



# How sustainable is sustainable intensification of agriculture?

An analysis of the effects of the increased efficiency in the potato value chain in North-West Rwanda

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the potato value chain in North-West Rwanda

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## Abstract

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The concept of sustainable intensification of agriculture has been recognised and promoted as the solution as a sustainable food production for all. Sustainable intensification of agriculture applies a holistic view, including output, economic, environmental, and social aspirations. The concept aims to increase crop production, increase profitability, minimise and decrease damage to the environment, and contribute to become more resilient to shocks and stresses. As a result of this intensification process, (1) farmers' productivity improves, (2) the ecosystem preserves and (3) farmers' livelihood enhances.

Based on this research, the overall impact concludes that the productivity improves. However, the smallholder farmers do experience economic, cognitive, and social barriers while adopting the new farming method of sustainable intensification of their agricultural land. Furthermore, the livelihood of the smallholder farmers faces physical, social, and economic barriers which constrain farmers from cultivating with the intensified technique. Besides, there are assets that enhance livelihood as gained knowledge and improved soil quality. But throughout the whole project gender dynamics are present. Gender roles are culturally unequal in the Rwandan agricultural sector, and this influences the involvement of women in the process of sustainable intensification of agriculture. Diverse influencing factors reoccurred throughout analysing the data, such as more required inputs, low access to finance, and unstable crop market prices. These factors correspond to the improved outputs of the smallholder farmers and their livelihood enhancement.

Overall, the effects of sustainable intensification of agriculture are very diverse and are, therefore, in line with the highly heterogeneous nature of smallholder farmers. But above all, it can be stated that, even though Rwandan smallholder farmers do not have full authority over their decisions, this study examined that the effects of the potato value chain program are positive when focusing on productivity. The unanticipated consequences may reduce the chance of a sustainable long-term adoption and decrease the resilience of most smallholder farmers.

## Acknowledgements

With great pleasure I present to you my thesis about the effects of sustainable intensification of potato value chain in North-West Rwanda. This thesis is the result of six months of fieldwork and data analysis. This research is part of the master program International Development Studies of the University of Utrecht, the Netherlands. Before starting this master program, I lived and worked in several African countries. Due to COVID-19, I came back to the Netherlands and decided to start this master. It does not come by surprise that my main interest throughout the master has been in the African continent. So when I saw that, out of the whole African continent, only the travel restrictions for Rwanda were lifted, I knew this was the place to conduct fieldwork for my thesis. Full of enthusiasm, I returned to East Africa for my master thesis in early February 2022.

Working and living in Rwanda for four months was mostly very enjoyable, but at times challenging and confronting. Gathering data was a pure joy from beginning to end. Experiencing the hospitality, enthusiasm, happiness, and gratefulness of many Rwandan farmers was wonderful. I am very grateful for this experience. Writing the thesis was definitely more stressful and challenging. At times, I was unsure if I was on the right track and how to move further. But whilst analysing the data, I discovered interesting results, which made me very enthusiastic and gave me the encouragement that the collected data actually came together as a consistent story.

In addition, I would like to express my gratitude to several people. First of all, my supervisor Dr. Romain Dittgen, who guided me through my thesis and provided advice and feedback during the process. Secondly, to Lisette Meulman and Aimable Uwihanganye from Delphy B.V., my host organisation in Rwanda. Thank you both for giving me a warm welcome, trusting me with executing this research, providing me with all assistance needed, introducing me to the Rwandan culture and answering my (too many) questions regarding potato cultivation. Thirdly, my translator Emmanuel deserves all the credits. Without his efforts to reach out to participants, his sense of direction in locating participants and translating, it would have been impossible to complete this thesis. And lastly, the dedicated smallholder potato farmers who were willing to talk to me about their experiences. Thank you for all your efforts in sharing your stories and for being so kind and open to me.

Last but not least, a big thank you to all my supportive family and friends. All of your continued support, while being abroad and being home, helped me to stay positive and to finish my thesis.

## Murakoze chane!

Claudy Luft

Utrecht, August 2022



*Photo: With Aimable, project coordinator  
Source: personal photo*



*Photo: Kinigi potato variety  
Source: personal photo*



*Photo: With Emmanuel, translator  
Source: personal photo*



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## List of abbreviations

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CIP	Crop intensification programme
FAO	Food and Agriculture Organization
GDP	Gross domestic product
ha	Hectare
ISFM	Integrated Soil Fertility Management
LWH	Land husbandry, water harvesting and hillside irrigation
MINAGRI	Rwandan Ministry of Agriculture and Animal Resources
ODA	Overseas development assistance
RPF	Rwanda Patriotic Front
RVO	Rijksdienst voor Ondernemend Nederland
SPF	Seed Potato Fund
SLF	Sustainable livelihood framework
SSA	Sub-Saharan Africa
UN	United Nations
UNDP	United Nations Development Program





## 1. Introduction

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Securing food for all is and will be an enormous task and has already for decades been on the top priority list of major development initiatives (Conceição, Levine, Lipton, & Warren-Rodríguez, 2016). The world population will most likely expand to nearly 10 billion in 2050 (United Nations, 2019), thus increasing the demand for food and thereby also the expectations to produce more food. Especially Sub-Saharan Africa (SSA) faces a tremendous challenge as the region already struggles with the highest prevalence percentage of hunger and, on top of that, is recognised as the fastest growing population in the world, expected to double by 2050 (Hall, Dawson, Macdiarmid, Matthews, & Smith, 2017); (Burchi, Scarlato, & d'Agostino, 2018). At the same time, challenges like climate change and scarce natural resources, like land and water, make it difficult to fulfil the expectations to produce more (Godfray, et al., 2010); (Beddington, 2009); (Porkka, Kumme, Siebert, & Varis, 2013); (Hunter, Smith, Schipanski, Atwood, & Mortensen, 2017). In addition, more attention globally arises for sustainability and the environment (Pretty, 2008); (Mahona, Crute, Di Bonito, Simmons, & Islam, 2018). Accordingly, the agriculture sector worldwide faces multiple challenges together with high expectations.

In response to these challenges, the United Nations (UN) (n.d.) advocates that increasing the productivity of agriculture and sustainable food production are crucial. In recent studies, Van Ittersum et al. (2016), Koning et al. (2008), Mueller et al. (2012) and Tilman et al. (2011) argue that the growing challenge of food demand can be solved through sustainable intensification of the yield potential on existing agriculture land. The concept of sustainable intensification of agriculture is recognised and promoted as the solution to the above challenges (Pretty, 1997); (Verlauwe, et al., 2014); (Sutherland, et al., 2015). Particularly in SSA, where available land is limited and expanding agricultural land is barely possible due to a lack of available suitable soil and densely populated areas in which the population is still growing (Vanlauwe, Hungria, Kanampiu, & Giller, 2019). Verlauwe et al. (2014) claim that sustainable intensification of the existing agricultural land is a must in SSA and is going to increase the agricultural production which will feed the expanding population (Verlauwe, et al., 2014).

Over the years, the concept has experienced an evolution towards a broader definition (Verlauwe, et al., 2014); (Garnett, et al., 2013) (Pretty & Bharucha, 2014), but the exact definition, aims and practices of sustainable intensification of agriculture are still under debate (Garnett, et al., 2013); (Garnett & Godfray, 2012); (Rockström, et al., 2017). The main premise of sustainable intensification of agriculture focus on an increase in crop production and profitability, minimizing and decreasing the damage to the environment, and contributing to become more resilient to shocks and stresses (Verlauwe, et al., 2014); (Garnett, et al., 2013); (Pretty, 2008). As a result of this intensification process, (1) farmers' productivity improves, (2) the ecosystem preserves and (3) its livelihoods improves (Rockström, et al., 2017); (Garnett, et al., 2013). To summarize, sustainable intensification of agriculture advocates a holistic view, including output, economic, environmental, and social aspirations.

Scholarly debates suggest it is desirable to focus on smallholder farms for sustainable intensification of agriculture for several reasons. Firstly, the majority of farms in the world are smallholders farms, smaller than two hectares (Harris, 2019); (Barrett, Reardon, & Webb, 2001); (Verlauwe, et al., 2014); (HLPE, 2013). Secondly, these smallholder farmers are highly vulnerable and climate change only increases this (Verlauwe, et al., 2014). Lastly, many smallholder farmers experience obstructing resource limitations and have therefore potential for increasing their productivity (Herrero, et al., 2010); (Pretty, Toulmin, & Williams, 2011). Thus, to effectively increase



food supply, investing in agriculture of smallholder farmers is seen as the main strategy (The World Bank, 2007); (FAO, 2012); (Garnett, et al., 2013); (Rockström, et al., 2017); (Pretty, 2008).

### 1.1 Problem statement

As Vanlauwe & Dobermann (2020) point out: *“No one with common sense will disagree with the need for farming systems in SSA - and in other regions of the world for that matter - to be sustainably intensified”*. However, it is more complicated than that. Intensification of agriculture does, in most cases, result in an increase in productivity (Harris, 2019). However, many studies, including Harris (2019), Liao & Brown (2018) and Verlauwe et al. (2014), suggest that smallholder farmers have not always achieved a sustained adoption and their livelihoods have not improved in response to an increase in productivity. This raises questions about the enhancement of smallholder farmers' livelihood in the process of sustainable intensification of their agricultural land.

Besides, there is a concern that sustainable intensification of agriculture leads to inequitable outcomes for women (Hagggar, Lamboll, Nelson, & Rodenburg, 2020); (Hagggar & Rodenburg, 2021). Mulema & Damtew (2016) state that several factors which relate to the process of sustainable intensification of agriculture obstruct women from getting involved and adopting the new farming techniques. Access to land, resources and services are the main challenges for women to achieve an intensified production. Therefore, it needs to be taken into account that access can differ between countries, regions, and cultures (Hagggar, Lamboll, Nelson, & Rodenburg, 2020).

There is a need to understand how livelihood and gender dynamics of households of smallholder farmers get affected during the process of sustainable intensification of their agricultural land. This knowledge gap reflects the disparity of outcomes of the process of sustainable intensification of agriculture for those households involved. Within this thesis, the knowledge will be drawn from a case study in North-West Rwanda, which provides access to information about the impact on livelihood and gender dynamics on a household level of those in the process of intensification of their agricultural land.

The case study focuses on the increased efficiency project of the potato value chain in North-West Rwanda. Agriculture is the backbone of Rwanda's economy, accounting for about one-third of the country's GDP and employing just over two-thirds of the labour force (World Food Programme, 2018); (The World Bank, 2021a). Besides, agricultural intensification has not gone unnoticed by the Rwandan Government. In 2008, the Rwandan government introduced the 'crop intensification program' (CIP) (MINAGRI, 2018). According to the National Agriculture Policy of the Rwandan Ministry of Agriculture and Animal Resources (MINAGRI), the focus is on increasing the resilience and sustainable intensification of Rwandan farmers. They aim to 'enjoy food security, nutritional health and sustainable agricultural growth from a productive, green and market-led agricultural sector' (MINAGRI, 2018). This state-led agricultural commitment illustrates the relevance of the chosen case study. The project is part of a country-wide, state-led initiative to intensify agriculture production. The lead partner of the project is the company Delphy. Based on internal documents of Delphy (2018), the overall goal of the project is to 'sustain a long-term income for potato farmers', 'make the farming enterprise more resilient to stresses and/or shocks', and 'create an optimal functioning value chain resulting in a fair and equitable economic benefit for all actors involved'. Furthermore, the project aims to 'give special attention to strengthening the position of women' (Delphy, 2018). Rwandan women



engaging in agriculture are a vulnerable, disadvantaged group and by providing extra care Delphy aims to contribute to women's empowerment in the value chain (UN Women, 2018); (Delphy, 2018).

This research focuses on smallholder potato farmers who are in the process of sustainable intensification of their agricultural land and looks at the effect on livelihood and gender dynamics. The increase in crop production and profitability is the main intended outcomes for the smallholder farmers. However, it is unsure whether this translates into an improved livelihood and more equitable gender dynamics at a household level. The objective of this research is to understand the impact on households of smallholder farmers' livelihood and to identify what the intended and unintended outcomes are when looking at their livelihood and gender dynamics. The overall objective of this research is to contribute to more academic knowledge on the adaptation of sustainable intensification of agriculture and its possibilities and limitations in relation to livelihood and gender dynamics of smallholder farmers. Besides, this case study will also formulate recommendations which can be of use as a guideline for project improvements and other policymakers in adjusting strategies for implementing sustainable intensification of agriculture in the future. Therefore, the main research question is:

*How does the process of sustainable intensification of the potato value chain affect the livelihood and gender dynamics of smallholder farmers in North-West Rwanda?*

This case study provides a multi-faced analysis of the effects of sustainable intensification of agriculture. The main research question will be answered with the support of three sub-questions:

1. *To what extent are the improved outputs, underlying sustainable intensification of agriculture, achieved for smallholder farmers' households?*
2. *What are the livelihood enhancements for smallholder farmers at household level involved in the process towards sustainable intensification?*
3. *How do gender dynamics of smallholder farmers (at household level) impact the process towards sustainable intensification of agriculture?*

## 1.2 Outline of the thesis

The following section describes the main literary statements, debates, ideas, and discussions on sustainable intensification of agriculture and other relevant concepts. This theoretical framework provides an overview of the academic literature available on conceptualizations and frameworks. These conceptualizations and frameworks are the basis of the research. Chapter three provides a geographical contextual framework for the institutional profile of Rwanda, the agriculture sector of Rwanda, the host organisation Delphy B.V. and more information about the potato value chain efficiency project. The research design will be presented in chapter four, which provides a transparent overview of the research methods and techniques used for data collection and analysis. In addition, this chapter includes a brief critical reflection on the conducted research. Chapter five and six outline, analyse, and discuss the research results based on collected data from the smallholder potato farmers. These chapters correspond with the three sub-research questions. The last chapter of this thesis is the conclusion which answers the main research question and provides recommendations for the project and future research.



## 2. Theoretical framework

In this research, the central concept is sustainable intensification of agriculture. This chapter defines the key concepts and discusses relevant theories which connect the research to existing knowledge. Exploring literature concerning the central concept and its linkages to smallholder farmers, livelihood enhancement, gender dynamics, and knowledge transfer, clarifies the theoretical and conceptual embedding of the research.

