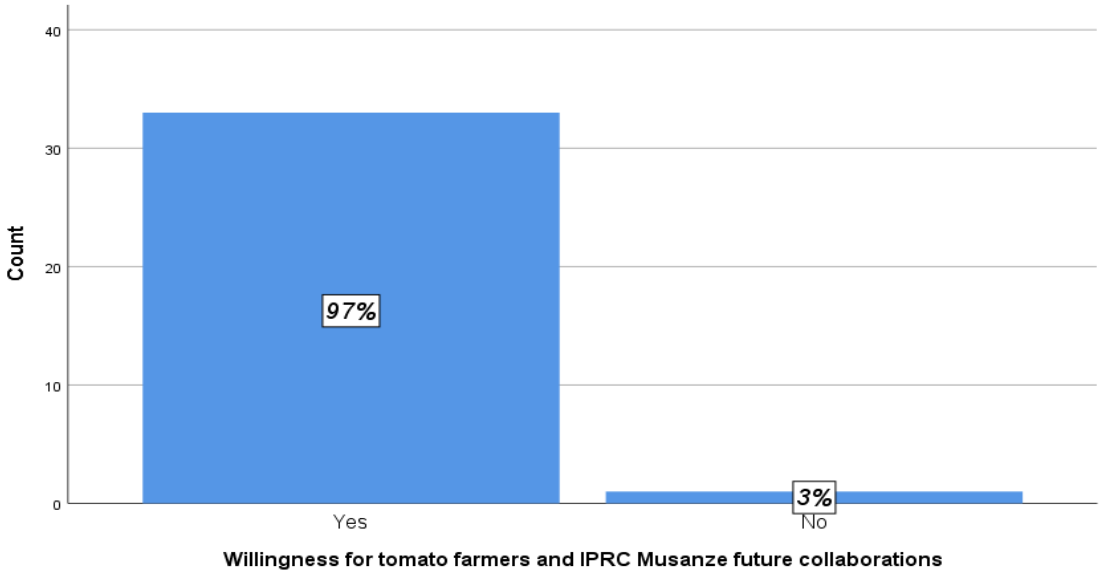
Figure 20: IPRC Musanze and tomato farmer's collaborations



Source: Farmers' survey (2020)

Interestingly, figure 21 shows that 97% of the respondents are willing to have future collaboration with IPRC Musanze in different areas.

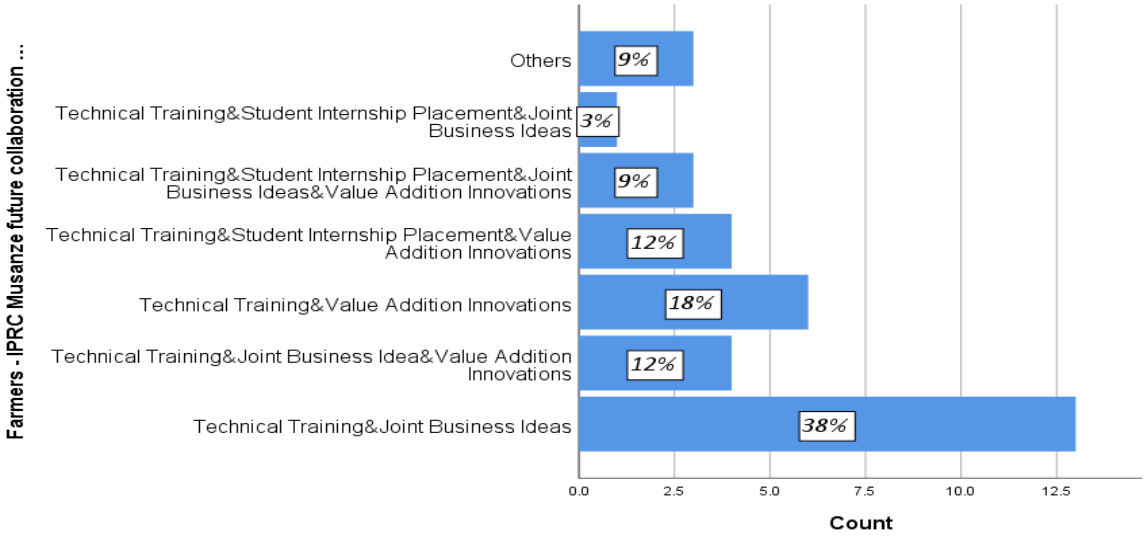
Figure 21: Willingness for future collaboration



Source: Farmers' survey (2020)

Tomato farmers in Nkotsi sector suggested different areas for future collaboration with IPRC Musanze. Technical Training and Joint Business Ideas were mostly suggested by 38% of respondents.

Figure 22: Suggested areas of collaborations



Source: Farmers' survey (2020)

4.2 Results from TVET Trainers Online Survey

4.2.1 Respondents description

The total number (N=13) of TVET trainers from the Agriculture and Food Processing department at IPRC Musanze responded to the given online survey. Table 7 describes the respondents by gender, age-range, and their marital status details.

Table 7: TVET trainers' description

Gender			Age range			Marital Status		
Males	**Females**	**Total**	**28 - 34**	**35 - 40**	**Total**	**Single**	**Married**	**Total**
9	4	**13**	8	5	**13**	2	11	**13**
69%	31%	**100%**	62%	38%	**100%**	15%	85%	**100%**

Source: TVET trainers' survey (2020)

The results from the online TVET trainer survey show the educational level and teaching experience of respondents, and the detailed findings are summarized in table 8.

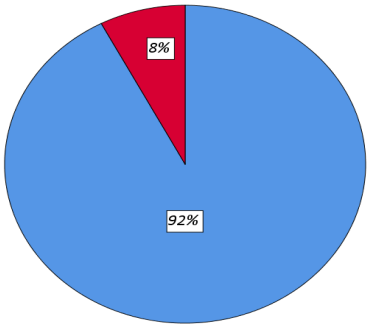
Table 8: TVET trainers' educational level and their experience

Education Level			Teaching Experience at IPRC Musanze						
Master's Degree	Bachelor's Degree	**Total**	Less than 1 year	1-2 years	2-3 years	3-4 years	4- 5 years	Above 5 years	**Total**
8	5	**13**	1	1	3	3	2	3	**13**
62%	38%	**100%**	8%	8%	15%	23%	15%	23%	**100%**

Source: TVET trainers' survey (2020)

Figure 23 shows that 92% of the respondents previously participated in different community outreach activities organized by IPRC Musanze.

Figure 23: Community outreach participation



Source: TVET trainers' survey (2020)

4.2.2 Respondents perspective about tomato farming in Nkotsi Sector

The results show 62% of the respondents confirmed that there are no advanced tomatoes farming activities present in Nkotsi Sector (figure 24). The online TVET trainers' survey revealed also that 92% of the respondents confirmed that crop farm-leftovers have effects on farming activities as well as the environment (figure 25).

Figure 24: Presence of advanced farming activities

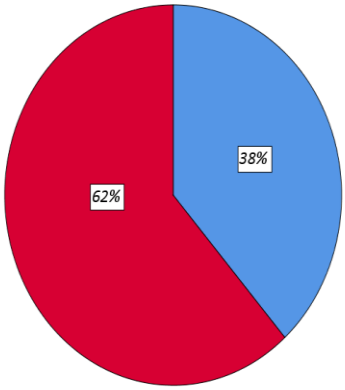
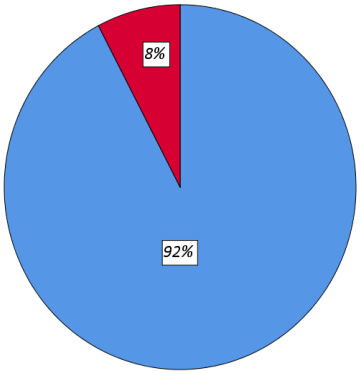


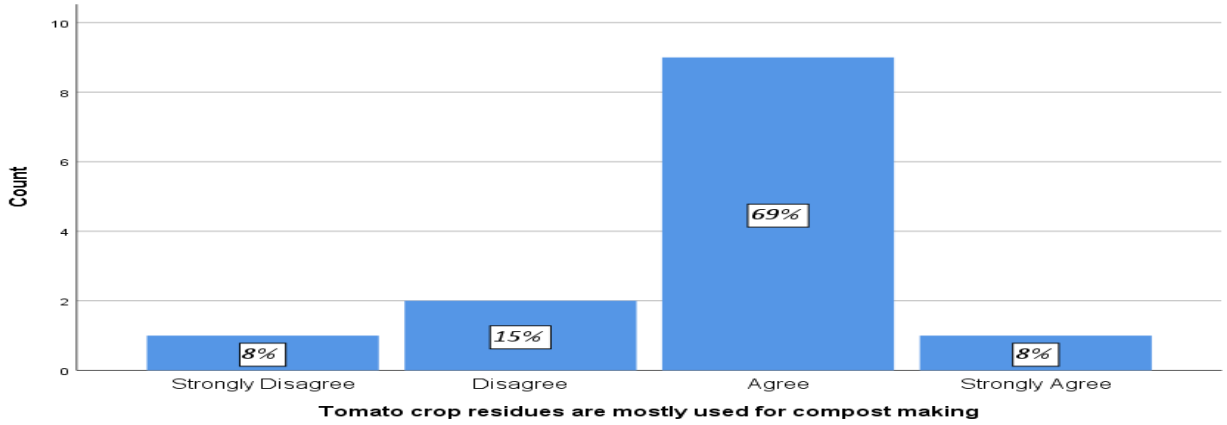
Figure 25: Crop farm-leftovers effects



Source: TVET trainers' survey (2020)

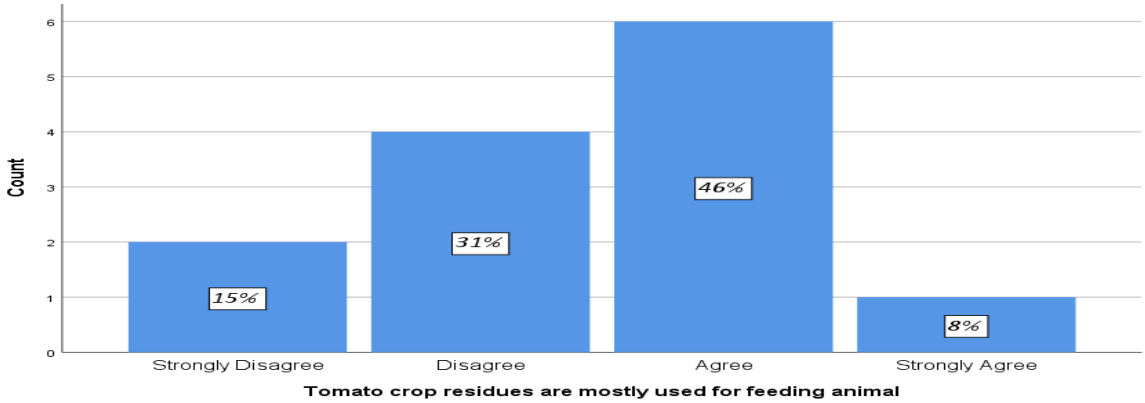
The detailed responses from TVET trainers' online survey about the usefulness of tomato crop farm-leftovers are respectively presented. Figure 26 shows that 69% of respondents agreed that tomato crop farm-leftovers are mostly used for compost making while 15% disagreed; figure 27 shows that 46% of respondents agreed that tomato crop farm-leftovers are mostly used for feeding animal while 31% disagreed; figure 28 shows that 46% of respondents agreed that tomato crop farm-leftovers can be used as raw material for other products (i.e. paper, packaging material, enzymes) while 23% disagreed and figure 29 shows that 69% of respondents strongly disagreed that tomato crop farm-leftovers are useless while only 8% agreed.