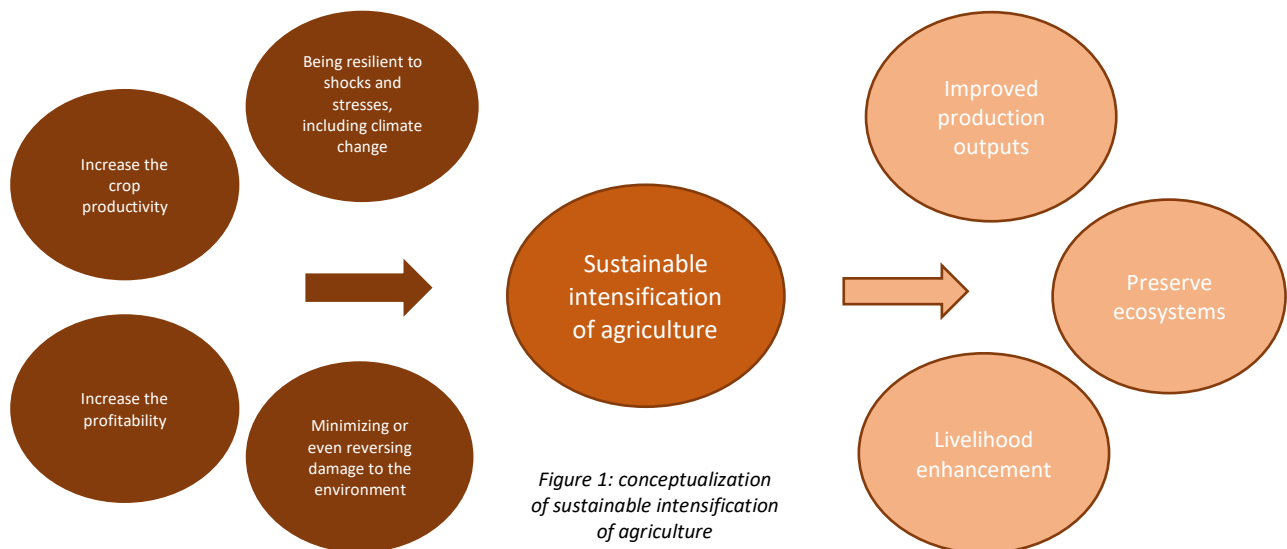
### 2.1 Sustainable intensification of agriculture

As briefly touched upon in the introduction, the human population is increasing rapidly and this results in a global challenge of achieving agricultural production efficiency (Tscharntke, et al., 2012); (Beddington, 2009); (Hunter, Smith, Schipanski, Atwood, & Mortensen, 2017). Increasing productivity of agriculture and achieving a sustainable food production is crucial in the battle to end hunger and malnutrition (United Nations, n.d.). Additionally, the competition for land increases worldwide and climate change challenges agricultural production (Parry, Evans, Rosegrant, & Wheeler, 2009). These challenges ask for rapid changes in food production by firstly focusing on higher productivity and secondly reducing the environmental impact. The strategy of intensification of agriculture is a crucial component towards the goal of producing more food to support the growing population (Verlauwe, et al., 2014).

The concept of sustainable intensification of agriculture originated in the nineties (Pretty, 1997) and largely focuses on improving agricultural productivity and at the same time reducing environmental damage (Pretty, 1997); (Godfray & Garnett, 2014). Rockström et al. (2017) state that *“sustainable intensification, in this context, seeks to increase agricultural output while keeping the ecological footprint as small as possible”*. This approach has gained popularity among a diverse group of stakeholders, including national governments (Mahona, Crute, Di Bonito, Simmons, & Islam, 2018); (UNAID, 2016), intergovernmental organisations (United Nations, 2015); (FAO, 2021a), inter- & transnational agriculture businesses (Godfray, et al., 2010) (AGRA, 2020) and research institutes (Musumba, Grabowski, Palm, & Snapp, 2017).

Sustainable intensification is a relatively new and evolving concept, for this reason, the exact definition, aims and practices are still under debate (Garnett, et al., 2013); (Garnett & Godfray, 2012); (Rockström, et al., 2017). A commonly used definition is: *“Sustainable agricultural intensification is defined as producing more output from the same area of land while reducing the negative environmental impacts and at the same time increasing contributions to natural capital and the flow of environmental services”* (Pretty, 2008); (Godfray, et al., 2010); (Barnes & Thomson, 2014); (Pretty, Williams, & Toulim, 2011). The definition suggests that environmental impact of agriculture takes up a big focus of sustainable intensification. Yet, several scholars, including Garnett et al. (2013) and Barnes & Thomson (2014), have argued that this definition of sustainable intensification lacks emphasis on the economic and social dimensions of the concept. In more recent years, the concept has experienced an evolution towards a broader definition, including the economic and social aspects as well as becoming more resilient to shocks and stresses (Verlauwe, et al., 2014); (Garnett, et al., 2013); (Pretty & Bharucha, 2014). The social aspect refers to the improvement and strengthening of livelihood of those involved (Rockström, et al., 2017); (FAO, 2021a). The economic element aims for a sustainable increase in the profitability of the crops (Barnes & Thomson, 2014); (Garnett, et al., 2013); (Godfray & Garnett, 2014).

Overall, the recent definition of sustainable intensification of agriculture is broader, with a holistic view including the output, economic, environmental, and social aspirations. *Figure 1* visualizes the conceptualization of sustainable intensification of agriculture. The concept aims to improve production output, preserve ecosystems, and enhance livelihood.



*Figure 1: conceptualization of sustainable intensification of agriculture*

Tscharntke et al. (2012) report that sustainable intensification of agriculture can contribute to global hunger reduction, but only when focused on the area where food is insecure. So, sustainable intensification of agriculture mainly contributes in rural locations in less-developed countries to the increase of food security, reduction of poverty and improvement of nutrition (United Nations, 2015); (Harris, 2019); (Tscharntke, et al., 2012).

Meanwhile, the impact of climate change is a growing challenge for agriculture production worldwide. According to the Food and Agriculture Organization (FAO) (2021b), climate variability and its extremes are the key drivers behind the increase in global food insecurity. Climate change causes climate variability and its extremes besides it influence the food security negatively. This points to the importance of becoming more resilient to climate change and thereby highlights the need for the sustainable intensification of agriculture (Garnett, et al., 2013). As climate change motivates to promote sustainable intensification, it also ensures a positive environmental impact and becomes more resilient to shocks and stresses (Verlauwe, et al., 2014).

Especially SSA faces challenges regarding food security, due to the rapidly growing population on the continent combined with a less developed agricultural sector compared to other continents (Schut & Giller, 2020). Investing in agriculture is presented as the main strategy to reduce hunger, even more so when the sector employs the majority of the population (The World Bank, 2007); (Pretty, 2008). According to the World bank (2021d), 53 percent of the population in SSA is employed in agriculture; globally employment in agriculture is 27 percent. Moreover, in SSA and specifically in Rwanda, available land is limited and expanding agricultural land is barely possible due to the densely populated areas and limited arable land (Vanlauwe, Hungria, Kanampiu, & Giller, 2019). Additionally, the African continent and more specifically Rwanda, experiences a yield gap which indicates potential for existing cropland (Van Ittersum, et al., 2016); (Baudron, Ndoli, Habarurema, & Vasco Silva, 2019). Internal documents of Delphy (2018) claim that the average yield of a Rwanda potato farmer is 12 tons per hectare. According to calculations by Delphy (2018), the estimated yield gap is within a range of



10 to 20 tons per hectare. They state that causes of this gap include 'lack of sustainable agricultural practices', 'use of low yield varieties' and 'high incidence of pest-related disease' (Delphy, 2018). Schut & Giller (2020) believe that investing in sustainable intensification of agriculture in SSA will have wide-reaching long-term benefits in terms of land productivity combined with economic prosperity. Which eventually leads to the essential development of producing food locally and economic growth (Schut & Giller, 2020).

## 2.2 African smallholder farmers

In order to achieve food security in SSA, scholars discuss the scale of agricultural production that needs to be focused on (Larson, Otsuka, Matsumoto, & Kilic, 2014). According to Harris (2019), Barrett, Reardon & Webb (2001), Verlauwe et al. (2014) and the FAO (2013), most farms in the world are owned by smallholder farmers, with farms smaller than two hectares. In SSA targeting smallholder farmers is highly relevant, as smallholder farming dominates the African agriculture relative to commercial farming (Van Ittersum, et al., 2016); (Schut & Giller, 2020). Rwanda's agricultural sector is also dominated by smallholder farmers, with 75 percent of the agricultural production coming from smallholder farmers (RDB, 2022). Moreover, these smallholder farmers are considered highly vulnerable and climate change increases this (Verlauwe, et al., 2014). Rwandan smallholder farmers practice rainfed agriculture. Irregularities in rainfall and increases of temperature due to climate change, are a severe threat to crop production (De la Paix, Anming, Lanhai, Ge, & Habiyaremye, 2011). It is therefore key to build resilient systems for this community of smallholder farmers. Herrero et al. (2010) and Pretty, Toulmin & Williams (2011) argue that many smallholder farmers experience resource limitations and therefore have great potential for increasing their productivity. Furthermore, as mentioned before, agricultural land is scarce in SSA and especially in Rwanda, so expanding is no longer an option for the smallholder farmers (Bizoza, 2014); (Vanlauwe, Hungria, Kanampiu, & Giller, 2019). Therefore, it is key to cultivate efficiently on existing agricultural land by sustainably intensifying the yield potential (Van Ittersum, et al., 2016). In short, focusing on smallholder farms for sustainable intensification of agriculture is thus desirable for a number of reasons.

Despite the comparable surface area of farmland, the nature of smallholder farmers is highly heterogeneous in terms of farmer production objectives, socio-technical conditions, and biophysical gradients. This results in various pathways towards sustainable intensification of their agricultural land (Verlauwe, et al., 2014). According to Verlauwe et al. (2014), the heterogeneous nature of smallholder farmers translates to many different pathways to adapt and practice a sustainable intensification of farmland. This indicates the need to be exceptionally flexible when implementing sustainable intensification on various farms. In addition, regional conditions of agro-ecological circumstances vary too, farming patterns differ, the ability and willingness of the farmer to invest may vary as well. These household resource variations will influence the likelihood of adopting a new intensified farming method on their farmland. Therefore, promoting a one-size-fits-all concept for intensification will not work. Integration and focus on the diversity of the local conditions at various scales is required (Verlauwe, et al., 2014).

Most smallholder farmers must diversify the household strategy by not solely relying on the output of the farm. This is relevant considering a household is relying on multiple income streams, the intensification of agriculture needs to provide enough benefits as it requires an investment (Harris, 2019); (Barrett, Reardon, & Webb, 2001); (HLPE, 2013). In addition, smallholder farmers expect





immediate benefits from farming, it is therefore extremely important that intensification will provide the predicted farm improvement of productivity (Harris, 2019). In fact, Schut & Giller (2020) report that food secure farmers are more likely to apply the intensification method in their own farmland compared to food insecure farmers. Verlauwe et al. (2014) point out that conservation or rehabilitation of other ecosystems is not a priority for the smallholder farmer. Smallholder farmers are generally interested in low-risk options with a short-term return on investment (Verlauwe, et al., 2014). This might explain why food secure farmers are more likely to adopt as they are secure in food production and therefore dare to take more risks compared to smallholder farmers, who encounter insecurities in their food system. Above all, Harris (2019) and Schut & Giller (2020) argue that the increase of farm produce accomplished by intensification, will not lift smallholder farmers out of poverty as the profit increase is marginal due to the small size of their farmland. Plus, many smallholder farmers with a diversified income will choose investment opportunities outside the farm (Schut & Giller, 2020).

### 2.3 Livelihood enhancement

Sustainable intensification of agriculture focuses on improved output and preserved ecosystems, but also aims to enhance livelihood of the involved smallholder farmers. The smallholder farmers sustain their livelihood with several strategies. Intensification of agriculture presents a strategy to secure rural livelihood. However, the cited scholarly authors below argue whether the livelihood of smallholder farmers improves while in the process of sustainable intensification of their agricultural land. Harris (2019) researched secondary data, focusing on the output of introduced sustainable intensification and the impact on smallholder farmers' livelihood. Unfortunately, in many cases the farmer did not achieve a sustained adoption of the intensified method of farming. Scholars wrote a considerable amount of literature on constraints to adoption (e.g. see (Feder, Just, & Zilberman, 1985); (Giller, Witter, Corbeels, & Tittonell, 2009)), but according to Harris (2019) the main constraint is poor access to inputs, knowledge and markets. In addition, Liao & Brown (2018) state that increasing food production of smallholder farms will one way or the other affect their livelihoods as their production system changes and the long-term impact is often unknown. Liao & Brown (2018) argue that the increase of income of farmers does not always materialise and can come at the expense of other aspects of livelihoods (income stability and diversification) or get unevenly distributed and thereby aggravate the existing poverty. So, the improvement of smallholder farmers' livelihood as an automatic response to the increase of sustainable intensification is scientifically not always confirmed.

Castella et al. (2013) conducted research in South-East Asia, where the transition towards a more intensive farmland use was introduced. The majority of rural households experienced an increase in income; however, this increase came at a cost of a reduction in livelihood diversity. This reduction can eventually compromise the livelihood adaptive capacity, social cohesion, and customary practice (Liao & Brown, 2018). Furthermore, while smallholder farms adopt the intensified production, they convert to a more monoculture commodity crop instead of diversified traditional farming. This leads to an increase of the risk of income stability (Liao & Brown, 2018); (Verlauwe, et al., 2014). Dahal, Sitaula & Bajracharya (2007) reported another example out of their research in Nepal. They conclude that the impact of sustainable intensification of agriculture in Nepal also includes negative consequences. The negative findings were mainly on land degradation and fertility losses of land (Dahal, Sitaula, & Bajracharya, 2007). Thereby, it needs to be taken into account that land is one of the most valuable assets of a farmer. Degradation of land or fertility losses have severe consequences for the farmers' livelihood. In another example of geographically relevant research in Rwanda, Clay &





Zimmerer (2020) report that agricultural programs reduce smallholder farmers' resilience by decreasing flexibility, as farmers are compelled to produce crops which are poorly suited for their land and resources. Plus, many smallholder farmers do not have access to the required resources. They state that their study shows that *"the top-down agricultural intensification in Rwanda has resulted in the unanticipated consequences of decreased resilience to climate shocks for a large segment of smallholder food producers"* (Clay & Zimmerer, 2020). According to Clay & Zimmerer (2020), especially poorer smallholder farmers experience negative effects as they pursue the intensification strategy under force which drain their resources even more.

Liao & Brown (2018) conclude that sustainable intensification is too narrowly focused, and they imply that it is necessary to move beyond the assumed twin connection between sustainable intensification and improvement of livelihood. With this in mind, Harris (2019) and Liao & Brown (2018) advocate including livelihood improvement as an input besides the set goals of increasing productivity, achieving higher profitability, being more resilient, and minimizing the impact on nature. Livelihood improvement is therefore an essential part of the process towards sustainable intensification of agriculture and cannot be assumed to improve automatically with the increase of income and production.

## 2.4 Livelihood approach

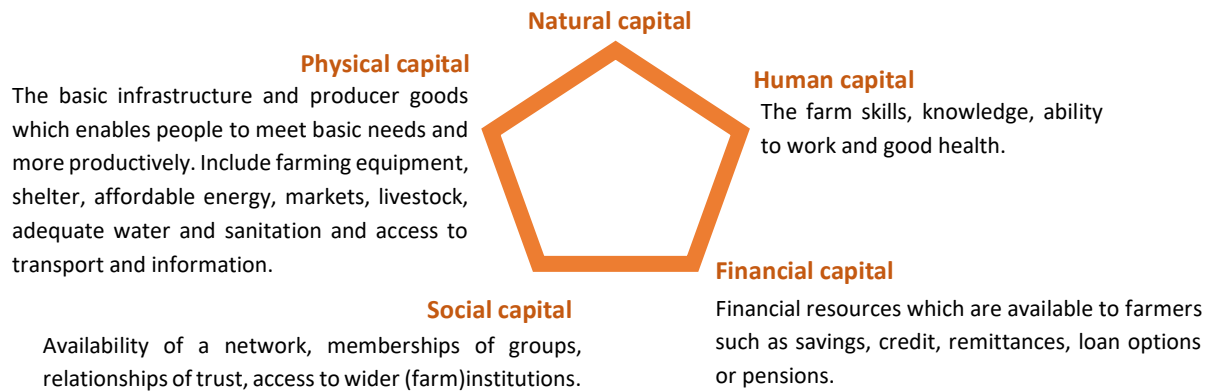
As mentioned before, livelihood improvement is one of the preferred outcomes of sustainable intensification of agriculture. Identifying that livelihood matters in the process of sustainable intensification is important, however the next relevant step is to explore how to measure livelihood. A livelihood at its simplest means 'gaining a living' (Chambers & Conway, 1992). The framework of Scoones (2009) helps to understand the complexity of rural livelihood in a development setting. The framework is known as the 'sustainable livelihood framework' (SLF) and offers a holistic and multi-dimensional approach to livelihoods in rural areas. The focus is on strategies of individuals and households. It looks beyond the subsistence of income by including links between different assets and other alternative activities to sustain a living (Pasanchay & Schott, 2021); (Scoones, 1998). The contribution of Chambers and Conway (1992) is considered highly meaningful for the dominance SLF has achieved. They define sustainable livelihoods as follows:

*"The capabilities, assets (stores, resources, claims and access) and activities required for a means of living: a livelihood is sustainable which can cope with and recover from stress and shocks, maintain, or enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation; and which contributes net benefits to other livelihoods at the local and global levels in the short and long-term."* (Chambers & Conway, 1992)

Since the 1990s, several major development actors have actively used the SLF, among whom the United Nations Development Program (UNDP), United Kingdom's Department for International Development and the UN's Food and Agriculture Organization (Mensah, 2011). According to Mensah (2011), *"the framework prioritized people as a focal subject of any policy planning and design, thus creating better scope for large scale poverty reduction strategies"*. SLF is designed to improve the understanding of livelihood, in particular of the impoverished people (Department for International Development, 1999). The SLF is people centred and identifies five categories of capital which together build a sustainable living (Neefjes, 2000). Sources of capital are the assets available to an individual or

household and are at the core of the SLF. The five livelihood assets upon which the smallholder farmers livelihood builds, is visually presented in *figure 2* (Potter, Binns, Elliott, Nel, & Smith, 2018).

The natural resource stocks from which resource flows and services useful for livelihoods are derived, include land, soil quality, trees, wildlife, and biodiversity.



*Figure 2: Livelihood pentagon*

Source: (Potter, Binns, Elliott, Nel, & Smith, 2018)

The five types of capital tied to the livelihood pentagon are the core of the SLF. The SLF consists of five interrelated dimensions, visualised in *figure 3*. The first dimension includes the vulnerability context, which analyses the conditions and trends of the external environment in which the smallholder farmer operates (Van Rijn, Burger, & Den Belder, 2012). Livelihoods get affected by external conditions over which the smallholder farmers have limited or no control. An example of a vulnerability is the seasonality of the rainfall which the Rwandan farmers are dependent on. Secondly, at the heart of the framework is the pentagon that includes the five livelihood assets (Potter, Binns, Elliott, Nel, & Smith, 2018). The aim is to get a realistic understanding of farmers' assets, how they are interconnected, and how they convert into a livelihood. Transforming institutional processes and organisational structures is the third dimension. This refers to policies, institutions, organisations, and legislations which determine the access to livelihood resources (Scoones, 2009). The ability to partly transform structures and processes determines the access to capital. The fourth dimension contains the livelihood strategies. The strategies refer to the output of the SLF. This entails the combination of people's choices and activities that are directly linked to the livelihood outcomes, being the last dimension of the framework. But there is a close link between the strategies, outcomes, and the livelihood assets. For example, a household may choose to diversify their income which might result in an increase in income and a reduction of their vulnerability. Their increase in financial assets could catalyse a virtuous circle of asset accumulation and provide the household with a sustainable livelihood. Overall, having access to more livelihood resources enables smallholder farmers to switch between different livelihood strategies to secure their livelihood and be less vulnerable (Van Rijn, Burger, & Den Belder, 2012).

Intensification of agriculture is an example of a livelihood strategy that could achieve a reduction of the smallholder farmers' poverty level or improve their assets. Improving the farm productivity and gaining a higher income focuses on two assets, however the process towards intensification could have an impact on a range of assets. Therefore, it is important to gain an accurate understanding of the effect of sustainable intensification of agriculture on the overall livelihood within the vulnerability context of the smallholder farmers.

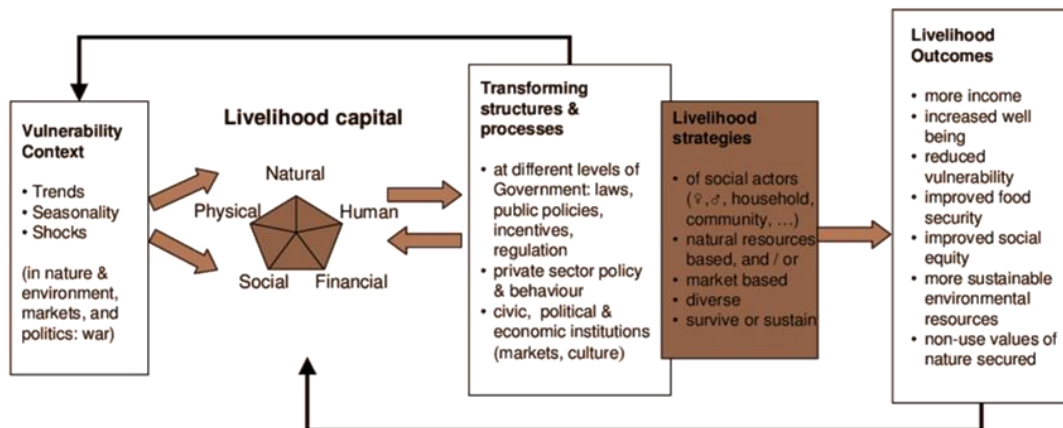


Figure 3: The sustainable livelihoods framework

Source: (Neeffjes, 2000)

The SLF also receives criticism, mainly because the SLF assumes that all capital components are equally accessible to all local community members (Jackson, 2021). While this is often not the case in real life. Gender specific constraints in accessing assets form a barrier, especially in the context of agriculture in SSA (Ndiritu, Kassie, & Shiferaw, 2014). Even though gender is often considered being part of social capital, Jackson (2021) advocates to include gender equality into the centre stage of the framework part of all capitals. Van Hoes & van Koppen (2005) even promote a gendered sustainable livelihood framework that allows considering the access and control mechanisms which differ between men and women. To conclude, it is highly valuable to acknowledge both male and female contribution to the pursuit of livelihood capabilities. Incorporating vocational and formal recognition of empowerment needs to be encouraged by ensuring human capital is fully investigated in the best interest of all gender groups (Jackson, 2019).

## 2.5 Gender strategy

Agricultural growth is an important engine of development and poverty reduction (The World Bank, 2007). In numerous contexts in Africa, women play a key role in farm work as they carry the responsibility of the family food security and home production (Meinzen-Dick, et al., 2010). Overall, men disproportionately control the resources for agriculture and receive the larger share of benefits (Bezner Kerr, 2008); (Grabowski, et al., 2020). The FAO (2011) states that the contribution of women in agriculture and food production is significant, unfortunately they say it is an impossible task to empirically verify the share produced by women. The participation rate of rural women in agriculture production varies across countries, regions, and cultures (Ndiritu, Kassie, & Shiferaw, 2014); (FAO, 2011); (Verlauwe, et al., 2014). But across Africa, women play a crucial role in enhancing food and nutritional security in both farm and non-farm activities (Ndiritu, Kassie, & Shiferaw, 2014). Besides, the FAO (2011) also mentioned that women are overrepresented in seasonal, unpaid, and part-time work and empirical evidence shows that women (for the same work) are often paid less than men.

When looking specifically at the process of sustainable intensification of agriculture, Mulema & Damtew (2016) state that, in their case study, several factors obstruct women to get involved. The recognised constraining factors are different capitals which are all interrelated. They identified that the natural, financial, human, physical, political, and cultural capitals are constraining women, by having limited access and fewer control over assets. Especially women's low decision-making power and inability to effectively manage the flows were recognised as key constraining factors (Mulema & Damtew, 2016). In addition, women often experience uncertain land rights, trade restrictions, lack of



access to the required materials and marginalization (Clay & Zimmerer, 2020). Verlauwe et al. (2014) add that institutional processes also exclude women, for example from land ownership and investments. However, increasing women's access to capital is not enough. Being able to increase the returns of the intensification and being able to control those benefits will boost equality (Mulema & Damtew, 2016). These social inequalities are often deeply rooted in societies and make marginalized groups more vulnerable (Clay & Zimmerer, 2020). Understanding how these social inequalities intervene with the participation in the sustainable intensification process of agriculture is one of the aims of this research.

To conceptualize gender equality and women empowerment, Kabeer (2005) categorizes three closely interrelated dimensions: agency, resources, and achievements. Agency differentiates the level of control over resources. Control over resources is both positively and negatively, it can refer to the 'power to' make own life choices and on the other hand to the 'power over' whereby other actors overrule the own choice. Resources refer to access to resources of agriculture. And lastly the achievements, this measures differences in gender in realizing various benefits in agriculture (Kabeer, 2005); (Feed the Future, n.d.). Achievements are the consequence of agency. At the same time, empowerment in terms of increasing a woman's ability to do as they choose can also result in disempowerment (Khader, 2018). Caution is needed when conditions of gender equality provide women with choices of (mostly) unacceptable alternatives, doing too much, and doing more (compared to men). Agency is therefore not automatically positive. Khader (2018) claims that the best option often results in disempowerment and looks more like a burden for women.

Including women in the implementation and benefits of sustainable intensification of agriculture is a complex process (Haggar, Lamboll, Nelson, & Rodenburg, 2020). The complexity is mainly constructed due to the lack of access to land, resources, and services which are essential to achieve an intensified production. Haggar, Lamboll, Nelson & Rodenburg (2020) therefore express a major concern regarding intensification of agriculture, which can lead to inequitable outcomes for women, while it is generally considered more equitable. Nonetheless, the level of access differs per country, region, and culture. Overall, determines the local social, environmental, and economic conditions how agency, resources, and achievements influence gender participation while in process towards sustainable intensification of agriculture (Haggar & Rodenburg, 2021).

## 2.6 Transferring knowledge

The process of sustainable intensification of agriculture includes diverse ways of transferring knowledge into practice and depends on the chosen, most suitable, intensification strategy (Tiftonell, 2014). For sustainable intensification, agricultural knowledge transfer is key to ensure the extension of sustainable agricultural practices. Within this research, 'traditional knowledge' defines the body of knowledge, science, and technology used by local communities based on indigenous knowledge confined to a particular society or culture. The term 'modern knowledge' refers to knowledge, science, and technology acquired through formal education, advanced studies, research, trainings, experiments, and mentoring (Swift, 1979). Where modern knowledge is mostly written, traditional knowledge is usually passed on orally. Local farmers generally receive their knowledge originally from their parents or grandparents (Husnah, et al., 2014). In terms of agricultural knowledge transfer for sustainable intensification, traditional knowledge refers to the method smallholder farmers used to



apply in their fields and modern knowledge refers to the newly introduced intensified method of farming.

When looking at transferring knowledge and development, Gegeo (1998) argues that the concept 'development' dictates from the outside rather than constructed with knowledge based in the local communities. He refers to the modernization process, which was prominent in the 1950s and 1960s, but in principle still exists when the local needs are not concerned in development processes. Senanayake (2006) adds that colonial education has replaced the traditional knowledge with western ideas. During the colonial era, traditional knowledge was considered primitive and simple by academics and scientists. This is the reason why traditional knowledge did not get recorded in written form which led to the loss of much traditional, valuable knowledge (Senanayake, 2006). Husnah et al. (2014) proclaim that even nowadays, there is a gap between modern knowledge and traditional knowledge. They state it is highly critical that both types of knowledge emerge, to further progress and develop. However, as Foucault (1980) argued, knowledge is often used as power to dominate others. The utilization of knowledge is determined by the dominant discourse at the time.

Since the 1990s local knowledge became more relevant for the scientific world, arguing that traditional knowledge should be the core of development (Briggs & Moyo, 2012). Husnah et al. (2014) state that traditional knowledge is an alternative starting point and needs to be taken seriously in development of agriculture. Local farmers' knowledge might not be developed by experts of modern science or based on the principles of reductionism. However, it is developed contextually through practical needs and social and cultural norms (Ali, 2000). Additionally, much emphasis of traditional knowledge lies on the ecosystems and on sustainable ways of using local natural resources (Senanayake, 2006).