Figure 26: Are farm-leftovers mostly used for composting?



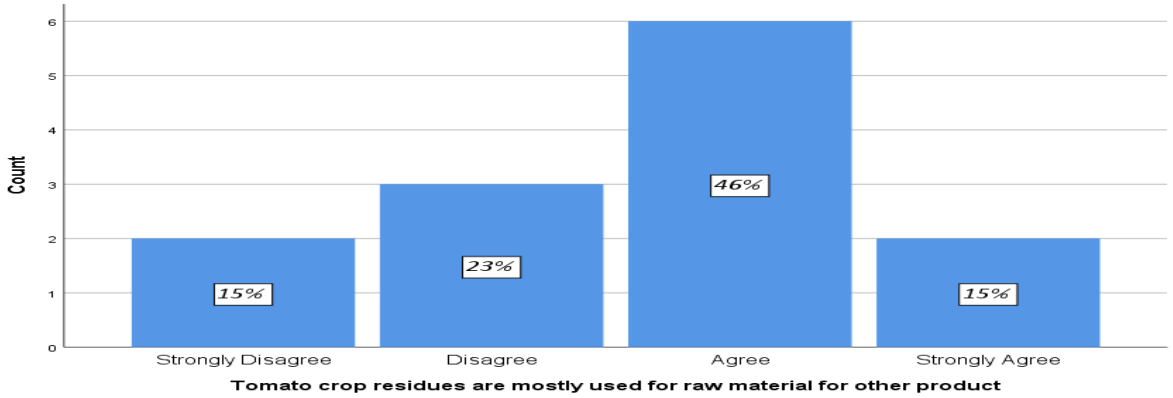
Source: TVET trainers' survey (2020)

Figure 27*: Are farm-leftovers mostly used for feeding animals?*



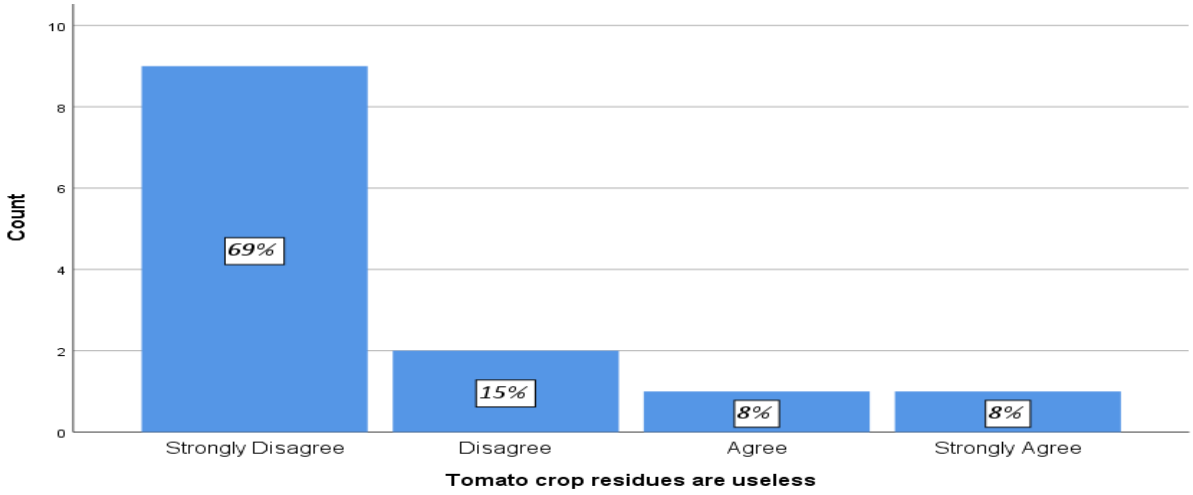
Source: TVET trainers' survey (2020)

Figure 28: Can crop farm-leftovers be used as raw material for other products?



Source: TVET trainers' survey (2020)

Figure 29: Are tomatoes crop farm-leftovers useless?



Source: TVET trainers' survey (2020)

4.2.3 Area of improvement, support, and collaborations with IPRC Musanze

a. Suggested area of improvement

The tomato farmers who responded to the online survey suggested three main areas of improvement which are: postharvest handling, farm crop residues management and farming practices with 77%; 62%; 54% of respondents respectively. The harvesting techniques were least suggested by only 31% of respondents.

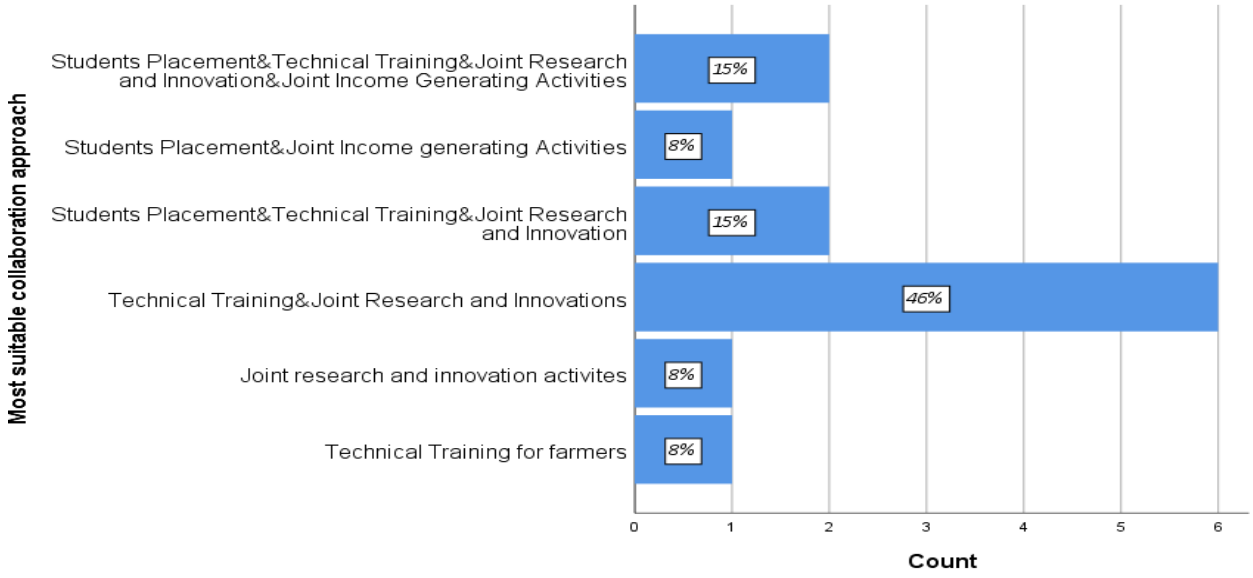
b. IPRC Musanze Support to tomato farmers in Nkotsi sector

IPRC Musanze as a TVET institution has a good working environment including training infrastructures, campus location as well as skilled and experienced staff that helped in various community outreach activities within the neighbouring community. The responses from online TVET trainer survey shows that IPRC Musanze can provide support to tomato farmers in Nkotsi sector through various technical training to farmers (GAP, Post-harvest, FFS), Joint research and innovations, consultancies (value addition units, farming techniques,) and by offering improved seeds to farmers.

c. Suitable collaboration approaches

Figure 30 shows that 46% of the respondents suggested that the technical training and Joint research and innovation activities are the suitable collaborations that could be established between tomato farmers in Nkotsi sector and IPRC Musanze.

Figure 30: Collaboration approaches suggested by TVET trainers



Source: TVET trainers' survey (2020

4.3 Results from in-depth online interviews

This section covers the results from the online interviews with key informants from different public and private institutions in close collaboration and/or mostly involved in horticulture farming development. The total number (N=6) of key informants are from RAB, Musanze District/Nkotsi Sector, IPRC Musanze, Holland Greentech, and Sunripe Farm. Results were presented following the second research question which was about the potential value addition processes that can be applied to tomato crop leftovers. By answering this research question the information about potential products from tomato crop farm-leftovers and its transformation requirements were highlighted and the possible approach for joint activities between IPRC Musanze and tomato farmers in Nkotsi Sector was suggested.