The public sector, the private non-profit sector, the private for-profit sector, or a combination of the three can lead development projects (Umali-Deininger, 1997). These development projects often include transferring knowledge in under-developed areas. A project focusing on increasing agricultural productivity of local communities, need to be highly cautious to avoid damaging local values and practices. Hushna et al. (2014) describe that the goal needs to be to mix modern knowledge with local wisdom and the use of local resources. On the other hand, Briggs & Moyo (2012) state that the use of traditional knowledge in rural Africa for development practices proved itself to be disappointing and elusive. The optimism in much of the writings in the 1990s and early 2000s (for examples see: Bicker, Ellen & Parkes (2003); Leach & Mearns (1996)) referring to traditional knowledge in development was unrealistic and overly optimistic, claim Briggs & Moyo (2012). Understanding the complexity of socio-economic realities of communities is often overlooked. Traditional knowledge is not as simple to understand, the cultural context is complex and requires a deep, clear, and meaningful understanding and engagement with the community from the start. The development industry often focuses on short-term and target-driven programs, this might explain the disappointment and 'failure' of the inclusion of traditional knowledge (Briggs & Moyo, 2012).

Improving agricultural practices of local communities as a development process, also called agriculture extension, is a top-down process. Scientists develop a new method of farming, agencies follow up by transferring knowledge and farmers are expected to adopt (Vanclay & Lawrence, 1994). Evidence suggest that these improved farming practices were invented decades ago, however smallholder farmers, particularly in Sub-Saharan Africa, hold very low adoption rates (Udry, 1996); (Duflo, Kremer, & Robinson, 2008). Schut & Giller (2020) estimate that only 11 percent to 14 percent

of African smallholder farmers adopt the introduced intensified method of farming. Achieving a high determinant of adoption is the goal for agricultural extensions. Common explanations for a low adoption rate are farmers’ attitudes to risk, socio-cultural factors, and credit constraints (Abebe, Bijman, Pascucci, & Omta, 2013); (Pan, Smith, & Sulaiman, 2018). The slow and low adoption rate often frustrates the efforts of the development project and initiatives. Most development projects are target-driven and tied to a certain budget cycle. To include more traditional knowledge a different timescale would be needed. At times, these target-driven programs and the inclusion of traditional knowledge create conflict on the time scale. Especially because these agricultural extension programs require high investments (Yigezu, et al., 2018). Shikuku (2019) and Yigezu et al. (2018) argue that the likelihood of effective information exchange on knowledge, awareness, and adoption increase with the use of direct trainings like field days and demonstration trials. So, providing face-to-face trainings for selected individuals improves the implementation rate of the newly introduced method of farming.

Overall, when transferring knowledge to smallholder farmers additional factors need to be considered. As a starting point smallholder farmers’ constraints, capabilities, resources, priorities, and attitudes are highly heterogeneous, cultural norms might influence the farmers and the adoption process, they might prioritize their livelihood over profit, and diffusion of information may go slower across the farming population (Llewellyn & Brown, 2020).

### 2.7 Conceptual framework

With reference to the research questions elaborated upon in the introduction, the conceptual model (see *figure 5*) reflects the relationship between the theoretical concepts which are related to the research’s theoretical foundation previously elaborated on. The model illustrates the most important relation of different concepts and how they influence each other. The model comprises two parts connecting to the concept of sustainable intensification of agriculture. The combination of the two components ‘main outputs’ and ‘livelihood enhancement’ ensure an understanding of the effects of the process of sustainable intensification of agriculture on the smallholder farmers.

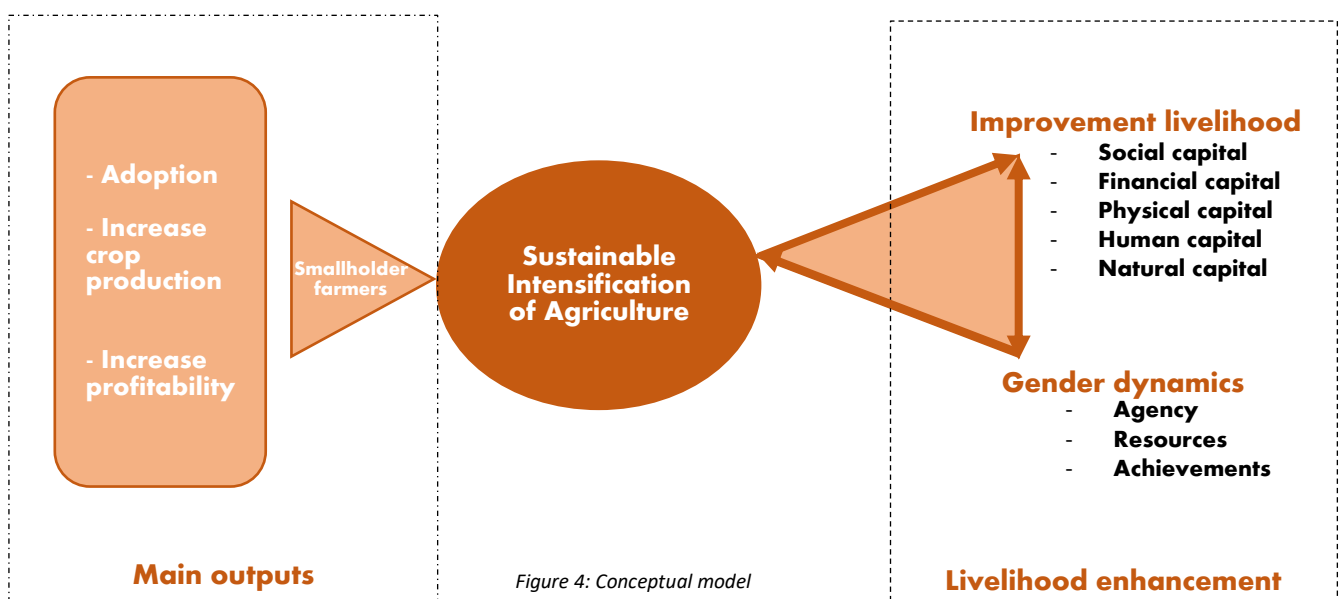


Figure 4: Conceptual model



### 3. Setting the context

#### 3.1 National context of Rwanda

##### 3.1.1 General info

The Republic of Rwanda is a landlocked country located in East Africa. Rwanda shares borders with the Democratic Republic of the Congo, Uganda, Kenya, Tanzania, and Burundi (see *map 1*). In 2020, Rwanda's total population estimated 13 million people, living on 24,670 km<sup>2</sup> of land; 538 people per km<sup>2</sup> (The World Bank, 2020a); (The World Bank, 2021e). With these numbers, Rwanda is globally one of the most densely populated countries. Even the Netherlands has a lower density of 521 people per km<sup>2</sup> (The World Bank, 2022b). Besides, Rwanda's population experiences an annual growth rate of 2.5 percent (The World Bank, 2021c). The increasing population density results in a decrease in available land. Consequently, this land stress endangers energy, water, and food security (Imasiku & Ntagwirumugara, 2019).



Map 1: Map of the Republic of Rwanda  
Source: (World Atlas, n.d.)

The majority of the Rwandan population, namely more than 80 percent, lives in the rural areas of the country (The World Bank, 2020d). Rwanda has an urban population of 17 percent which is globally one of the least urbanised countries (The World Bank, 2020e). This is even well below the average urbanisation rate in SSA of 41 percent (The World Bank, 2020f). However, in the past decade, Rwanda has experienced rapid urbanisation by rural-urban migration and natural growth of the urban population. Scholars expect this rapid urbanisation rate to continue in both the capital Kigali and secondary cities (World Bank Group, 2017).

Over the last two decades, before COVID-19, Rwanda showed a consistent annual growth of around 7 percent (The World Bank, 2020c). The annual growth of other countries in SSA is lower. Unfortunately, poverty is still a significant challenge. According to the Human Development Index, 54.4 percent of Rwanda's population live in multidimensional poverty and 22.2 percent experience severe multidimensional poverty (United Nations Development Programme, 2020). In addition, one-fifth of the total population is food insecure (World Food Programme, 2018); (World Food Programme, 2021). On top of these concerning numbers, COVID-19 caused a dramatic increase of the poverty rate per headcount (Diao, Rosenbach, Spielman, & Aragie, 2021).





### 3.1.2 Institutional profile

To get a better understanding of the institutional profile of the republic of Rwanda, it is essential to know its history. Especially as the current institutional profile is embedded in the historical context of the country.

Since the year 1962, Rwanda operates as an independent state before they were under the colonial power of Germany (1890-1916) and later Belgium (1918-1962) (Manirakiza, Mugabe, Nsabimana, & Nzayirambaho, 2019). Historically, the Rwandan population comprises three ethnic groups Hutu, Tutsi, and Twa (Buckley-Zistel, 2009). In pre-colonial Rwanda, there was one important socio-geographical division, being the Hutu kingdoms and the Tutsi kingdoms (Uvin, 1997). Oral history points out that Rwanda's monarchy was formed in the 11<sup>th</sup> century and existed until late 19<sup>th</sup> century. Uvin (1997) states that the monarchy dominated by a Tutsi king and a predominantly Tutsi court system ruled over most Rwandans. This resulted in a challenging division of power, were both fought to be the central kingdom of Rwanda and overseeing the land. Once the colonial German military power arrived, the kingdoms got forcefully incorporated into what is now known as Rwanda (Uvin, 1997).

According to Buckley-Zistel (2009), the ethnic groups were strongly framed against each other when the colonial powers arrived. Due to the popular racial scholarship discourse in Europe at the time, these three different groups of Rwandans became ethnically categorized. By the strategy of divide-and-rule, these groups turned into homogeneous categories. The Tutsi became the superior race as their racial features (being their nobility and stature), economic and political skills, as well as their physical appearance, had the most affinity to European standards (Lacger, 1959). Consequently, the Hutu and the Twa were treated as second-class citizens. The discrimination translated to less access to social and economic resources, less access to education and almost no access to higher administrative positions (Newbury, 1998). Buckley-Zistel (2009) state that the colonial time has a tremendous impact on the current social, economic, and political structures in Rwanda.

Post-independence, the roles became reversed. A Hutu president argued that Tutsi were foreign immigrants in Rwanda and advocated they had to 'return the country to its owners', meaning the Hutu (Enry, 1994). The first widely observed violence against Tutsi happened in the North between 1959 – 1963, which resulted in many displaced Tutsi seeking refuge in neighbouring countries (Uvin, 1997). Around 1990, another more violent wave of resentment from Hutu against Tutsi had arrived, another period of extreme ethnic divisions and hatred. The main reason was to safeguard the Hutu's political position in Rwanda. Tutsi were again portrayed as foreigners and enemies of the state, while Hutu identified as indigenous and former victims of injustice (Rutembesa, 2002). Via propaganda machines, Hutu were called for action, meaning to exterminate all Tutsi (Chrétien, 1995). In 1994, this resulted in a genocide against Tutsi.

With these main events the genocide often gets explained. However, McDoom (2005) and Strauss (2006) state that the genocide and civil war period was significantly more complex and varied. Therefore, the relationship between perpetrators and survivors was not as straightforward as described above, which makes it extremely complex (Hintjens, 2008). Several scholars, among whom Wallis (2015) and Jones (2021) and a highly controversial BBC documentary (Conroy, 2014), question official accounts of the 'genocide against the Tutsi' and the role of the current President Kagame. The political party of President Kagame, the Rwanda Patriotic Front (RPF), is in power ever since. By shifting the historical genocide narrative, the RPF legitimacy to rule gets questioned. Therefore, Beloff (2021)



claims that the president wants to combat genocide critics and deniers to secure political power. The true version of the past is still contested (Buckley-Zistel, 2009).

Post-genocide Rwanda was not only a time for healing and reconciliation, but also for transforming politically and economically (Noack, 2012); (Goodfellow & Smith, 2013); (Mwongeli Malonza & Andre Ortega, 2020). To achieve this, Rwanda received an enormous amount of overseas development assistance (ODA) to rebuild infrastructure and institutions after 1994 (Ezemenari, Kebebe, & Lahiri, 2008). A couple of decades after the genocide, Ezemenari, Kebebe & Lahiri (2008) state that the total ODA dropped from 95 percent as a share of gross domestic product (GDP) in 1994 to 19.8 percent in 2011. Note, 19.8 percent is still very high, for example Kenya received 7.4 percent of their GDP as ODA in 2011 (The World Bank, 2022a). This large quantity of foreign aid makes scholars debate about the aid dependency of Rwanda (Ezemenari, Kebebe, & Lahiri, 2008); (Collier, 2012).

In the government policy document of Vision 2020, the Rwanda government formulated their main aspirations which are transforming into a 'middle income country' by 2035 and achieve the status of a 'high income country' by 2050 (Rwandan Ministry of Finance and Economic Planning, 2000); (Government of Rwanda, 2012); (Mwongeli Malonza & Andre Ortega, 2020). Since the genocide, Rwanda has experienced rapid development and spectacular economic growth (Manirakiza, Mugabe, Nsabimana, & Nzayirambaho, 2019); (The World Bank, 2021b). Scholars often refer to Rwanda as an economic miracle, but questions get asked how sustainable this growth is (Ayittey, 2017); (Ezemenari, Kebebe, & Lahiri, 2008).

In 2008, the Rwandan government introduced the crop intensification program (CIP) which led, according to the MINAGRI, to a growth spurt in food crops (MINAGRI, 2018). In 2013, the Rwandan government announced to transform the agricultural sector by the National Agriculture Policy led by four pillars. One of the pillars focuses on increasing resilience and sustainable intensification (MINAGRI, 2018). Their vision is: *"a nation that enjoys food security, nutritional health and sustainable agricultural growth from a productive, green and market-led agricultural sector"* (MINAGRI, 2018). This state-led agricultural commitment is created to assist the government in their Vision 2020. Moreover, the government receives a lot of support for this program from development initiatives such as The World Bank's land husbandry, water harvesting and hillside irrigation (LWH) project, USAID, and the Bill and Melinda Gates Foundation (Clay & Zimmerer, 2020).

Besides all the positive comments focusing on the blooming progress of Rwanda, there are also critical notes to it. The government of Rwanda consists of a single-party rule, legitimised by elections. But according to Human Rights Watch (2001); (2017) and Amnesty International (n.d.), Rwanda's elections have been flawed from the beginning and have been associated with disappearances, intimidation and targeted killings. The RPF leaves little to no space for political opposition. Besides, Reyntjens (2004) advocates that Rwandans are well aware of the fact that their civil and political rights are taken away from them and are therefore frustrated, angry and even desperate. In other words, most Rwandans think twice before challenging the remaining power in charge and expressing their views (Amnesty International, n.d.).

### 3.1.3 Agriculture sector

The World Food Programme (2018) refers to agriculture as the backbone of the Rwandan economy. In Rwanda, 62.4 percent of the total population is employed in agriculture (United Nations Development Programme, 2020). This includes any activity in producing goods or providing services for payment in the agricultural sector. The World Food Programme (2018) even states that 89 percent of the rural households in Rwanda practice small-scale farming. However, climate change, droughts, floods, pests, and a limited amount of land suitable for agriculture, continues to make agriculture a vulnerable practice (World Food Programme, 2018).

The service sector dominated Rwanda's GDP in 2020 with 46 percent (see *figure 4*) (Statista, 2021). Second was the agriculture sector, contributed 26 percent to Rwanda's GDP (Statista, 2021); (The World Bank, 2020b). Rwandans consume about 90 percent of the locally produced food, only the produced tea and coffee mainly get exported and account for 70-90 percent of the total export value (MINAGRI, 2009). Besides, smallholder farmers dominate Rwanda's agriculture sector and agriculture plays a significant role in the livelihoods of the smallholder farmers (Nyasimi, Radeny, & Hansen, 2016). Around 62 percent of Rwanda's population is employed in agriculture, this number is even higher when focusing on the female population of Rwanda. Over 70 percent of Rwandan women are involved in farming activities (UN Women, 2018); (The World Bank, 2021a). In the focus region of this research, the percentage of population employed in agriculture is even higher, with 68 percent (National Institute of Statistics of Rwanda, 2012a). Moreover, female participation in the focus region is almost twenty percent higher compared to males (National Institute of Statistics of Rwanda, 2012a).

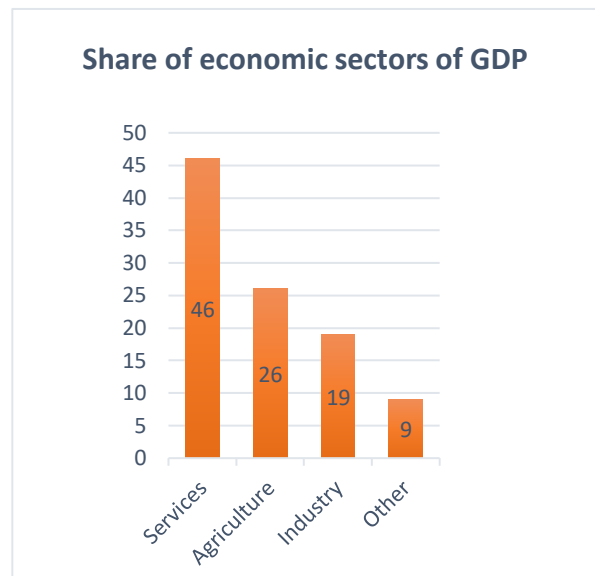


Figure 5: Share in percentage of economic sector of gross domestic product (GDP)

Source: (Statista, 2021); (The World Bank, 2020b)

Climate change influences the agriculture sector in Rwanda (Nyasimi, Radeny, & Hansen, 2016). Based on the ND-GAIN Matrix (2020), Rwanda ranks 15th on the list of most vulnerable country in the world when it comes to climate change vulnerability. Predictions indicate that climate change results in increased temperatures, intensified rainfall, and long dry periods which will cause erosion and desertification. This has disastrous effects on the rural population and agriculture capacity (ND-GAIN Matrix, 2020). Nyasimi, Radeny & Hansen (2016) state that the vulnerability of the agriculture exists due to limited adaptation strategies in combination with little capacity to deal with climate variability. This is due to a lack of both traditional and scientific knowledge and skills enabling the farmer to cope with climate change and variability (Nyasimi, Radeny, & Hansen, 2016). According to Delphy (2018), the focus areas are the main productive districts for Rwanda's potato production due to its high altitudes and favourable climate conditions. Climate change will present challenges for the potato farmers in the mountainous North-West focus area of the country.

In addition to this, Rwanda's agriculture sector faces serious land scarcity (Bizoza, 2014); (Musahara & Huggins, 2005). Due to the rapid population growth and its high density, there is huge pressure on land (Abbott, Mugisha, & Sapsford, 2018); (Musahara & Huggins, 2005). According to



Huggins (2009), this scarcity could even potentially cause instability and conflict in Rwanda, especially because 80 percent of the population depends in some form on agriculture land to secure their livelihood. Besides the shortage of land availability, the agriculture sector of Rwanda also has to deal with land degradation and soil erosion (FAO, n.d.). The Rwanda Development Board (2022) states that 61 percent of the Rwandan soil is fertile and therefore suitable for agriculture. Additionally, around 90 percent of agriculture land lies on slopes which results more easily in erosion, soil loss and a decreased fertility (Kuria, et al., 2019); (FAO, n.d.).

Rwandan women face even bigger challenges when looking at land rights. Land reforms and gender equality are important in post-genocide Rwanda, and they have established great implications regarding women's land rights (Djurfeldt, 2020); (Polavarapu, 2011). In 1999, the Rwandan government passed a series of laws and regulations of equal women's land rights to that of men (Polavarapu, 2011). However, social obstacles appeared in society and certain conservative behaviours prevents women from accessing these land rights (Abbott, Mugisha, & Sapsford, 2018); (Polavarapu, 2011). By law gender equality may be regulated, however in practice men and women are treated equally.

### 3.2 Host organisation Delphy

This research is conducted in collaboration with the Dutch organisation Delphy. Delphy is the lead partner and applicant of the potato value chain project in North-West Rwanda. According to its official website, Delphy is a 'worldwide expert on food and flowers and known as the largest global commercial service provider in the field of cultivation and production knowledge' (Delphy, n.d.a). Their services include crop advice, trainings, and projects to farmers, applied research, agricultural companies, and investors worldwide (Delphy, n.d.a). They have formulated their ambition to contribute to health, food safety, sustainability, and well-being of people on earth. In addition, they want to optimise the worldwide production of food and flowers through development and implementation of (shared) knowledge and expertise (Delphy, n.d.a).

Delphy is based in Wageningen, the Netherlands and operates globally. Based on information on its website of Delphy, they are running several private sector development projects in Africa, all surrounding their expertise in the agriculture sector (Delphy, n.d.b). Out of the 16 active projects in Africa (including the potato project), 11 received finance by Dutch government in the form of grants from the Rijksdienst voor Ondernemend Nederland (RVO) or Nuffic Dutch organisation for internationalisation in education.

While in Rwanda, Lisette Meulman (project manager) and Aimable Uwihanganye (project coordinator) of the potato value chain project of Delphy, supervised the research. Lisette and Aimable were involved in the operational side of the field research as both have knowledge about the research location and have the contacts of the participants for the field work. The outcome of this research is part of the mid-term review of the host organisation Delphy. The RVO requested this mid-term review and is due at the end of July 2022



### 3.3 SDGP potato value project

The project focusing on the increased potato value chain efficiency started on 01/07/2019 and will run till 30/06/2023. Besides the lead partner Delphy, there are five other partners involved: SPF (Seed Potato Fund) Joint Ventures Ltd (Rwandan), Stichting Agriterre (Dutch), Hollanda Fairfoods Ltd (Rwandan), Dodore Kenya Ltd (Kenyan) and the MINAGRI (Rwandan). The project budget equals 5,117,879 euros with a subsidy request of 2,500,000 euros (Delphy, 2018). The RVO of the Dutch government granted the subsidy (Delphy, n.d.c). The financial contribution of the partners (except MINAGRI) was just over 2.6 million euros (Delphy, 2018).

According to internal project documents, the project focuses on inefficiencies in the potato value chain and aims to contribute to strengthening the value chain and improving market dynamics for a food-secure Rwanda. They state that ‘a lack of sustainable agriculture practices, use of low yield varieties and high incidence of pest-related diseases negatively affected the potato production’. They aim to ‘introduce (modern) good agricultural practices, using the expertise of Delphy and Holland Greentech, so potato farmers are able to enhance their agronomic practices’. *Appendix VIII* explains the traditional and intensified potato farming techniques. According to Delphy (2018), the newly introduced agricultural practices are mainly focused on the improvement in yields, introduction of sustainable agricultural practices, prevention of soil depletion, management of climate change, and increase adaptation. Through outgrower schemes with lead and support farmers, the project aims to ‘improve the farmer’s business with improved agricultural practices and business development skills’. The Farmer Field Days and outgrower scheme will be developed with local agronomic support. Every season the involved farmers are invited for pre-, during- and post-harvest Farmer Field Days, these three face-to-face training sessions demonstrate the modern intensified farming technique throughout one farming season.



## 4. Research design and methodology

The research is conducted in Rwanda during a sixteen-week fieldwork period, from February until the end of May 2022. This chapter explains the operationalisation of the concepts, the methodology and the research limitations.

### 4.1 Operationalisation of the main concepts

Based on the most used definitions in existing literature, this research's central and abstract concepts are operationalised into measurable indicators. Three concepts are operationalised in corresponding criteria alongside a selection of indicators. Each of the indicators has an exploring function to shed light on all possible details surrounding the implementation of the intensified farming technique. The indicators drawn from the foundation of literature referred to in the theoretical framework. The indicators are all focused on the end user, the smallholder farmer, who is the research's target group. In *table 1*, each concept is explained by criteria and indicators. This operationalisation is the starting point for the questionnaire and interview guides. The indicators elaborate on the change and influence of the intensified farming technique compared to the traditional way of farming potatoes.

*Table 1: Operationalisation of main concepts*

Concept	Criteria	Indicator
1. Sustainable intensification of agriculture	1.1 The farmers have <b>adopted</b> the intensified farming technique	1.1.1 Adoption rate of cultivating with the intensified technique
		1.1.2 Positive changes regarding the intensified farming technique experienced by smallholder farmers
		1.1.3 Challenges regarding the intensified farming technique experienced by smallholder farmers
	1.2 The farmers who <b>applied</b> the intensified farming technique have an improved output	1.2.1 Impact on the yields experienced by smallholder farmers
		1.2.2 Impact on income experienced by smallholder farmers
		1.2.3 Impact on profit experienced by smallholder farmers
2. Smallholder farmers	2.1 Smallholder farmer <b>characteristics</b>	2.1.1 Age
		2.1.2 Gender
		2.1.3 Estimated field size (in total and specifically for potatoes)
		2.1.4 Members of the family



3. <i>Livelihood enhancement</i>	3.1 <b>Human capital</b>	3.1.1	Change in knowledge about farming potatoes of male/female of the household
		3.1.2	Knowledge regarding the different steps of the intensified technique of farming potatoes
	3.2 <b>Financial capital</b>	3.2.1	Price of required inputs for the intensified farming technique; seeds, fertiliser, pesticide, manure; labour
		3.2.2	Access to finance/loans of smallholder farmers
		3.2.3	Market price for potatoes experienced by smallholder farmers
		3.2.4	Materialisation of income
	3.3 <b>Physical capital</b>	3.3.1	Main source of family income
		3.3.2	Possible change in the diversity of farm produces
		3.3.3	Change in required labour to cultivate with the intensified farming technique
		3.3.4	Access to different markets
	3.4 <b>Social capital</b>	3.4.1	Farm participation (hours of labour of male & female head of household)
		3.4.2	Change in farm participation of male/female
		3.4.3	Financial responsibility (male/female)
		3.4.4	Gained knowledge of male/female
		3.4.5	Decisions-making power (male/female)
		3.4.6	Acceptance of the introduced intensified farming technique
	3.5 <b>Natural capital</b>	3.5.1	Rotation of crops
3.5.2		Quality of potatoes	
3.5.3		Change in use of the amount of required inputs; seeds, fertiliser, pesticide, manure, labour	
3.5.4		Pest and diseases detected in potatoes	

#### 4.2 Research strategy & methodologies

This research applied a mixed method approach. The research strategy consisted therefore of three parts: secondary data, quantitative data, and qualitative data. Structured questionnaires and semi-structured in-depth interviews were the research tools to answer the research questions. The reason for this mixed methodology is that survey provided insights into trends and patterns amongst the large population of smallholder farmers involved in the intensification project. Plus, the in-depth interviews generated more insights into participant attitudes, thoughts, and actions and will therefore be used to explain the trends and patterns found in the survey (Harris & Brown, 2010).



#### 4.2.1 The first phase: secondary data

The first part mainly builds on desk research which was predominantly executed in the Netherlands before starting the fieldwork. The outcomes of the desk research allowed me to develop the chapter literature review with a theoretical framework and the previous chapter reviewing the geographical contextual framework specifically focused on Rwanda. These chapters are put together with secondary data which has been analysed, reviewed, and discussed. This research phase had an exploratory function which was very helpful in getting a better understanding of the meaning and available knowledge about sustainable intensification of agriculture. Besides, by reading secondary data, I could identify the processes related to sustainable intensification of agriculture and develop a clear concept based on existing data.

#### 4.2.2 The second phase: primary quantitative data

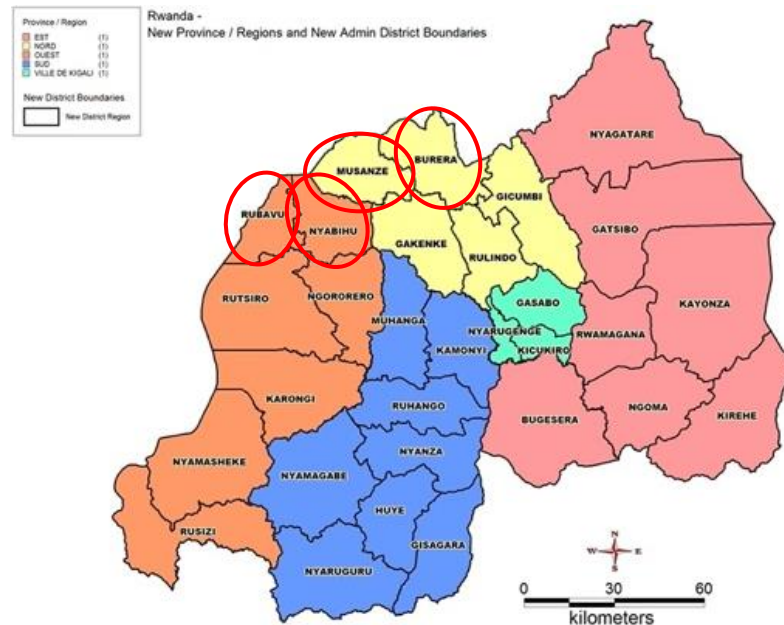
In the second phase, I collected primary data during my fieldwork in Rwanda. This fieldwork started after I arrived in the first week of February 2022. At first, it was necessary and valuable to familiarise myself with the project, the partners involved and to gain a deeper understanding of the culture. Once I settled in and was familiar with the project, the quantitative survey research started with designing a questionnaire.