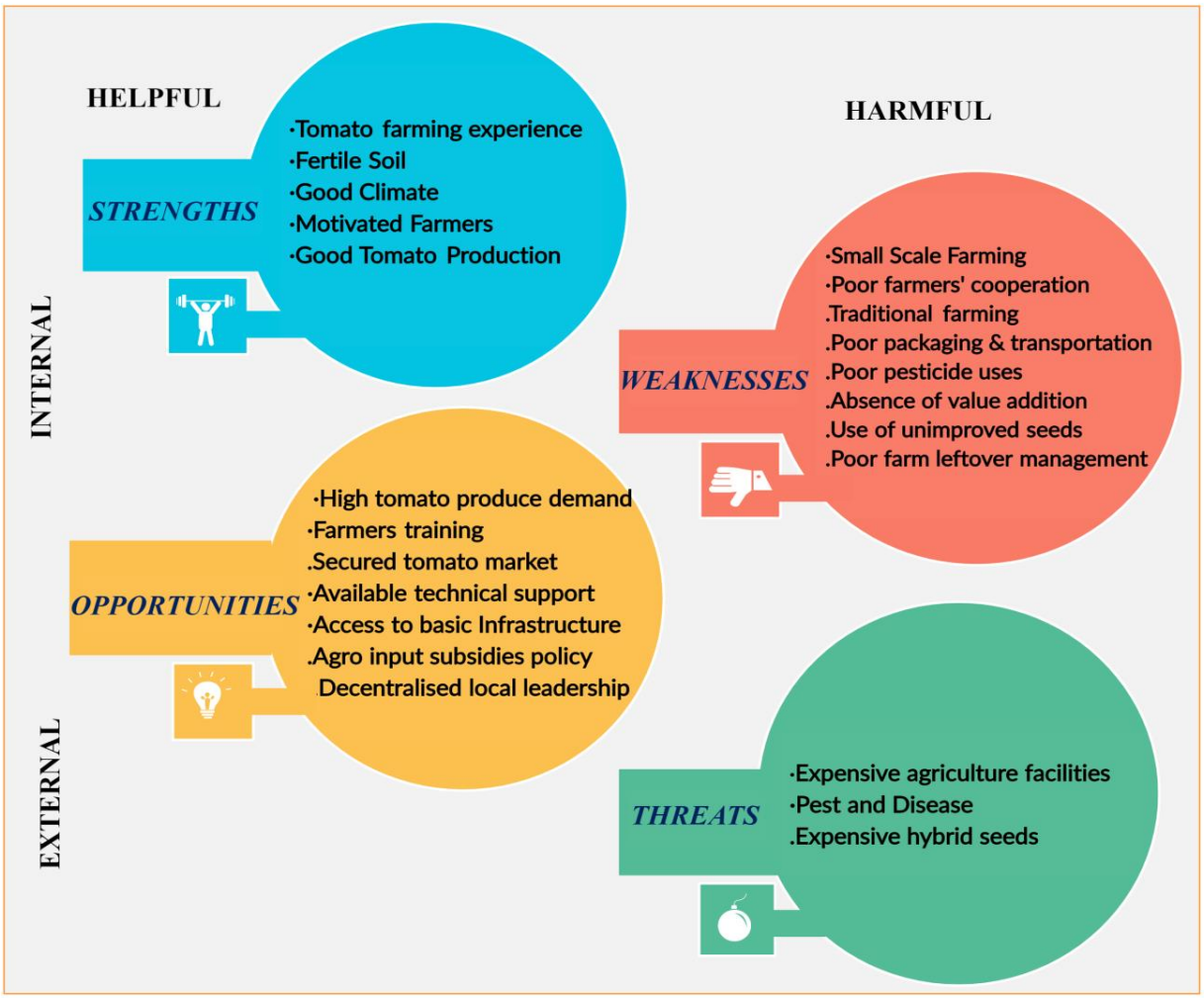
4.3.1 Products made from tomato crop farm-leftovers

The tomato farming in Nkotsi Sector is considered as small scale and its moderate primary production generates comparative farm-leftovers. One of the interviewees confirmed the available opportunities that can help tomato farmers in Nkotsi sector to scale up to medium farming. The informant said: "***The opportunities are that the tomatoes are highly produced in the region, there is a fertile land, farmers are motivated, there is a huge market for tomatoes in (Gakenke, Nyabihu, and Rubavu Districts), the accessibility to the basic infrastructures (road, water, electricity), farmers supply their produce to the nearby local market, and the local leadership is nearby them".***

All key informants reported that they do not know any other products that can be manufactured from tomato crop farm-leftovers apart from compost. Interviewee no 2 said: ***"No. I have no idea if the crop farm-residues can be improved to produce a new usable product. Only compost I know***". Another interviewee reported and confirmed that apart from compost she does not know any other product made from tomato farm-leftovers. She said***: " Even though I do not know what else can be made from those leftovers, but if possible it may be good news for farmers to be confident that when they are farming tomatoes they can have several income sources both from tomatoes fruits and farm-leftovers".***
Even though key informants do not recognise any other product made from tomato farm-leftovers, they confirmed the importance of the leftovers in farming activities. The interviewee no 5 argued that: ***"farm crop residues are used for organic manure making for soil reconstitution or farmers use them for mulching and then making organic manure".***

Through the online conversation, 100% of the key informants were curious and recommended further research that could come up with the manufacturing process, and trials or prototypes of new products made from tomato crop farm-leftovers. The interviewee no 6 said that: ***"I was thinking like pesticides and fertilisers"*** while the interviewee no 5 testimonies about farm-leftovers usages and said***: "in wheat farming, the residues at farm-level were wasted but now are becoming an important product because they are used in mushroom farming. So, if tomato farm-leftovers can be valorised too, it might be very good for farmers and could be a motivation for their tomato farming improvement".*** Based on the various qualitative information gathered for this research through triangulated data collection methods, the Helpful and Harmful aspects for tomato farming in Nkotsi sectors have been identified and summarized by the researcher in Figure 31.

Figure 31: SWOT analysis for tomato farming in Nkotsi Sectors



Source: Research findings (2020)

4.3.2 Ways of collaboration between IPRC Musanze and Tomato farmers

The insights from key informants on possible collaboration between tomato farmers and IPRC Musanze are clear and promising but also conditional and require steps for its implementation. The Interviewee no 3 said: ***"I think the first thing that IPRC Musanze can do is to identify the strong farmers who understand the policy ahead and discuss on what they are going to deal with, maybe at the production stage but also IPRC Musanze will assist them and tell them that after the production they want to show them other ways of taking care of the residues so that they can generate additional money".*** Beforehand, the identification of farmers who can understand the partnership concept is one of the first steps. Farmers should be aware that the college is willing to collaborate with them and be explained the purpose, responsibilities and benefits of each party before any engagement is done

IPRC Musanze as a TVET school, they intend to strengthen cooperation in terms of training people who are willing and reside near the campus. The interviewee no 4 said that: ***"the best thing is just to support them, the way we think will be more productive but of course, if like the last time we assigned students from the beginning of farm preparation, plantation, and all the care until the harvesting. I think that one we did we can extend that approach as one part of our students learning".*** The existing collaborations between IPRC Musanze and farmers are done through MoU with big farmers or cooperatives while small farmers are just supported.

The farmers can appreciate and adopt a proposal given to them depending on the level of involvement in its concept from the beginning. The interviewee no 6 said: ***"To make a sustainable collaboration with the farmers, you could let themselves make the choice. Don't approach them saying we bring this for you this is why many projects fail, they think in farmers' place, you may make like a survey on farmers and ask them what they want, and it can originate from themselves".*** When farmers understand and are involved in the designing of the concepts it is even easier to mobilize and explain to them the benefits for organized farmers' groups. The Interviewee no 6 said: ***"As an example, there is a group of farmers from Musanze District, Muhoza Sector, we trained and got a market to supply broccoli in the UK and they had a good contract. We trained them, they grew vegetables, then they met a funder and made a contract to give them broccoli seed and he supplies the harvest to the UK".***

Therefore, through continuous stable relations and trust creation, the establishment of farmers' groups should be an easy way for better coordination, quality and quantity production, and from there the long-life joint activities for both parties are assured. Once the partnership is agreed, it should be governed by a signed agreement that describes the roles and responsibilities of parties, thus IPRC Musanze needs to be in constant communication with the farmers for smooth implementation.

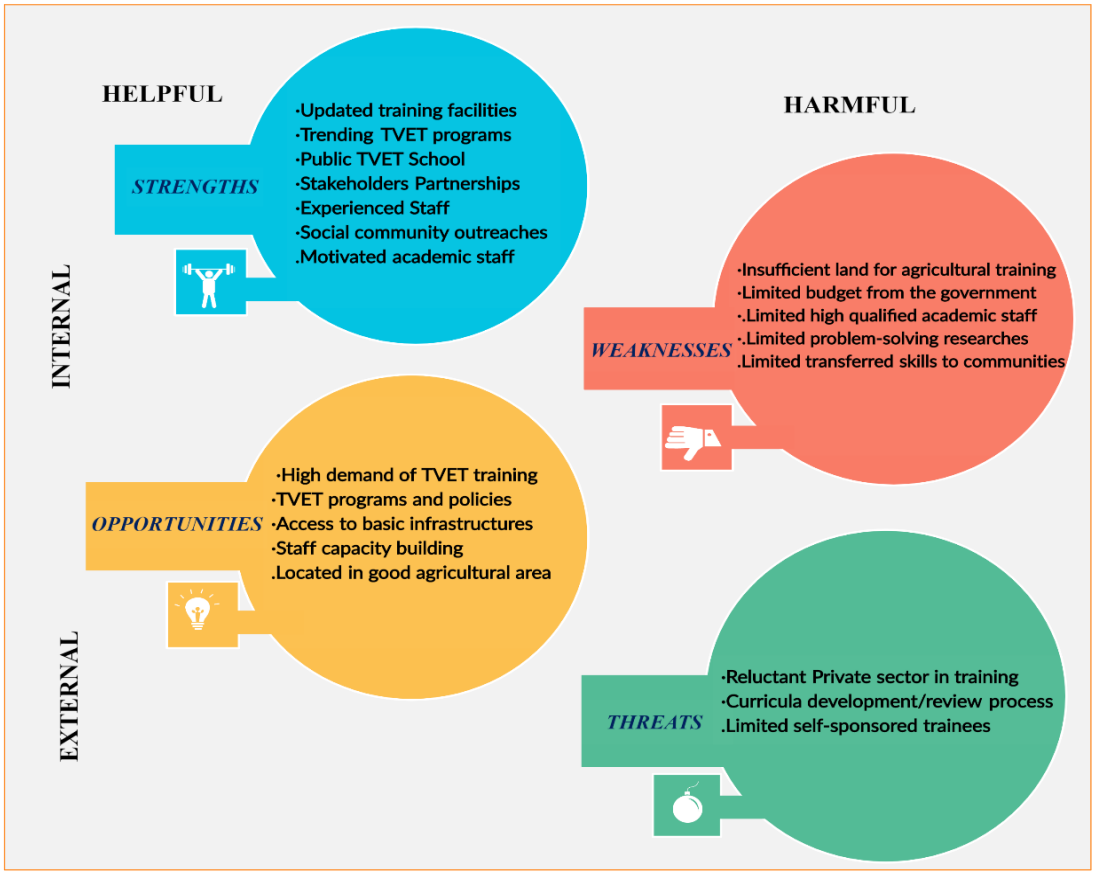
4.3.3 Potential joint activities between IPRC Musanze and Tomato farmers

The possible joint activities that could be done by IPRC Musanze and tomato farmers have been identified and hereafter described. IPRC Musanze can provide improved seeds developed from its greenhouse, give technical assistance on the field, involved in the farming system while the farmers can avail the land from which the farming activities could be performed. The interview no 4 said: ***" If they are not far from our institution we can help them because after all, we have a greenhouse, so in terms of seeds we can play a role in that to make sure that we can give them the best seeds".***

Through the usual collaboration with Musanze District/Nkotsi sector and RAB, IPRC Musanze via Agriculture and Food Processing Department can organize sensitization on land consolidation and training about GAPs (e.g. pest and disease control), improved compost making, postharvest handling and value addition to tomato crop. The interviewee no 5 said: ***"Crop residues value addition is interesting but the way it should be implemented I don't know it yet. I think after the research there should be physical results, then after we can meet farmers and explain to them the procedure".***

Figure 31 shows helpful and harmful factors identified from the qualitative data collected through different sources and summarized by the researcher for the current study. The IPRC Musanze support can be expressed in terms of training, research and innovation activities responding to local challenges and providing solutions. The emphasis should be on the crop breeding where IPRC Musanze students and academic staff can focus on crop multiplication that should be adopted by farmers following the facts from successful laboratory trials.

Figure 32: SWOT analysis for IPRC Musanze



Source: Research findings (2020)

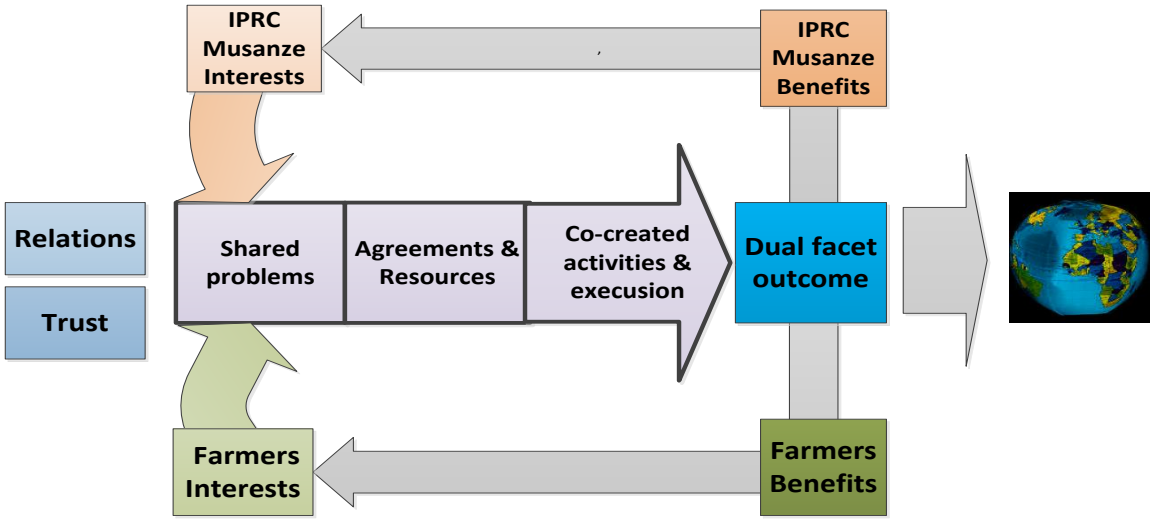
4.4 Proposed collaboration model

The information garnered from key informants and surveys' respondents show that there is no formal and structured collaboration strategy between IPRC Musanze and farmers in Nkotsi sector. However, some community outreaches (mainly social activities) have been organised by IPRC Musanze and some neighbouring citizens benefited. The current research sources of information provided insights into the possible collaboration model based on the interests and benefits of both parties. The proposed model should begin with establishing stable relations and trust amongst involved parties. ***Relations*** can refer to linking intervention activities from both parties (community outreach, training) while ***trust*** is defined as firm beliefs and reliabilities with facts of the abilities/capabilities of each party that are in place at the beginning of any collaboration. Additionally, the interests of both parties should be well described and understood beforehand. The IPRC ***Musanze has interests*** in quality technical training at all levels, impactful societal contributions (research, innovation, and outreach) while ***farmers have interests*** in improved quantity and quality production, secured market and maximized incomes.

In any collaboration, parties foresee benefits brought by the collaboration outcomes. During the implementation of the proposed farmer-academia collaboration model, ***IPRC Musanze will benefit*** from improved quality of training, students' exposure to the practical field of experience, improved institutional

branding and corporate image, published applied research papers while ***farmers will benefit from*** acquiring new knowledge and hands-on skills, applying modern farming techniques, and also gain from IPRC Musanze capabilities (technologies, equipment, skilled staff, consultancy). Beyond the direct collaboration of beneficiaries, the dual facet outcomes will reach to the society in general, starting to a nearby community, regional, national and international levels. Outcomes from the collaboration will provide benefits to the society through new sets of job creation, new opportunities to diversify production/activities and new opportunities to sustain the environment. Figure 33 shows the illustration of the proposed farmer-academia collaboration model between IPRC Musanze and tomato farmers.

Figure 33: IPRC Musanze and Farmer Collaboration Model



Source: Researcher's design (2020)

The designed collaboration model is not to implement in one day, it needs steps. One of the interviewees said: ***"I think the first thing that IPRC Musanze can do is to identify the strong farmers who understand the policy ahead and discuss on what they are going to deal with, maybe at the production stage but also IPRC Musanze will assist them and tell them that after the production they want to show them other ways of taking care of the residues so that they can also generate additional money for them".*** Based on the above statement, there is a need for a piloting phase to a small number of farmers (e.g. one farmer per each cell) to try and test the model before expanding it to the whole sector. The college should initiate the process and with the help of Nkotsi sector, the first step should be the identification of farmers to participate in the piloting phase.

After defining the shared problems, both parties should have a clear work agreement that will govern their activities. Each party should have well-defined tasks and responsibilities in the collaboration agreement and the source of resources (physical, economical, human) should be well explained. Once the agreement is in place, the joint activities should be co-created and executed taking into consideration the parties' interests, shared problems, mutual benefits responding to individual interest, and good leadership as well. Depending on the reasons and the intended outcomes of the farmer-academia collaboration model, some key activities may be joint problem-solving initiatives through applied research and innovation, provision and farming of improved seeds, training on new farming technologies through students involvement(internship and/or mentorship). The intended collaboration outcomes should be looked at fulfilling the expected benefits of both parties like joint-up discoveries and new knowledge and skill creation and their application.

CHAPTER FIVE: RESULTS DISCUSSION

Chapter five of the current report discusses the results from farmers' online survey, TVET trainers' online survey and interviews, in the line of answering the research sub-questions. The knowledge gap about the absence of the structured problem-solving relationship between tomato farmers in Nkotsi Sector and IPRC Musanze is discussed in this part of the report.

5.1 Results from online farmers' survey

The tomato crop stems are the main type of farm-leftovers mentioned by tomato farmers in Nkotsi sector, and they are generated in significant quantities from their farms but also leaves and roots are generated in small quantities. This is supported by (UN, 2016) definition of agricultural wastes as any materials not primarily produced for the market and are the results of production, conversion, consumption, and which are discarded.

The previous literature describes the compost as the organic product obtained through an aerobic process whereby microorganism activities transform all kinds of organic materials available at the farm (stem, leaves, roots) into the stable and hummus-like product (Pergola et al., 2020). The final destinations of the generated tomato crop farm-leftovers are various in Nkotsi Sector; thus, the compost is the main end-use confirmed by farmers.

The major and only tomato crop farm-leftovers usage in Nkotsi Sector reflects the farmers' limited knowledge in other value addition techniques that can be applied to tomato crop farm-leftovers to process other valuable products. Even though the way composting is done; burying the tomato crop farm-leftovers is not professional. The literature associates the large quantities of discarded plant biomass from primary production to be either used for biofuel production, composted, or are discarded with costs (Junker-Frohn et al., 2019). Feeding animals and mulching other crops are the other uses of tomato crop farm-leftovers in Nkotsi Sector.

In many cases, the crop farm-leftovers are known as useless, discarded and remain unused at the farm location. The tomato farmers in Nkotsi sector are neither aware of any negative impact of farm-leftovers on their farming activities and the environment nor that tomato crop farm-leftovers can be a source of monetary benefits. 100% of farmers who responded to the online survey do not gain any money from tomato crop farm-leftovers generated from their farms. Consequently, there are no value addition activities done on the tomato crop farm-leftovers and even the composting activities performed are not profitably valued to generate additional income to the farming business. Bianchi et al., (2020) confirm that composting organic waste is an opportunity to earn a small income in Ghana, where the processed compost is sold to farmers by unemployed young people who welcomed the initiative as an alternative way of gaining money. Therefore, tomato farmers in Nkotsi sector lack knowledge and practical skills and the areas for improvement for their farming business are the application of agricultural best practices, postharvest handling, farm crop residues management.

5.2 Results from online TVET trainer's survey

The majority of TVET trainers (62%) from IPRC Musanze in the Department of Agriculture and Food Processing confirm the absence of advanced tomatoes farming activities in Nkotsi Sector. This situation reflects farmers' limited knowledge and skills in updated farming techniques and lack of capital investment in advanced farming infrastructures, consequently, improperly managed tomato crop farm-leftovers affect the farming activities as well as the environment. Some of the negative effects are pest and disease transmission to other crops, host for harmful microorganisms, and the environmental pollution caused by emitted gases (CO_2, NO_2)

From this basis, TVET trainers confirm again the uselessness (in terms of money generation) of tomato crop farm-leftovers generated from farms in Nkotsi Sector. Nevertheless, they agree on the only possible technique used by farmers to add value to their crop farm-leftovers through compost making.