Before starting the official questionnaires, I conducted two pilot tests. The final questionnaire layout was constructed with feedback from two pilot tests, my supervisor, and the local coordinator of the project. In March, I started with the actual quantitative fieldwork. In *Appendix 1* is the questionnaire added. As the participants do not speak English and my

knowledge of Kinyarwanda was not sufficient, I needed a translator. The translator is from Musanze area and has knowledge about potato cultivation as his mother is a potato smallholder farmer. In total, me and the translator conducted 62 questionnaires. Participants responded to predetermined answers, being multiple choice questions and Likert scales, and a few open questions.

The project focuses on four districts: Musanze, Nyabihu, Burera and Rubavu (see *map 2*). The translator and I travelled by car to the participants to conduct the questionnaires. The travel distance to the participants in Burera and Rubavu was quite extensive, the furthest was a 2,5-hour drive to get to the participants. We were able to conduct around six questionnaires a day.

Survey sampling was, at times, challenging. The sample got taken from participation sheets of the training days (farmer field days) of the project. The participation sheets are handwritten, and the



Map 2: Geographical location of the field research  
Source: (Delphy, 2018)



handwriting of those sheets was not always readable (in *appendix II* is one participation sheet attached). I selected the sample by using the method of cluster sampling. The whole population of smallholder farmers are sub-divided into lead farmers who are connected to support farmers. Each lead farmer links to forty support farmers who get invited to the training days (the Farmer Field Days). The selection process for the questionnaires started by selecting one lead farmer randomly. Connected to this lead farmer is one subgroup of support farmers. The main reason for choosing this sample method is a logistical advantage. The lead farmer and the support farmers all live in the same area. Out of the subgroup of support farmers, five participants got randomly selected. By selecting these participants, gender representation was taken into consideration by dividing the subgroup into male and female and taking the random sample out of these two subgroups. Based on the aim of this research, selecting an equal number of male and female participants was essential.

Every day, we conducted questionnaires with three males and three females (of whom one lead farmer). The translator informed all participants one day prior to the planned visit by phone. Besides, they discuss the informed consent and availability for the next day. If the participant was not available the next day, we randomly picked another participant in the gendered subgroup. A few times, the farmers told us they would be available but cancelled our visit last minute due to other obligations. At that moment we would select another participant connected to the same lead farmer on the spot and call the farmer to check availability. As remote areas in Rwanda do not have addresses, we could locate the farmers by calling them and asking for directions. The overview of questionnaire participants and their characteristics can be found in *appendix III*. Their last names and the region in the districts are deleted for confidentiality reasons.

The length of the questionnaire varied between 20 and 30 minutes. The questionnaires consist of four elements: general information, livelihood activities, changes after joining the project, and looking back and into the future. As the focus of the third section is on the results of the intensified farming technique, participants could only answer if they had applied and harvested the intensified technique of farming potatoes. Out of the 62 questionnaires, 37 participants answered the third section. All the data was analysed quantitatively with the program SPSS. The SPSS outcome is added in *appendix IV* and is elaborated on further in the following chapters. SPSS was the tool to statistically analyse the questionnaire data using cross tables, reliability analyses, correlation analyses, frequency tables and several figures.

#### 4.2.3 The third phase: primary qualitative data

The third phase is the in-depth interviews with smallholder farmers. In-depth interviews are one of the most appropriate methods when seeking information on individual, personal experiences from people about a specific topic (Hennink, Hutter, & Bailey, 2020). The interview guide was determined based on the outcome of the previous research phase and the advice of the local coordinator of the project to take the cultural appropriateness into account. Find the interview guide in *appendix V*. The main aim of the in-depth interviews was to understand and explain the trends and patterns found in the survey and gives context surrounding people's choices and gender dynamics when in the process of sustainable intensification of agriculture. This qualitative method is particularly suitable as talking about gender is considered a sensitive topic (Hennink, Hutter, & Bailey, 2020).

There were two selection criteria with regards to the target group, firstly the smallholder farmer is identified as a lead farmer and secondly the farmer is involved in the project for at least two seasons. Lead farmers are well known in the community and frequently speak with their support

farmers, therefore are more knowledgeable about what influences their fellow community member potato farmers. Especially because the number of interviews is limited, the information coming from the lead farmers is more insightful.

Out of the digitalized list of all lead farmers, I selected participants firstly by cluster sample, divided in four districts and subdivided again by gender. A randomly chosen district was the target location for one day conducting interviews. Out of the lead farmers in that district, I took a random sample out of male and female subgroups. The aim was to conduct three interviews a day for a total of four days, each day we visited another district. However, even when selecting one district, the lead farmers did not live near each other, resulting in a time-consuming logistical plan. In total, we were able to conduct eleven interviews. In *appendix VI*, the list of interview participants and characteristics is added. Again, their last names and the region in the districts are deleted for confidentiality reasons.

The same translator who assisted me during the second research phase also translated during the interviews. Before conducting the interviews, it was important to train and inform the translator how to conduct an interview and discuss the interview guide together. His role during the interview was not only translating what is being said, I expected the translator to take a more active role during the interviews in which he asks the participant to go further into depth and clarify more. This is important for the flow of the interview to the benefit of the participant who felt more at ease when the flow of the interview was like a conversation. During the pilot interview, the focus was to understand the basic steps of interviewing and how the translator and I work together to conduct the interview. The translator called the participants one day before the interview to ask them for consent to participate and inform them about the interview.

The length of the interviews varied between 30 and 45 minutes. I recorded eight out of eleven interviews by phone with informed consent. Meanwhile, during the interviews, I took notes which served as the interview transcripts. *Figure 6* gives an impression of an interview setting in the field. Working with live translations provided me with more time to be able to take extensive notes during the interviews. Once we conducted all interviews, the coding process started.



*Figure 6: Conducting an interview in the field*  
Source: personal photo

I used an indicative strategy for developing codes. The coding was done manually the first step was to categorize and identify the open codes in the relevant data. By bringing all open codes together in an excel overview, I identified overarching axial codes. The coding process of re-interpreting and re-coding was done over several times until no new codes came forward. In *appendix VII*, the code tree is added which provided a valuable overview of the identified codes and the relations between different data foci. The research phases two and three combined, forms the basis for the results chapters of this thesis. In the results chapters quotes of participants are added that have been translated by the translator from Kinyarwanda to English and are quoted verbatim. Quotes are inserted directly and match the wording of the original source.



### 4.3 Validity and reliability

The triangulation by using multiple methods and different data sources as well as connecting existing literature to the findings has a positive effect on the validity and reliability of the data, analyses, and interpretations. The different data gathering methods as the existing data, the quantitative and qualitative research allowed for cross-validation of information. In terms of the secondary data, extra emphasis was put on the use of reviewed academic articles and other official publications. Besides, during the conversation with respondents, regularly they validated the notes which strengthens the credibility. Overall, verifies and explains the interview data the outcome of the survey. Altogether, the data showed a high level of consistency. Lastly, before speaking to questionnaire and interviews respondents, the data collection guides were discussed, finalised, and adjusted together with the local coordinator of the project and by executing pilot tests in the field to ensure local terms were used in the instruments and to ensure relevance and contextual appropriateness. While verifying wording, relevance, and appropriateness with the local coordinator and in the field with pilot tests, possible cognitive dissonance reduces as unfamiliar terms are eliminated and methods are finalised with accuracy (Hennink, Hutter, & Bailey, 2020).

### 4.4 Research limitations

During the fieldwork and during the research process, some limitations came to light which is worth mentioning. It is essential to acknowledge research shortcomings, therefore findings should be interpreted with some caution.

First, a translator was essential during data collection due to the language barrier. Qualitative research with a translator has one disadvantage, some data was inevitably lost in the translation process. It can occur that there is difference between the precise translation or an equivalent meaning to what the participant has shared. In some cases, the translator struggled with translating as some terms have no corresponding word in English. Besides, the process of translating during the semi-structured interviews resulted in less flexibility and spontaneity. Translating an interview on the spot felt at times like pausing the conversation between translator and participant.

Second, the translator can be biased regarding the translations. The translator is a sociable human being and grew up in Musanze district, Kinigi town. Besides, his mother is a potato farmer and joined the project last February as a lead farmer. This provided him with certain practical knowledge about farming potatoes and the project. During the fieldwork, the translator was not familiar with any of the participants. In addition, his mother had only joined the project recently, which decreases potential bias.

Third, the number of respondents in the research is relatively low. In total, the project includes 188 lead farmers who all are connected to 40 support farmers which results in a total of around 7,520 smallholder potato farmers involved in the project. As the sample size is relatively small, this reduces the power of the study and questions the validity. Due to the driving distance, the rural unpaved road conditions during raining season, budget, and time limitations, a larger sample was not possible.

Fourth, the conduction of this thesis research as part of the mid-term evaluation of a development project implemented by a foreign Dutch company Delphy in the Rwandan setting, could result in possible influence on the answers and outcome of the research. Overall, conducting research in more rural communities and being associated with Delphy, the lead project partner, and being a foreign researcher, might have influenced the responses given during the questionnaires and



interviews. It could have translated into a certain carefulness from the side of the participants not to criticize the project. Besides, Delphy hired me as an independent consultant. This may question my positionality as a researcher as I am employed by the lead partner of the project. By setting up precise and explicit rules on how to conduct research and how to interpret the findings and letting this be peer-reviewed by a third party, being the supervisor of the University of Utrecht, the objectivity will increase. Besides, the triangulation of the multiple research methods demands objectivity.

Fifth, this research was focused on one case study in North-West Rwanda. Therefore, comparison between other cases and other countries is not possible. This single case study offered an empirically rich analysis with internal validity. However, there is a concern that this single case study lacks external validity. As a result, the finding cannot be generalized as results for the wider population involved in the sustainable intensification of agriculture.

#### 4.5 Ethical consideration

Conducting research in a developing country raises ethical issues regarding the researcher and the research population. The research population can be identified as vulnerable for various reasons as they often experience disadvantages economically and educationally (Punjwani, 2015). Besides, there are power relations between the researcher and the research population. The research is part of the project evaluation and included only adults. During all research activities, the translator informed all participants beforehand and they had one day to consider their participation. Besides, all participants could withdraw their involvement at any time. An integral component of the data collection was the check by local experts before starting the fieldwork. As a foreign researcher, my aim was to consider and give extra attention to make sure the questions were appropriate to ask.

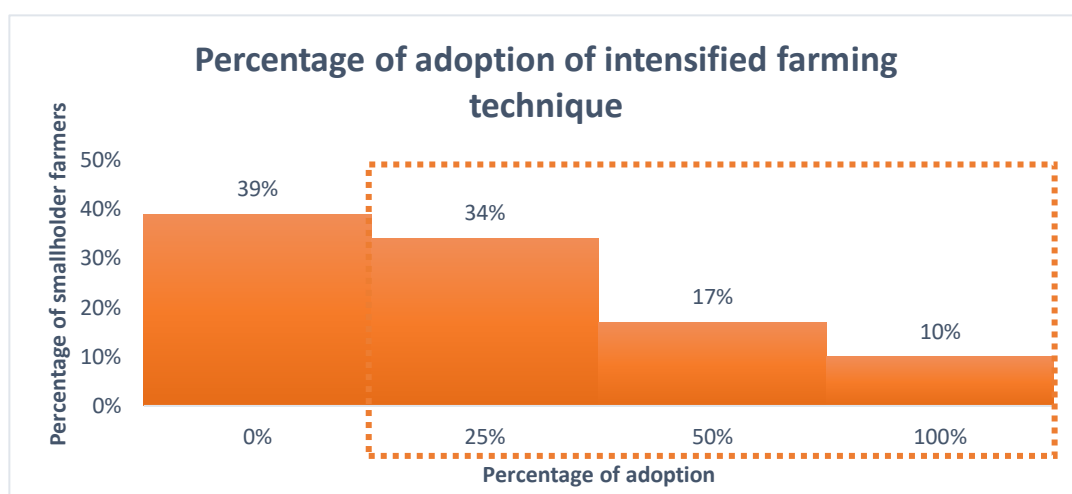
## 5. Analyses - Improved output

In the literature review, it became clear that sustainable intensification of agriculture focuses on improved outputs. The outputs include adopting the intensified technique and an increase in yields, income, and profit. This chapter reports on the findings and connects these findings to the theory found in literature. Note that some of the results return in the next chapter as results can be linked to more than one aspect.

### 5.1 Adoption

One of the objectives is to analyse whether the intensified technique is adopted and to understand the determinants of the adoption decisions. The research object centres the smallholder farmers, and this section focuses on their behavioural practices regarding the practice of sustainable intensification. Based on the results of the research, the factors affecting the adoption of the new technique of sustainable intensification are the (1) farmer's profile and (2) socio-economic factors. The factors affecting the adoption rate connected to the farmer's profile are field size, age, gender, and number of seasons involved in the project. The affecting socio-economic factors include increased need for labour, high product prices for the required items, fluctuating crop market prices and the limited access to credit.

Before analysing the factors affecting the adoption, it is necessary to outline the adoption rate of the smallholder farmers. *Figure 7* shows the percentage of adoption of the new farming technique on their farmland. The findings refer to a percentage of adoption: 100 percent meaning a full adoption of all potato farmland, 50 percent indicating half adoption of the potato farmland and 25 percent a quarter adoption of the new technique in the potato farmland. Altogether, over 60 percent of the participants adopted the new farming technique on their farmland. 10 percent applied the intensified farming technique on all their potato farmland. Just under 40 percent did not apply the intensified farming technique. This adoption rate is higher compared to the estimation indicated by Schut & Giller (2020) where only 11 percent to 14 percent of African smallholder farmers adopt the intensified method. The factors affecting the adoption rate will be explained next.



*Figure 7. - Percentage (%) of farmers adopting the intensified technique on their own farmland. The percentages circled with the dotted line represent the percentage of smallholder farmers who have adopted the intensified farming technique partly (25% or 50%) or fully (100%) on their own farmland. (N = 62)*





- **Farmer’s profile**

The extent to which the new modern technique gets adopted, depends on the farmer’s profile, including the factors of field size, age, gender, and number of seasons involved in the project. These factors influence whether the intensified technique gets adopted by the smallholder farmer.