On the other hand, TVET trainers mention activities to be carried out to contribute to the above-mentioned existing problems. Technical training (e.g. GAP, postharvest handling) for farmers and applied research and

innovation (e.g. farming techniques, crop value addition) are the main activities to start with as they belong to the primary interests of IPRC Musanze as TVET School. This is supported by MIFOTRA (2020) which mentions Rwanda as a rapidly transforming and competitive knowledge-based country that requires new ways of teaching and learning accompanied by applied research to address community challenges.

5.3 Results from in-depth online interviews

The information obtained from in-depth interviews confirms that apart from compost made from tomato crop farm-leftovers there are no other known products currently made from those organic materials. With curiosity, all informants recommend further research on products that can be manufactured from tomato crop farm-leftovers to help farmers generate additional income to their tomato farming business. The interviewee number 2 said: ***"You need to create clear expectations because they can start thinking that you will buy fruits from them and that is not the case from what you just told me. So, suppose they grow and there is no market for their tomatoes, it can demoralise them.*** Previous researches indicate various crop-based products that are manufactured from crop farm-leftovers and commercialised to serve in different purposes. The use of a low, medium, and high technology result into the low-value products (compost, animal feed), medium value products (biochar, briquette) and high-value product products (bio-based packaging material, enzymes). The crop leftovers valorization is a process that needs resources from different players and the reason why it needs the cooperation of different stakeholders.

This is a big challenge that can arise when the initiative is adopted because product manufacturing requires raw material (farm-leftovers) that are obtained after primary production. Therefore, a clear process should be understood from the beginning to avoid miscommunication and complaints that could arise along the implementation stages. Interviewee no 5 said that: ***"Crop residues value addition is interesting but the way it should be implemented I don't know it yet. I think after the research there should be physical results, then after we can meet farmers and explain to them the procedure".***

The discoveries of other products made from tomato crop farm-leftovers are possible through the partnership of willing parties. The collaboration between IPRC Musanze and tomato farmers is possible based on previous experience where the college collaborated successfully with maize farmers. The interviewee number 4 said: ***"We try to help farmers but so far we dealt with farmers of maize we did not touch farmers of tomatoes".*** Two major preliminary conditions to be in place before any collaboration is initiated are stable relations and trust between parties. The interviewee number 6 stated: "***You can use a down top approach so that farmers say what they want to be done and this can be sustainable because beneficiaries are involved in the process from the beginning".*** The long-term collaboration involving different participants is not a one day implemented intervention it requires trials to test its practicability.

Therefore, a piloting phase of the collaborative model between IPRC Musanze and a few identified tomato farmers is the starting point, then after its evaluation, the expansion to the whole Nkotsi sector may be done. For whatever cases, the collaborative activities should be governed by clear and designed agreement for the interests and benefits of both parties. Some farmer-academia collaborative activities may be the development and farming improved seeds, the postharvest handling activities, problem-solving applied research, and agriculture-related innovation initiatives.

5.4 Reflection

The research trajectory was the last step for my self-development and achieve the study program goal. After a taught period of 9 months, it was the staring of the hard block reserved specifically for thesis research. I was very motivated to perform a study on tomato crop which is one of the most produced and consumed crops in Musanze District/Nkotsi Sector in Rwanda which was also the study area. This reflection is all about the worries, restrictions and experiences faced during the research trajectory and lessons learnt during the research period till the last time of thesis report submission.

Beforehand, the background information was obtained through desk research, and the real exercise started with a research proposal writing which was not easy to figure out the research topic and clear research problem. I played around the research topic, problem statement, objectives and research questions several times and in consultation with my supervisor, I finally got the final draft of my research proposal. After the research proposal presentation, I got the green light for the field data collection step, and this gave me motivation in early-stage to dip dipper in my research context. Depending on the research plan, I had two weeks of online work to gather additional information about my research population because I did not go physically on the field due to movement restrictions to prevent the spread of COVID 19 pandemic. For this reason, I hired two research assistants, to support in fieldwork activities but with close online consultation with me. With the support of research assistants and the sector agronomist, the struggle of getting appointments for key informants and farmers ended up, and immediately the following week the real data collection exercise started.

All data collected was gathered electronically whereby I did myself series of in-depth online interviews, I collected TVET trainer's online survey responses and with help of research assistants, I got also farmers' survey responses via online tools. At the end of every day, a summary of activities done was compiled and it was an early stage of data analysis. According to the research plan I had, after three weeks of collecting data, the next stage of writing down the findings, analysis, and full thesis report writing stated. Throughout the whole process consultation with my supervisor was done, and I appreciated valuable inputs and guidance that contributed to my learning process.

The feeling of doing independent research was frightening in the staring stages but as time goes on I got the direction especially after the approval of the research proposal, I got encouraged and committed to go further and implement what I learnt in class. Back-home in my institution, I participated in many small research activities and I thought I had a good background. After now learning different approach of applied research, I began to feel like I start a new experiential time. The quantitative research method was something I was not fully involved in before, and finally, I feel confident and proud of performing it.

The research trajectory is not a straightforward process to get outcomes immediately. During my research activities, I found it a tiresome and wide task which require more hours in days and nights with enough concentration. The time I wrote my proposal and drafts of thesis report to submit to my supervisor, I was thinking I made perfection, but after receiving feedbacks I realised many things I did not do well, and which are very important. Through feedbacks, I learnt a lot not only during the research thesis but also during the whole master program. During data collection exercise some farmers were thinking that the research assistants were going to give them money or immediate farming support and were complaining that they participated in several different research activities and no feedback provided to them. Fortunately, I briefed my research assistants in advance to properly explain the research purpose and the activity went well. Besides, the study was in crop growing period and farmers were busy for their farm activities, with support of my research assistants, I had to pass through sector agronomist and local leaders to get in touch with them. The data analysis section proved to be difficult, l had data from different sources which I had to triangulation to get interesting and complete meaning to the study. The good thing I encountered was the enthusiasm and commitment of my research assistants who supported me to respect the plan of activity, and the TVET trainers who responded promptly to the given online survey.
The main thing I learnt is the complexity of the research process and its need to improve, change or innovate new ways in the nowadays live in the world. The research data collection tools (online questionnaires, online

in-dept interview checklists) were designed in the English language. Together with my research assistants, I had to translate the online questionnaire for farmers in the local language so that they complete the questionnaire in the presence of research assistants and submit it to me via online software. Some of the provided responses were difficult to interpret and caused small confusion during data analysis. Moreover, previously in the research proposal, I planned to make field observations, but the strategy changed a bit later as COVID 19 consequences, and I used only online surveys and in-depth online interviews. Furthermore, some of the appointments with key informants were not honoured because I was not physically on the field to follow up personally their commitment to participate in a research interview. However, with the support of research assistants, the exercise of data collection provided useful and reliable information about the research topic because they were on the field and in close online communication with me. I organised an online briefing meeting with my research assistants two days before the starting of the data collection exercise, and every day they must report activities done. During the actual data collection activities any decision to be taken, they had to consult me for approval.

As I said, carrying out research activity is not common sense, so why everything must be clearly defined and well explained. During the thesis report writing period, having laid down the results and in consultation with my supervisor l had to slightly adjust my research problem and one of the research sub-questions to have a linked meaning with the results. At be beginning, I felt those small adjustments were unnecessary but when my supervisor advised, in doing so l get to learn. As the learning process is concerned, l appreciated the comments and guidance that at the end of the year l should be confident to design research process without uncertainties in my mind.
This master's program has taught me lots of things that I am appreciating. The learning environment and the blended teaching methods helped me to see the other side of the world away from the back-home country. I appreciate that I managed to reach the objectives I set at the beginning of the program. A big task in front of me is how best I will use my acquired knowledge and skills for better future of myself, my organization, and my country at large. The research process has made me aware of some of my mistakes in the way l used to do data collection. The major take away from the research trajectory is my improved knowledge and skills on how to conduct mixed quantitative and qualitative research, especially in a remote situation (not being physically on the field), which is very helpful for horticulture specialist to be knowledgeable in it. Both qualitative and quantitative approaches to Agriculture Production Chain Management initiatives are very important as it takes account of all the details about quantities as well as its background explanations.

Conclusively, the research journey has been a great period. My major plan after completion of this masters' programme is to dig deeper into quantitative and qualitative data analysis techniques as I envisage to pursue further training in my specialisation. I want to learn more about quantitative and qualitative data analysis software because slowly everything is becoming computerised, l see it as another learning challenge for me as Horticulture chains specialist. The Organisational Development and Institutional analysis module coupled with the research thesis, have made me realise some areas that need change. I intend to become a facilitator of change and lead to some positive sustainable outcomes for our training activities. Among others, the major highlight l learnt is how our initiatives called participative, are not incorporating the participation aspect as we are imparting things upon beneficiaries than working with them from the beginning to come up with what works best.

CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

This chapter describes the conclusion drawn from information gathered through an in-depth semi-structured interview, online tomato farmers' survey questionnaire, and online TVET Trainers' survey questionnaire. It also presents the recommendations addressed to tomato farmers in Nkotsi sector, IPRC Musanze, and Nkotsi sector on the way forward concerning the future activities.

6.1 Conclusion

This research aimed to identify potential value addition activities to tomato crop farm-leftovers and investigate the current farm-leftovers uses, to suggest a collaboration model between tomato farmers in Nkotsi Sector and IPRC Musanze.

The online surveys and in-depth online interview results confirm that tomato farming in Nkotsi sector is at a small-scale level, with individual farmers and moderate primary production of tomatoes, thus relatively farm-leftovers quantity is generated per year. The most generated farm-leftovers are stems while leaves and roots are also present in the tomato farms. All produced tomato farm-leftovers are mainly used for compost making and a limited quantity is used as animal feeds, mulch, and used as a fire source for cooking. The study results revealed that in whatever end-use of tomato crop farm-leftovers, they do not generate any additional money to the farmers. Composting is the only farm-leftovers management technique practised even though it is not professionally done. The farmers' limited knowledge and skills, absence of agricultural-related applied research and innovation, and the inexistence of farmer-academia collaboration are the main reasons why the farm-leftovers are not transformed into other different valuable crop-based products in Nkotsi Sector.

Based on its previous experience, IPRC Musanze is willing to strengthen the collaboration with farmers in line with its mandates and capacity in practical training to all levels and carrying out impactful community outreaches. The farm-academia collaboration new model should be tried and tested on a small number of tomato farmers in Nkotsi Sector, and that piloting phase should be governed by a signed agreement between both parties. Thus, there is a need of the long-term collaboration whereby several possible value addition processes can be applied to tomato crop farm-leftovers to improve the tomato farming subsector in Nkotsi Sector and simultaneously boost the quality of practical training of IPRC Musanze.

The sustainability of farmer-academia collaboration will depend on how the farmers are involved in the process of the concept designing and the commitment and leadership of the college. The discussion about the potential opportunities, the mutual benefits of the cooperation, and how the piloting activities will be done are the key factors for the long-life of the partnership. So, the collaboration between tomato farmers and TVET School is possible and should be mainly based on technical training, joint problem-solving initiatives, applied research, and the provision and farming of improved seed.

Therefore, the proposed farmer-academia collaboration model between tomato farmers and IPRC Musanze should be initiated by the college. Through its academic staff assigned to carry out applied research, with students' participation, and in close involvement of few selected neighbouring farmers representing their fellows, IPRC Musanze will play a decent contribution to the development and valorisation to tomato crop in Nkotsi Sector.

6.2 Applied recommendations and further works

As a result of this research, the possible recommendations are addressed to tomato farmers, IPRC Musanze and Nkotsi Sector as potential players to be involved in farmer-academia collaboration establishment.

6.2.1 Tomato farmers

- With the help of Nkotsi Sector agronomist, within three months, one tomato farmer (per each cell) willing and capable to represent his/her cell in the piloting process of collaboration with IPRC Musanze should be selected.

- Currently, tomato farmers in Nkotsi Sector might begin notifying IPRC Musanze, as TVET school in their location, the farming challenges that need to be addressed by academic experts from the college.

- Tomato farmers in Nkotsi Sector might commence changing their small-scale farming business to medium and large-scale farming to access to several support services offered by different stakeholders.

6.2.2 IPRC Musanze

- Through its specific teaching department, once in three months, IPRC Musanze should organize and carry out Good Agricultural Practices training (e.g. pest and disease control, harvesting techniques, postharvest handling, packaging and transportation, and value addition technologies) to tomato farmers in Nkotsi Sector.

- The IPRC Musanze should emphasise on problem-solving applied research, innovation, and dissemination of research findings to respond to existing farming challenges (e.g. farm-leftover management) which will also enhance their quality of training.

- Piloting the farmer- academia collaboration model in one-year time should be the best starting point for sustainable future collaborations involving farmers participation.

6.2.3 Nkotsi Sector

- As a decentralised local administration, Nkotsi Sector should encourage and facilitate tomato farmers' group formation to facilitate access to supporting services from different stakeholders.

- Nkotsi sector in collaboration with RAB Musanze station should facilitate land consolidation in Cyizi marshland in Nkotsi Sector to ease the application of modern agriculture practices to boost tomato production.

6.2.4 Further works

- Further research should be done on the manufacturing process, trials and cost analysis (in the local context) for the low-value-added products (animal feed, improved compost), medium-value-added products (biochar, briquette) from tomato crop farm-leftovers.

- With the involvement of various stakeholders (RAB Musanze station, Musanze District, IPRC Musanze), the creation of tomato farmers' group (i.e. cooperative) in Nkotsi sector should be processed and supported as the starting point for farmers to be vertically integrated into the tomato value chain.

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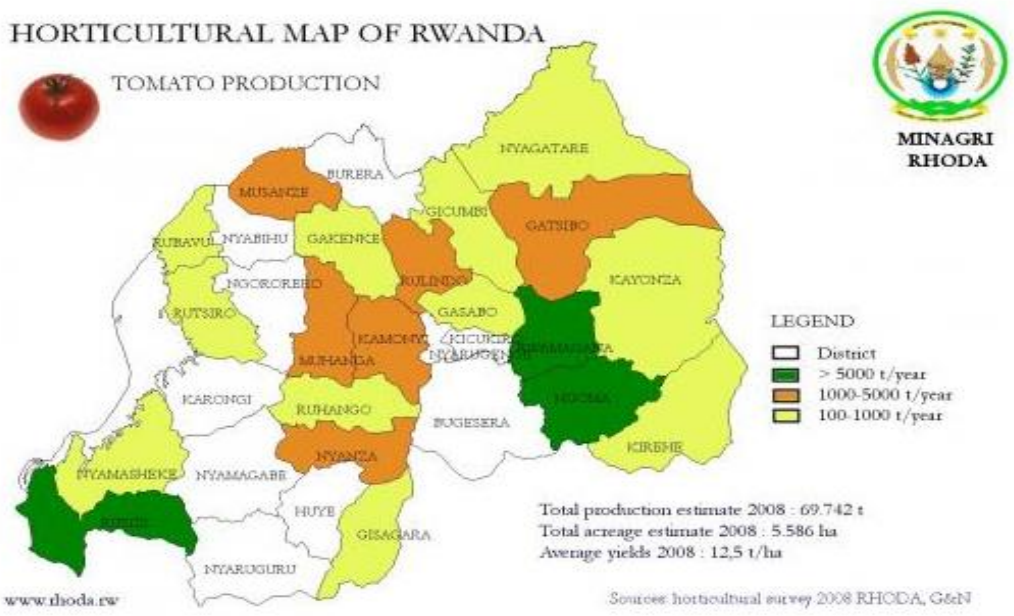
APPENDIXES

APPENDIX 1: RESEARCH PROJECT TIMEFRAME

SN	Activity / Timeframe	May 2020				June 2020				July 2020				August 2020				September 2020			
		wk 1	wk 2	wk 3	wk 4	wk 1	wk 2	wk 3	wk 4	wk 1	wk 2	wk 3	wk 4	wk 1	wk 2	wk 3	wk 4	wk 1	wk 2	wk 3	wk 4
1	Desk Study																				
2	Research Proposal																				
3	Design of Data Collection Tools																				
4	Data Collection																				
5	Data Processing																				
6	Data Analysis																				
7	Thesis report writing																				
8	Presentation (Defence)																				

Note: wk means Week

APPENDIX 2: RWANDA HORTICULTURE PRODUCTION MAP (TOMATO PRODUCTION)



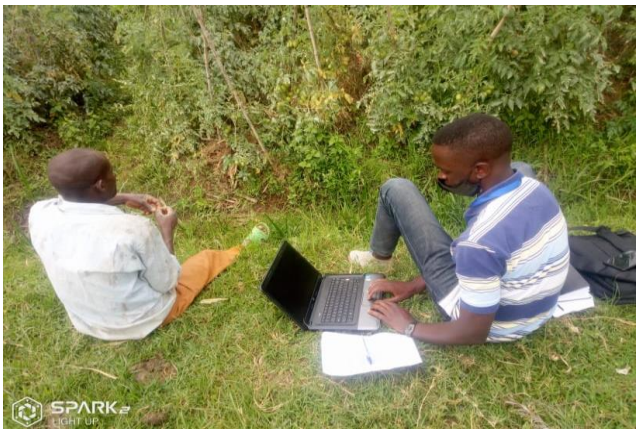
Source: *http://amis.minagri.gov.rw/maps/tomato-production-horticultural-map-rwanda*

APPENDIX 3: PHOTOS OF TOMATO FARMER ON HIS FARM IN RWANDA


Source: *https://www.newtimes.co.rw/section/read/203679*

APPENDIX 4: TOMATO FARMERS WITH RESEARCH ASSISTANTS IN NKOTSI SECTOR


APPENDIX 5: TOMATO FARMERS WITH RESEARCHER ASSISTANT DURING DATA COLLECTION

APPENDIX 6: TOMATO FARMERS' ONLINE SURVEY

Farmers Online Questionnaire

My name is Aimable UWIHANGANYE, a Master Student at Van Hall Larenstein University of Applied Sciences in Agriculture Production Chain Management program (Horticulture Chains Specialisation). I am researching the contribution of IPRC Musanze in creating valuable uses of tomato crop leftovers at farm locations specifically in the Musanze District/ Nkotsi Sector. I would like to request your answers to the below questions that will take around 15 minutes of your time. Your answers will be used only for this study and will be kept confidential. Thank you for your cooperation.

1. Farmer's Name

2. Gender

- Female
- Male

3. How old are you?

4. What is your marital status?

- Single
- Married
- Divorced
- Widowed

5. What is your highest level of education?

- Primary Level of Education
- Ordinary Level of Education (S1, S2, S3)
- Secondary Level of Education (S4, S5, S6)
- IPRC Level of Education (A1)
- Bachelor's Level of Education
- Master's Level of Education
- PhD Level of Education

6. Does your family live in Musanze District, Nkotsi Sector?

- Yes
- No

7. If question 6 is yes, in which Cell do you live in Nkotsi sector?

8. In which cell is your tomato farm(s) located in Nkotsi Sector?

- [ ] Bikara Cell
- [ ] Gashinga Cell
- [ ] Ruyumba Cell
- [ ] Rugeshi Cell
- [ ] Mubago Cell

9. How long have you been in the tomato farming business?

- ○ Less than 1 year
- ○ 1 year-1 year and 11 months
- ○ 2 years-2 years and 11 months
- ○ 3 years-3 years and 11 months
- ○ 4 years and above

10. What is the size of your tomato farm? (Note: 1 acre = 4046.86 m2 = 0.4 Ha)

- ○ Less than 1 acre
- ○ 1-2 acres
- ○ 2-3 acres
- ○ 3-4 acres
- ○ 5 acres and above

11. Is the tomato farmland yours or is a leasing land?

- ○ Own Land
- ○ Leasing Land
- ○ Partly own and partly leasing land

12. What is the yearly estimated quantity of tomato harvested from your farm(s)? (in kg)

13. What is the estimated quantity of harvested tomatoes do you sell (in kg)?

14. Where do you directly sell your harvested tomatoes?

- [ ] Not sold (home consumption)
- [ ] Local market (at my village)
- [ ] Open Market in Musanze Town (Kariyeri)
- [ ] Wholesalers
- [ ] Supermarkets in Musanze District
- [ ] The market in Kigali Town
- [ ] Other markets (Specify below)
- [ ]

15. What is the estimated yearly quantity of tomato crop farm leftovers (roots, stems, leaves, etc) generated from your farm? (in kg)

16. What is the most tomato crop farm leftovers generated from your farm (s)?

- [ ] Leaves
- [ ] Stems
- [ ] Roots
- [ ] Others (specify below)
- [ ]

17. Are you aware that tomato crop farm leftovers can generate additional money for your business?

- ○ Yes
- ○ No

18. What do you use for tomato crop farm leftovers from your farm(s)?

- [ ] Feeding Animals
- [ ] Burning
- [ ] Composting
- [ ] Remain at farm unused
- [ ] Others (Specify below)
- [ ]

19. By using tomato crop farm leftovers for one of the above (question 18), what do you gain in terms of money (Rwandan francs)?