Table 2. - Total field size \* adoption

		New modern technique size applied (% of total field)									
		0%		25%		50%		100%		Total	
Total fields size	<1 ha	23	45%	17	33%	6	12%	5	10%	51	
	>1 ha	1	11%	4	35%	5	45%	1	11%	11	

The circled information indicates a high percentage of smallholder farmers with less than 1 ha of farmland and have not adopted the intensified farming technique. The second indication shows that the majority of the smallholder farmers have less than 1 ha of farmland. (N = 62)

The first farmer’s profile characteristic is the field size of the household. There is a correlation between ‘the total field size’, ‘seasons involved in the project’, ‘seasons cultivated in the new technique of farming’ and ‘new technique applied in farmland’ (appendix IV, table 1). This correlation indicates that when the total field size of the farmer is larger, the number of seasons cultivated using the new modern technique and the degree of application of the new modern technique to the farmland increases. Table 2 specifies the adoption of the new technique and the total field size. When looking at the total field size of the smallholder farmers, the majority of smallholder farmers cultivate on less than 1 hectare (ha). Besides, a large share of the <1 ha farmers did not adopt the new modern technique of cultivating potatoes. When the field size increases (>1 ha), the adoption percentage increases too. When exploring the reason why the field size affects the adoption of the new modern technique to intensify the farmland production, a cognitive barrier arises based on the interviews. This cognitive barrier connects to the risk that comes with changing the farming method. Adopting a new unknown technique comes with risks that farmers need to manage. Having small farmland (<1 ha) makes the risk of switching bigger, “if the farmer is poor [with small farmland] the risk is too big” (Francois, 55 years). This makes smaller farmers more reluctant to adopt the newly introduced techniques. Farmers with more than 1 ha farmland are more likely to adopt the new technique which contributes positively to the adoption of sustainable intensification of agriculture. Besides, this finding is also in line with the Schut & Giller (2020), who observed that food secure farmers are more likely to apply the new method in their farmland than food insecure farmers. African farmers are more food secure with larger farmland (Bashir & Schilizzi, 2013). Smallholder farmers with smaller farmland generally tend to choose the low-risk option with a short-term return on investment (Verlauwe, et al., 2014). The farmers with larger farmland can take more risks as their food production is secured.

The second farmer characteristic influencing the adoption of the new technique of sustainable intensification is the age of the participant. The variable ‘age’ combined with the variable ‘adoption’ is considered reliable with a correlation coefficient of 0.690, which is

Table 3. - Age \* adoption

		New modern technique size applied (% of total field)	
		0%	25% - 100%
Age	< 25	44%	66%
	26 – 40	36%	64%
	41 – 60	35%	65%
	> 61	60%	40%

The circled percentages highlight the high percentages of the younger- and middle-aged groups who have adopted partly or fully the intensified farming technique. (N = 62)





considered reliable at a confidence interval of 95 percent. This is considered highly reliable and acceptable (*appendix IV, table 2*). *Table 3* indicates that out of all age groups, the age groups <60 years have a higher percentage who adopted the new modern technique of farming compared to the percentage that did not adopt the new technique. Only when looking at the oldest age group (> 61 years) this is different. Participants older than 61 years are more likely not to adopt the intensified technique. This reveals that participants of an older age are more hesitant to get involved with a new farming technique, which negatively effects the adoption of sustainable intensification of agriculture. Most of the young and middle-aged groups have adopted the intensified farming technique. These groups have, generally speaking, an advantage as they are more physically able and more mentally attentive to learn about new methods compared to older farmers (Agwu, 2004).

The third farmer characteristic is gender. While gender does not significantly correlate with the level of adoption, *table 4* shows some interesting insights. Namely, more females have not adopted the new modern technique of intensified farming. In addition, none of the female farmers has fully adopted the new modern technique for their entire farmland. In contrast to 22 percent of the males who have adopted the new technique of farming on their entire farmland. Ndiritu, Kassie & Shiferaw (2014) have researched the gender differences in the adoption of sustainable agriculture intensification practices in Kenya and their results show that socio-cultural inequalities between males and females are the reason for a profound difference in adoption practices. Gender differences, social networks and access in terms of information, knowledge, markets, and services are often culturally defined by gender roles which obstruct women to get involved (Ndiritu, Kassie, & Shiferaw, 2014); (Mulema & Damtew, 2016). This might explain more hesitation for the Rwandan female smallholder farmers choosing not to adopt the new method of farming. This indicates gender constraints in the North-West region in Rwanda. In chapter 6.4, social capital of livelihood enhancement, the gender difference is further elaborated.

Table 4. - Gender \* adoption

		New modern technique size applied (% of total field)							
		0%		25%		50%		100%	
Total fields size	Male	9	33%	9	33%	3	11%	6	22%
	Female	15	43%	12	34%	8	23%	0	0%

This table highlights that a larger percentage of females did not adopt the intensified farming technique compared to males. The second indication reflects that none of the females adopted all (100%) of their farmland with the intensified farming technique. (N = 62)

The last farmer's profile characteristic is the number of seasons farmers are involved in the project. The 'adoption of the new farming technique' is positively connected and significantly correlated to the 'number of seasons involved in the project' (*appendix IV, table 1*). Most farmers who chose not to adopt the new technique are the farmers who recently joined the project. Once the number of seasons increases, so does the adoption rate of applying the new, intensified farming technique. While exploring the reason why the number of seasons involved affects the adoption rate, a social barrier comes to the surface. Namely, a resistance to this intensified technique and participants first wanting to see the improved productivity with their own eyes. Smallholder farmers "just [want] to see first result of the demo plot if the results are what has been told" (Dative, 28 years). Overall, "there is resistance to change because of culture farming technique [traditional way is culture]. People don't believe in learning how to farm; they know, they have done it for a long time and think they know everything" (Isaac, 65 years). The social barrier decreases as the number of seasons involved in the

project increases which increases the adoption rate. Facing the results of the implementation also decreases the social barrier. This shows that the offered face-to-face trainings (Farmer Field Days) and demonstrations trials are effective as the adoption increases by season. These findings agree with the findings of Shikuku (2019) and Yigezu et al. (2018).

- **Socio-economic factors**

Besides the farmer's profile, socio-economic factors do also affect smallholder farmers in adopting the new sustainable intensified farming technique. The socio-economic factors which restrict the smallholder farmers' adoption are the increased need for labour, the high product prices for the required items, decreasing crop market prices and the limited access to credit. All these factors are in line with a lack of financial capital. Besides these restricting factors, another socio-economic factor contributes positively to adopting the new technique: education. The access to information about how to intensify potato cultivation is well-arranged and this appears to be the main reason for participants to join the project towards an intensified method of farming potatoes. *"Best gift is training"* (Diana, 49 years).

The first restricting factor is the increase of labour needed to farm and prepare the farmland. One of the identified challenges by more than half of the respondents is that the required labour increases (*appendix IV, table 3*). It costs more *"time and more labour in [farming the] modern way"* (Theoville, 27 years). On the other hand, *"it need time to get familiar with it"* (Theoville, 27 years), it is an investment of time at the beginning to get familiar with a new method of farming. Increased labour is a common challenge found by other sustainable intensification approaches (Tripp, 2011). De Schutter & Vanloqueren (2011) reject this argument and state that sustainable intensification is highly site-specific and not always requires more labour. In addition, an increase in required labour can also be seen as a valuable contribution to the community, especially when the area has few other employment opportunities (De Schutter & Vanloqueren, 2011). Based on the interviews, labour is plenty available. So, the new technique being more labour intensive, it does not necessarily cause constrain to the new farming technique. However, *"extra cost of labour [as the] modern [method is] more labour needed"* (Deborah, 55 years). This requires more investment capital from the smallholder farmers, which not all smallholder farmers have. The respondents in the questionnaires and interviews had a mix of small (more impoverished) and large (wealthier) farmland. This is the reason why the increased labour gets experienced as a restricting factor for some smallholder farmers.

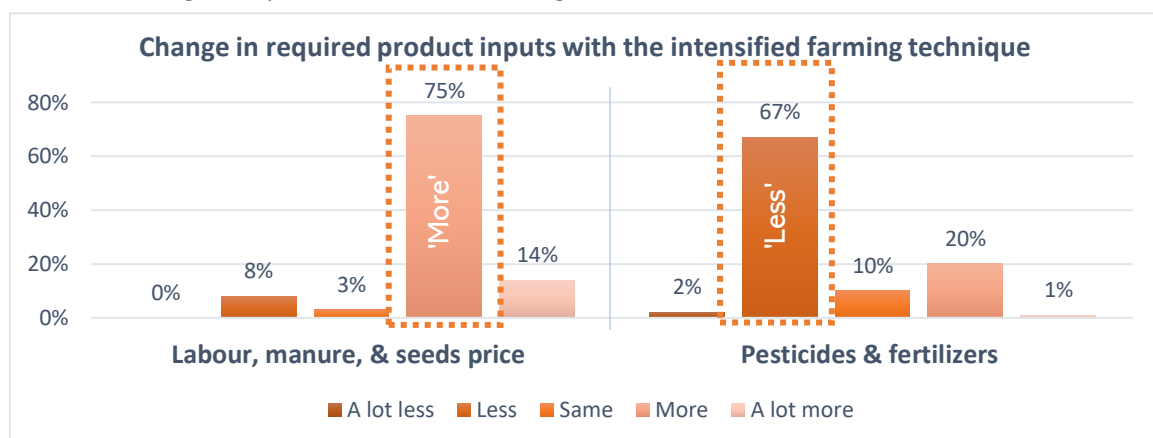


Figure 8. – The change in required product inputs with the intensified farming technique is measured on a Likert scale. The percentage reflect the change in input provide by the smallholder farmers. The dotted circles indicate that 75 percent of the smallholder farmers mentioned that the intensified farming technique required 'more' labour, manure & a higher seed price. On the other hand, claimed 67% of smallholder farmers that 'less' pesticides and fertilisers are used with the intensified farming technique. (N = 37)



The second socio-economic factor restraining the smallholder farmers from adopting the new technique is the prices of the required products. *Figure 8* displays the different needed products and the difference in quantity presented compared to the traditional way of farming. Looking at the left side of *table 8*, demand for labour and manure increased and seed prices raised. In contrast to the right side of *table 8*, pesticides and fertilisers are required less because of the new intensified technique of farming. Still, the price of these pesticides has more than doubled, and access is difficult. In addition, fertilisers are costly and unavailable. Overall, it can be said that the new sustainable intensification farming technique requires more investment for the required products. Due to the market and the required products, which have increased in quantity and price, smallholder farmers are constrained to achieve a sustained adoption (Harris, 2019). In chapter 6.3, this challenge of physical capital gets explained in more depth.

The third socio-economic restriction is the fluctuation of the market price for potatoes. The interviews clarified that the price of the potatoes on the market is unstable and fluctuates throughout the season. The lowest price occurs just after harvest, “*more potatoes available and few demands equals a price low*” (Isaac, 65 years). In other words, the potato market price drops due to the increase of available crops versus the unchanged Rwandan demand. Besides, Rwanda has a relatively insignificant potato processing industry. Haverkort, Woldegiorgis, van Koesveld, Ntizo, Wustman & Zhang (2015) explain that no large international processing companies are based in Rwanda as there are no large areas of irrigated land available, guaranteeing year-round production of potatoes with a quality consistency for the needed final product. If Rwanda had potato processing factories, this would create added value throughout the whole supply chain and farmers would be less dependent on domestic consumption. Expanding the Rwandan potato sales market will also have an effect on the potato output price which will become more stable (Haverkort, et al., 2015). As the new technique requires more investment and the market price turns out not favourable for the farmer, the result is a financial loss. The unstable potato market price is a risk for farmers and makes them more hesitant to invest.

The last socio-economic factor is the limited access to finance for smallholder potato farmers. “*Access to finance is important to get access to all needed items*” (Theoville, 27 years). According to Abebe, Bijman, Pascucci & Omata (2013) and Pan, Smith & Sulaiman (2018) is experiencing credit constraints a common reason why farmers cannot adopt the intensified method of farming. Besides, the combination of the price increase for the required products and the unstable potato market price makes banks hesitant to grant loans to smallholder potato farmers. Almost half (48 percent) of the farmers said they do not have access to finance. Even more, there is a significant correlation between ‘the challenge of not having access to finance’ and ‘the willingness to learn how to get access to finance’ (*appendix IV, table 4*). This means that when access to finance is a challenge, the number of people who want to learn about finance increases. In other words, farmers who lack the financial capital for investment experience limitations in access to finance and thereby are restricted to start adopting the new farming technique.

## 5.2 Increased yields, income, and profit

The participation of the smallholder farmers is mainly determined by the profitability of the sustainable intensification production. Especially small farmers seek direct incentives out of their agriculture practices, as they are more dependent on their farm produces (Xie, Huang, Chen, Zhang, & Wu, 2019). Improving yields, income, and profit are priorities for the smallholder farmers in the process to sustainable intensification of their agricultural land. Based upon the results out of the research, yields and income have mostly increased, however the increase in profit is less obvious.