20. Are you aware of tomato crop farm leftovers' negative impact on your farming and the environment?

- Yes
- No

21. What are the reasons for your answer above (question 20)?

22. Do you know IPRC Musanze?

- Yes
- No

23. How do you categorize IPRC Musanze?

- Vocational Basic School
- Vocational Secondary School
- Vocational High Learning Institution
- University

24. Do you know some community outreach activities performed by IPRC Musanze?

- Yes
- No

25. If question 24 is yes, mention 1 horticultural related community outreach activity done by IPRC Musanze

26. Do you have any collaboration with IPRC Musanze?

- Yes
- No

27. What are the reasons for your answer to Question 26?

28. In the future, would you like to have sustainable collaboration with IPRC Musanze in terms of agriculture development (i.e tomato farming)?

- Yes
- No

29. What are the reasons for your answer above (question 28)?

30. In which activity would you request IPRC Musanze to collaborate with tomato farmers in Nkotsi Sector?

- Technical Training
- Joint Business Idea
- Student's Internship Placement
- Value addition innovations
- Others (Specify below)

APPENDIX 7: TVET TRAINERS ONLINE SURVEY

IPRC Musanze TVET Trainers Online Questionnaire

My name is Aimable UWIHANGANYE, a Master Student at Van Hall Larenstein University of Applied Sciences in Agriculture Production Chain Management program (Horticulture Chains Specialisation). I am researching the contribution of IPRC Musanze in creating valuable uses to tomato crop farm leftovers specifically in the Musanze District/ Nkotsi Sector. I would like to request your answers to the below questions that will take around 15 minutes of your time. Your answers will be used only for this study and will be kept confidential. Thank you for your cooperation.

1. Gender

- ○ Male
- ○ Female

2. Age

3. Marital Status

- ○ Single
- ○ Married
- ○ Divorced
- ◉ Widowed

4. Level of Education

- ○ A2 (Secondary Level)
- ○ A1 (Advanced Diploma Level)
- ○ A0 (Bachelor's Degree Level)
- ○ Master's Degree Level
- ○ PhD Level

5. Area of Specialisation

6. Non-Teaching professional experience (in years)

7. Teaching Experience at IPRC Musanze

- ○ Less Than 1 year
- ○ 1 to 2 years
- ○ 2 to 3 years
- ○ 3 to 4 years
- ○ 4 to 5 years
- ◉ Above 5 years

8. From which department are you teaching in?

9. Is your department practically involved in community outreaches?

- ○ Yes
- ○ No

10. Which community outreach activity are you mostly involved in (as staff)?

11. From which practice(s) do you see tomato farmers in Nkotsi Sector contributing to your teaching activities?

- ☐ Students Study visit
- ☐ Farm practical demonstration
- ☐ Harvesting practical
- ☐ Post-harvest handling
- ☐ Horticultural food product processing
- ☐ None
- ☐ Others (specify below)
- ☐

12. Do you notice some advanced farming practices done by Nkotsi tomatoes farmers?

- ○ Yes
- ○ No

13. What are the reasons for your answer above (question 12)?

14. What are the most needed areas of improvement that could you suggest for tomatoes farming in the Nkotsi sector?

- ☐ Farming practices
- ☐ Harvesting techniques
- ☐ Postharvest handling
- ☐ Farm crop residues management
- ☐ Others (specify below)
- ☐

15. As Lecturer/Instructor do you recognize some farm crop residues effects on horticulture farming and the environment?

- ○ Yes
- ○ No

16. From your experience, what are the most positive effects of tomato crop farm leftovers/residues on horticulture farming and the environment?

17. From your experience, what are the most negative effects of the tomato crop farm leftovers/residues on horticulture farming and the environment?

18. What is your position on the following statements?

	Strongly Disagree	Disagree	Agree	Strongly Agree
Tomatoes crop farm leftovers/residues are mostly used for compost making	○	○	○	○
Tomatoes crop farm leftovers/residues are mostly used for feeding animal	○	○	○	○
Tomatoes crop leftovers/residues can be used as raw material for other products (i.e paper, packaging material, enzyme)	○	○	○	○
Tomatoes crop farm leftovers/residues are useless	○	○	○	○

19. What can be the most sustainable collaboration approach between IPRC Musanze and Tomato farmers in Nkotsi sector?

- ☐ Students' internship placement
- ☐ Joint income-generating activities
- ☐ Technical training for farmers
- ☐ Joint research and innovation activities
- ☐ Others (specify below)
- ☐

20. Which products below from tomato crops can IPRC Musanze process/manufacture within its premises?

- ☐ Tomato Products (Juice, Paste, Puree, Powder)
- ☐ Improved compost from tomato crop farm leftovers/residues
- ☐ Crop-based packaging materials
- ☐ Enzyme production from agricultural leftovers/residues
- ☐ Other product (specify below)
- ☐

21. What are the facilities in place at IPRC Musanze that can be used/ are used for processing/manufacturing the above-mentioned product(s)? (your answer of question 20)

22. What support do you think can be provided by IPRC Musanze to contribute to tomatoes farming development in Nkotsi Sector?

APPENDIX 8: INTERVIEW CHECKLIST FOR IPRC MUSANZE MANAGERS

Interviewer: UWIHANGANYE Aimable
Master Student at Van Hall Larenstein
Agriculture Production Chain Management (Horticulture Chains)
Netherlands

Date: ……/July/2020 Interview duration: 30 Minutes

Key informant: Name:……
Organisation:…….
Position:…….

1. Informant introduction
   - What is your name, professional background and position and responsibility at IPRC Musanze?

2. IPRC Musanze description
   - IPRC Musanze mission and vision (mandate)
   - IPRC Musanze main/Key activities
   - IPRC Musanze services beneficiaries (customers)

3. IPRC Musanze activities to horticulture farmers (i.e tomatoes farmers in Nkotsi sector)
   - IPRC Musanze activities offered to Tomato Farmers in Nkotsi sector?
   - Are those activities continuous (daily, weekly, monthly, quarterly or yearly)?
   - What are the positive activity results/benefits for both farmers and IPRC Musanze?

4. Areas in horticulture farming that need IPRC Musanze support for improvement (opportunity maximization)
   - What are the opportunities brought by horticulture farming (in Musanze, Nkotsi Sector)?
   - What are areas in horticulture farming that need IPRC Musanze Support for improvement?

5. Academia-farmer collaboration (IPRC and farmer)
   - Is there any existing/formal mutual collaboration between farmers and IPRC Musanze?
   - Dou you see needs/reasons for that collaboration?
   - What could be the possible areas for that collaboration?
   - What collaboration type/approach can be adopted and work sustainably?
   - What are/could be the economic benefits resulting/could result from the collaboration?

6. Any other additional information.

APPENDIX 9: INTERVIEW CHECKLIST FOR SECTOR AGRONOMIST

Interviewer: UWIHANGANYE Aimable
Master Student at Van Hall Larenstein
Agriculture Production Chain Management (Horticulture Chains)
Netherlands

Date: ……/July/2020 Interview duration: 30 Minutes

Key Informant: Name:
Organisation:
Position:

1. Informant introduction
   - What is your name? Professional background? Position and responsibility at NKOTSI Sector?

2. NKOTSI Sector/Agriculture department description
   - NKOTSI Sector/ Agriculture department mission and vision (mandate)
   - NKOTSI Sector/ Agriculture department main/key activities
   - NKOTSI Sector/ Agriculture department services beneficiaries (customers)

3. NKOTSI Sector services offered to horticulture farmers (i.e tomatoes farmers)
   - What are NKOTSI Sector services offered to Tomato Farmers?
   - Are those services continuous (daily, weekly, monthly, quarterly or yearly)?
   - Are those services offered to individual farmers or for a group of farmers?
   - What do farmers benefit from NKOTSI Sector Services?

4. Areas in horticulture farming that need special support for improvement (opportunity maximization)
   - What are the opportunities brought by tomato farming in Musanze/Nkotsi Sector?
   - Do you see some signs of farmer's awareness about those opportunities?
   - What areas in horticulture farming that need support for improvement?
   - Do you recognise any effects (positive and negative) of farm crop residues on farming and the environment?
   - What types of tomato crop farm residues are mostly present on-farm/field?
   - Do you see any need to add value on those residues? (Valorisation)
   - Why? What could be made out of those residues? Who can perform it? How can it be done? What are the basic requirements?

5. Advice on academia-farmer collaboration strategies
   - IPRC Musanze as a research institution is willing to establish a mutual collaboration with horticulture farmers (i.e tomato farmers), what could you advise them?
   - What collaboration type/approach can be adopted and work sustainably?

6. Any other additional information.

APPENDIX 10: INTERVIEW CHECKLIST FOR AN EXPERT FROM HOLLAND GREENTECH

Interviewer: UWIHANGANYE Aimable
Master Student at Van Hall Larenstein
Agriculture Production Chain Management (Horticulture Chains)
Netherlands

Date: ……/July/2020 Interview duration: 30 Minutes

Key Informant: Name:……
Organisation: **…….**
Position:……

1. Informant introduction
   - What is your name? Professional background? Position and responsibility at Holland Greentech

2. Holland Greentech description
   - Holland Greentech mission and vision (mandate)
   - Holland Greentech main/Key activities
   - Holland Greentech services beneficiaries (customers)

3. Holland Greentech services offered to horticulture farmers (i.e tomatoes farmers)
   - What are Holland Greentech services offered to Tomato Farmers?
   - Are those services continuous (daily, weekly, monthly, quarterly or yearly)?
   - Are those services offered to individual farmers or for a group of farmers?
   - What do farmers benefit from Holland Greentech Services?

4. Areas in horticulture farming that need special support for improvement (opportunity maximization)
   - What are the opportunities brought by tomato farming in Rwanda?
   - Do you see some signs of farmer's awareness about those opportunities?
   - What areas in horticulture farming that need support for improvement?
   - Do you recognise any effects (positive and negative) of farm crop residues on farming and the environment?
   - What types of tomato crop farm residues are mostly present on-farm/field?
   - Do you see any need to add value on those residues? (Valorisation)
   - Why? What could be made out of those residues? Who can perform it? How can it be done? What are the basic requirements?

5. Advice on academia-farmer collaboration strategies
   - IPRC Musanze as a research institution is willing to establish a mutual collaboration with horticulture farmers (i.e tomato farmers), what could you advise them?
   - What collaboration type/approach can be adopted and work sustainably?

6. Any other additional information.

APPENDIX 11: INTERVIEW CHECKLIST FOR EXPERTS FROM SUNRIPE FARM

Interviewer: UWIHANGANYE Aimable
Master Student at Van Hall Larenstein
Agriculture Production Chain Management (Horticulture Chains)
Netherlands

Date: 02/July/2020 Interview duration: 30 Minutes

Key Informant: Name: ……..
Organisation: **……**
Position: **……**

1. Informant introduction
   - What is your name? Professional background? Position and responsibility at Sunripe Farm

2. Sunripe Farm description
   - Sunripe Farm mission and vision (mandate)
   - Sunripe Farm main/Key activities
   - Sunripe Farm services beneficiaries (customers)

3. Sunripe Farm services offered to horticulture farmers (i.e tomatoes farmers)
   - What are Sunripe Farm services offered to Tomato Farmers?
   - Are those services continuous (daily, weekly, monthly, quarterly or yearly)?
   - Are those services offered to individual farmers or for a group of farmers?
   - What do farmers benefit from Sunripe Farm Services?

4. Areas in horticulture farming that need special support for improvement (opportunity maximization)
   - What are the opportunities brought by tomato farming in Rwanda?
   - Do you see some signs of farmer's awareness about those opportunities?
   - What areas in horticulture farming (i.e tomato) that need support for improvement?
   - Do you recognise any effects (positive and negative) of farm crop residues on farming and the environment?
   - What types of tomato crop farm residues are mostly present on-farm/field?
   - Do you see any need to add value on those residues? (Valorisation)
   - Why? What could be made out of those residues? How can it be done? Who can perform it? What are the basic requirements?

5. Advice on academia-farmer collaboration strategies
   - IPRC Musanze as a research institution is willing to establish a mutual collaboration with horticulture farmers (i.e tomato farmers), what could you advise them?
   - What collaboration type/approach can be adopted and work sustainably?

6. Any other additional information.

APPENDIX 12: INTERVIEW CHECKLIST FOR AN EXPERT FROM RAB

Interviewer: UWIHANGANYE Aimable
Master Student at Van Hall Larenstein
Agriculture Production Chain Management (Horticulture Chains)
Netherlands

Date: ……/July/2020 Interview duration: 30 Minutes

Key Informant: Name:……..……
Organisation:……
Position:……..

1. Informant introduction
   - What is your name? Professional background? Position and responsibility at RAB?

2. RAB description
   - RAB mission and vision (mandate)
   - RAB main/Key activities
   - RAB services beneficiaries (customers)

3. RAB services offered to horticulture farmers (i.e tomatoes farmers)
   - What are RAB services offered to Tomato Farmers?
   - Are those services continuous (daily, weekly, monthly, quarterly or yearly)?
   - Are those services offered to individual farmers or for a group of farmers?
   - What do farmers benefit from RAB Services?

4. Areas in horticulture farming that need special support for improvement (opportunity maximization)
   - What are the opportunities brought by horticulture farming in Rwanda?
   - Do you see some signs of farmer's awareness about those opportunities?
   - What areas in horticulture farming that need support for improvement?
   - Do you recognise any effects (positive and negative) of farm crop residues on farming and environment?
   - Do you see any need to add value on tomato crop farm residues? (Valorisation)
   - Why? What could be made out of those residues? Who can perform it? How can it be done? What are the basic requirements?

5. Advice on academia-farmer collaboration strategies
   - IPRC Musanze as a research institution is willing to establish a mutual collaboration with horticulture farmers (i.e tomato farmers), what could you advise them?
   - What collaboration type/approach can be adopted and work sustainably?

6. Any other additional information.

APPENDIX 13: LIST OF RESPONDENTS (TOMATO FARMERS IN NKOTSI SECTOR)

NS	Names of respondent	Gender	Village	Cell	Date of survey	Contact
1	BIMENYIMANA Emmanuel	Male	Gitaraga	Gashinga	7/July/2020	-
2	SEBAHIRE Augustin	Male	Rusebeya	Gashinga	7/July/2020	-
3	KAMANZI Jean D'amour	Male	Rusebeya	Gashinga	7/July/2020	0784421207
4	NDUWAYEZU Theogene	Male	Buhanga	Gashinga	7/July/2020	0788663132
5	TWIZERIMANA Jean Bosco	Male	Gitaraga	Gashinga	7/July/2020	0787207631
6	MURWANASHYAKA Phocas	Male	Rusebeya	Gashinga	7/July/2020	0780580161
7	MANIKUZE Janvier	Male	Rusebeya	Gashinga	7/July/2020	0783250341
8	NIYINKUNDA Modeste	Male	Gitaraga	Gashinga	7/July/2020	0783699813
9	NGARUKIYINTWARI Theoneste	Male	Karambo	Rugeshi	8/July/2020	0782500341
10	MUGARUKIRA Dasson	Male	Gasebeya	Rugeshi	8/July/2020	0789955526
11	MBARUSHIMANA Jean Damascene	Male	Gasebeya	Rugeshi	8/July/2020	0788410329
12	TWAGIRAMUNGU Vianney	Male	Gasebeya	Rugeshi	8/July/2020	0783755648
13	MUSABYIMANA Jerome	Male	Gasebeya	Rugeshi	8/July/2020	-
14	NTAKAMARO Celestin	Male	Kivugiza	Ruyumba	8/July/2020	0787654965
15	HITIMANA Theophile	Male	Gasiza	Ruyumba	8/July/2020	0787651103
16	HAKIZIMANA Jean de Dieu	Male	Kamushehe	Ruyumba	8/July/2020	0783275935
17	NZAGEZAHE Jean Damascene	Male	Kamusheshe	Ruyumba	8/July/2020	-
18	NKEKABIGWI Jean Damascene	Male	Kivugiza	Ruyumba	8/July/2020	078309769
19	NDAYAMBAJE Phocas	Male	Nyakinama	Bikara	8/July/2020	0789496465
20	SIBONONDEYE Damien	Male	Nyakinama	Bikara	8/July/2020	0781771429
21	ABINGOMA Protais	Male	Nyakinama	Bikara	8/July/2020	-
22	TWAGIRIHIRWE Jean D'amour	Male	Nyakinama	Bikara	8/July/2020	-
23	NYIRABASHYITSI Vestine	Female	Nyakinama	Bikara	8/July/2020	-
24	TUYISHIMIRE Pacifique	Male	Nyakinama	Bikara	8/July/2020	-
25	NTEZIRYAYO Simeon	Male	Nyakinama	Bikara	8/July/2020	0787433898
26	HABANABAKIZE	Male	Nyakinama	Bikara	8/July/2020	0786168395
27	UMWANZIRAMWABO Alphonsine	Female	Nyakinama	Ruyumba	8/July/2020	-
28	BAPFAGUHEKA Phabien	Male	Nyakinama	Bikara	8/July/2020	0783808466
29	MURENGERANTWARI Ferdinand	Male	Musembe	Mubago	9/July/2020	0784755605
30	NZABANITA Eugene	Male	Musembe	Mubago	9/July/2020	0786474584
31	HITIMANA Sylvain	Male	Musembe	Mubago	9/July/2020	0788971492
32	TERIMBERE Donatien	Male	Musembe	Mubago	9/July/2020	0780481646
33	MANIRIHO Emmanuel	Male	Nyagahogo	Mubago	9/July/2020	0784239774
34	MBANZABUGABO Cyprien	Male	Bugugu	Mubago	9/July/2020	0731536226

APPENDIX 14: LIST OF RESPONDENTS (TVET TRAINER AT IPRC MUSANZE)

NS	Names of respondent	Gender	Education level	Area of Specialisation	Department
1	MUGISHA Janvier	Male	Bachelor's Degree	Food Science and Technology	Agriculture and Food Processing
2	TUYAMBAZE Africain	Male	Bachelor's Degree	Food Science and Technology	Agriculture and Food Processing
3	NTIRENGANYA Noe Cyprien	Male	Bachelor's Degree	Food Science and Technology	Agriculture and Food Processing
4	HAKIZIMANA Jean Damascene Salvator	Male	Bachelor's Degree	Crop Science	Agriculture and Food Processing
5	SEKARIGENGE Francois	Male	Master's Degree	Food Science and Technology	Agriculture and Food Processing
6	NIYONSENGA Evergiste	Male	Bachelor's Degree	Crop Production	Agriculture and Food Processing
7	BYUKUSENGE Epaphrodite	Male	Bachelor's Degree	Animal Production	Agriculture and Food Processing
8	NIYONSHIMA Protais	Male	Master's Degree	Education	Agriculture and Food Processing
9	MUHORACYEYE Cecile	Female	Bachelor's Degree	Agriculture	Agriculture and Food Processing
10	NISHIMWE Gaudence	Female	Master's Degree	Horticulture	Agriculture and Food Processing
11	NGENDO Clement	Male	Master's Degree	Soil Science	Agriculture and Food Processing
12	MUSANABAGANWA Stephanie	Female	Bachelor's Degree	Agriculture	Agriculture and Food Processing
13	NDEKEZI Annick	Female	Bachelor's Degree	Food Science and Technology	Agriculture and Food Processing

APPENDIX 15: LIST OF KEY INFORMANTS

Informant Names	Gender	Organisation	Position
MUKAMASHYAKA Jeanne	Female	Holland Greentech	Field Agronomist in Horticulture
MACHARIA William	Male	Sunripe Farm	Farm Manager
NIYONSENGA Amon	Male	Sunripe Farm	Quality Assurance and sales officer
MFINANGA Joseph	Male	IPRC Musanze	Deputy Principal in Charge of Academic and training
UWIRINGIYIMANA Jean Damascene	Male	Nkotsi Sector	Sector Agronomist
INGABIRE Marie Aimee	Female	Rwanda Agriculture Board	Research Technician