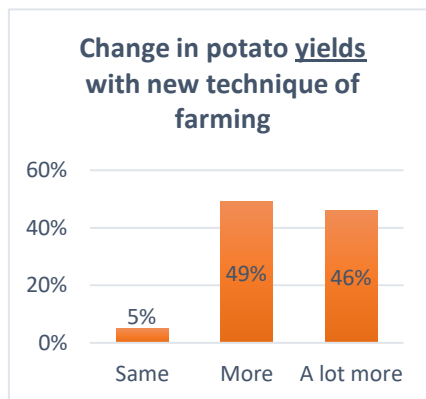


Figure 9. – The change in potato yields is measured on a Likert scale indicated by the percentage of the frequency of the answers of the smallholder farmers. (N = 37)

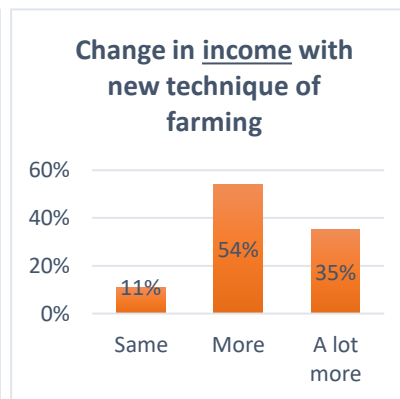


Figure 10. - The income is measured on a Likert scale indicated by the percentage of the frequency of the answers of the smallholder farmers. (N = 37)

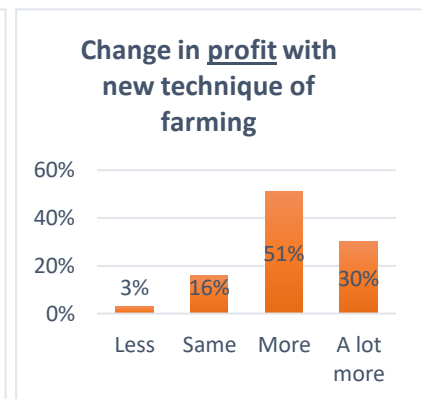


Figure 11. - The change in profit is measured on a Likert scale indicated by the percentage of the frequency of the answers of the smallholder farmers. (N = 37)

The variables ‘yields’, ‘income’, and ‘profit’ are with the new technique of farming regarded as reliable. A Cronbach’s Alpha score of 0.910 reflect these variables internal consistency (*appendix IV, table 5*). Overall, the outcome of the intensification process for participants when looking at the yields (*figure 9*) and income (*figure 10*) are very positive. Most farmers have experienced more or a lot more yields and income from the new technique of farming potatoes. However, when looking at the profit (*figure 11*) generated out of the new technique of potato farming, the answers became more diversified. The percentage of profit that had stayed the same has almost doubled compared to the ‘yields’ and ‘income’ and a small percentage of participants have even experienced a ‘loss’ in profit since the start of the project. When exploring this remarkable outcome during the interviews, it became clear that the reason for the loss in profit has two causes. Firstly, “fertiliser and manure and seeds are expensive and as a result less profit” (Emmanuel, 50 years) and in addition “you need more [inputs] with the new technique of farming” (Deborah, 55 years). Secondly, there is an “unstable price of potatoes in the market” (Deborah, 55 years), besides the “crop is not able to be conserved for a long time” (Diana, 48 years). Not experiencing a profit at the end of the season “can be the reason to stop and not adopt, needs to be profitable to start” (Deborah, 53 years). Achieving profits in the current economic settings is challenging and relatively difficult. The varying prices uphold a considerable risk (Schut & Giller, 2020). In the end this might mean that Harris (2019) and Schut & Giller (2020) are right and the increase in profit is too marginal and will not lift these smallholder farmers out of poverty.

Another interesting finding is that over half of the farmers (51 percent) chose to increase the plot size for the cultivation of potatoes after starting the project. When the plot size for potatoes changes, the potato yields, and income also changes as these variables of ‘plot size for potatoes’, ‘potato yields’, and ‘income from potato farming’ correlate significantly (*appendix IV, table 6*). This indicates a positive effect for the farmer that when the plot size for potatoes increases, the potato yields go up and the income increases too. The main focus of the “*training [is] about farming more potatoes on small land but now they focus [more] on one crop, and they want to get more crops [yields], so they focus more on one [produce]*” (Emmanuel, 50 years). Nonetheless, this does influence the diversification of the farm production. Kuyah et al. (2021), Liao & Brown (2018) and Verlauwe et al. (2014) report that a less diversified production system increases the risks associated with monocultures, like the risk of income instability. More details regarding the diversification in chapter 6.3, the physical capital of the smallholder farmer.

Altogether, when the variables of yields, income, and profit get transformed into a combined variable of the overall improved output (*see figure 12*), the Likert scale ‘more’ and ‘a lot more’ represent almost 90 percent of the respondents. This instigates that the overall output has increased and improved due to the intensification of the technique of potato cultivation. However, for some smallholder farmers involved it has not impacted their outputs and for a couple of smallholder farmers the intensified technique has resulted in less outputs.

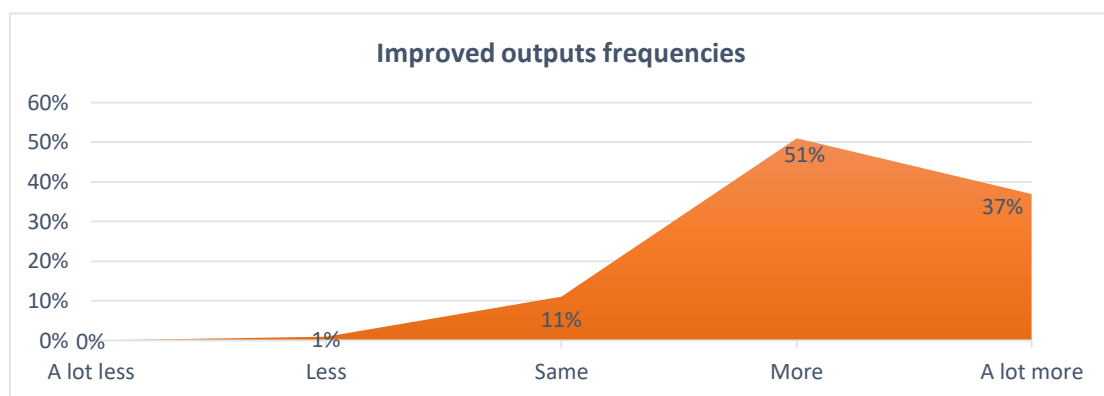


Figure 12. – The overall improved outputs are measured on a Likert scale indicated by the percentage of the frequency of the answers of the smallholder farmers. The right side of the figure, ‘more’ and ‘a lot more’ are the more regularly chosen answers. (N = 37)

### 5.3 Concluding remarks

The analysis of the improved outputs underlying sustainable intensification of agriculture based upon the data from the survey and interviews provides a comprehensive picture of the intensified way of farming potatoes in North-West Rwanda. The findings indicate that the project enables farmers to improve their farm outputs which means the farmers can achieve an increase in yields, income, and profit. In addition, the high adoption rate shows the willingness of the farmers. However, the path to adopting the new technique seems to uphold a certain dependency. As the intensified technique is financially challenging and labour intensive, the required unavailable products are often costly, and the market price is unstable. Plus, external finance is inaccessible for most potato farmers. The project aims to ‘improve the farmer’s business with improved agricultural practices and business development skills’ for a ‘long-term sustainable income for potato farmers’ (Delphy, 2018). These aims, expressed by the project initiators, suggests that empowering farmers’ business is equal to achieving a long-term sustainable income. Above all, the project aims are not focused on profit but a sustainable income.



The assumption behind a sustainable income suggests that the objective is to have an income which is consistent and steady over time. However, ultimately the profitability of intensification of agriculture will determine whether smallholder farmers adopt the new intensified farming method. Upgrading investment is for smallholder farmers not always the best pathway to greater profit and the main reason is the rise in costs. Similarly, Gneiting & Sonenshine (2018) report that the costs of investing in sustainable certification for smallholder farmers as an upgrading strategy for their business often do not match the benefits. The current economic setting constraints smallholder farmers and could turn out to be a bottleneck to the long-term adoption of the 'improved agricultural practice'. Besides, there is social resistance towards the new intensified technique which makes farmers more hesitant to adopt the technique.

Furthermore, the findings of this research confirm the heterogeneous nature of smallholder farmers. The diverse farmer profile and the personal socio-economic factors translate into many pathways to adopt and practice the sustainable intensified method of cultivating potatoes. Adopting a new farming technique brings along risks and to be able to cope with these risks, farmers take rational decisions based on their personal circumstances. Rwandan smallholder farmers all have a different starting point which determines the outcome of the intensification process.

Overall, it can be said that the intensified method does pay off in terms of yields, income, and profit for the majority of involved smallholder farmers. At the same time, smallholder farmers experience economic, cognitive, and social barriers while starting and continuing the process of sustainable intensification of their agricultural land. The impact of these barriers varies from farmer to farmer and depends on the farmers and the farms' characteristics.



## 6. Analyses - Livelihood enhancement

The sustainable intensification of agriculture focuses on enhancement of livelihood for the smallholder farmers involved. To determine in what way the livelihood of the smallholder farmers in North-West Rwanda are affected by the intensification process of their potato cultivation, an analysis per livelihood capital is performed. This is relevant as sustainable agriculture practices are supposed to be in line with a positive impact on the livelihood capital and thereby contribute to a better livelihood. In contrast, unsustainable practices deplete livelihood assets and do not contribute to a better livelihood. During the extensive analysis of the livelihood capitals, extra emphasis will be on the gender aspect of the different livelihood capitals. The presented results and the concluding paragraph are connected to the finding and linked to academic literature.

### 6.1 Human capital

The first out of five livelihood capitals is human capital. Human capital captures the skills and knowledge of the farmer to manage their farm. The newly introduced farming technique influences the human capital of the smallholder farmers' livelihood. Their human capital gets influenced by an increase in knowledge. Out of the gathered data appears that the main reason for farmers to join the project is to increase their knowledge about farming potatoes, "*develop the community by spreading the knowledge*" (Xaverine, 48 years). Besides, participants liked to gain knowledge while being involved in the project. Moreover, there is a correlation between 'knowledge being the reason to join the project' and 'gaining knowledge being the chosen aspect of the project that participants liked the most', with a significance of .006. Furthermore, the participants claim that the head of the household has gained knowledge because of the project, both male (*figure 13*) and female (*figure 14*) have increased their knowledge about farming potatoes. The constraint that Harris (2019) mentioned about poor access to knowledge is not applicable to the smallholder farmers involved in this research. In contrast, the project cannot involve all potato farmers in North-West Rwanda. Knowledge is not available to all potato farmers in the region and is exclusively available to farmers involved in the project.

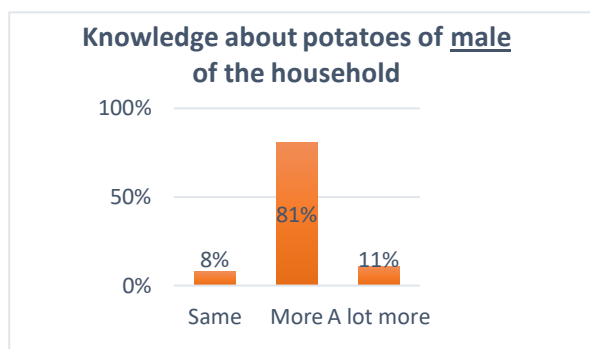


Figure 13. – The change in knowledge of the male of the household is measured on a Likert scale indicated by the percentage of the frequency of the answers of the smallholder farmers. (N = 62)

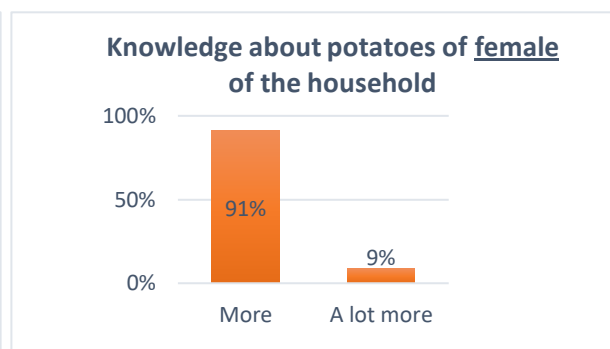


Figure 14. – The change in knowledge of the female of the household is measured on a Likert scale indicated by the percentage of the frequency of the answers of the smallholder farmers. (N = 62)

Some smallholder farmers did not mention all required steps to the new technique of cultivating potatoes. *Figure 15* provides an overview of the steps and the frequencies of the mentioned steps. The step of 'measuring the distance between the seeds', 'applying rotation', and 'selecting quality seeds' were not mentioned by most of the participants. This questions the correct application

and full adoption of the new intensified technique of cultivating potatoes. The participants of the interviews shared why smallholder farmers did not follow all steps. The main reasons are that “*some [farmers] can’t add that step because the access to what they need is too difficult*” (Xaverine, 48 years) and it “*depends on the finance if they [the farmers] can pay for the input*” (Isaac, 65 years). On the other hand, it could also be that farmers emerged the traditional knowledge of potato farming with the modern, intensified technique of farming potatoes. Hushna et al. (2014) describe the emergence of modern knowledge and local wisdom as the goal when transferring knowledge in a development process. But the project is a top-down process whereby a new method of farming gets introduced by smallholder farmers who adopt and apply the new technique. During this development process, local values and practices are highly vulnerable and this could lead to a select adoption of the new intensified method (Vanclay & Lawrence, 1994). During the data gathering, participants could also have been nervous and forgot to mention some of the steps.

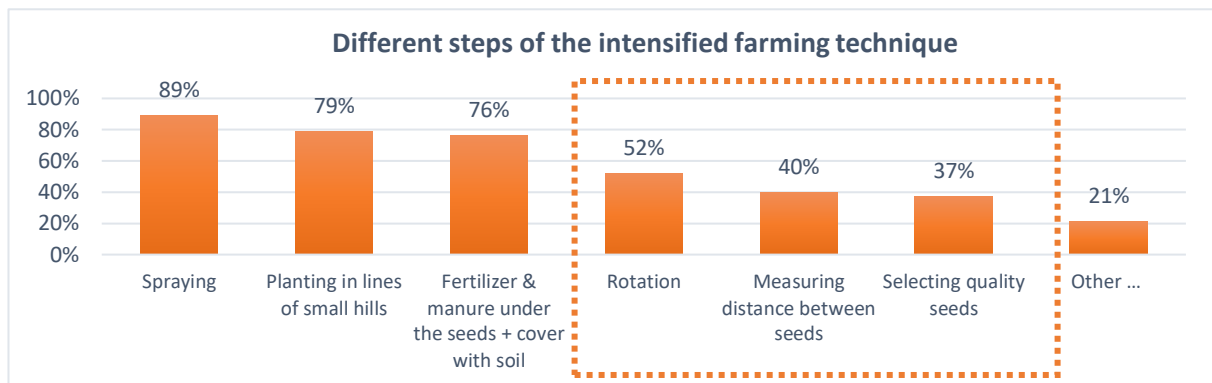


Figure 15. – Presentation of the different steps of the intensified farming technique. The percentage is the frequency the smallholder farmers mention the step, participants could provide multiple answers. The highlighted section includes three relevant steps for the intensified method that were often not mentioned by smallholder farmers. (N = 37)

With the gained knowledge of the farmers due to the project, the interviewed farmers indicated that they are convinced that the new technique will continue in the future. Besides, 97 percent of the respondents want to start or continue with the new technique and would recommend the new technique to others. The main reason for continuing with the new technique is that “*they [the smallholder farmers] will produce more yields, [is] more productive, so they will continue*” (Diana, 48 years). When mentioning the unstable market price for potatoes, a valuable argument came to light: “*if you harvest a few on the unstable price, at least you have a bigger production with the new technique*” (Jean Bosco, 35 years). Overall, the smallholder farmers assure a long-term adoption of the new intensified farming technique.

## 6.2 Financial capital

The second livelihood capital is the financial capital which refers to the available financial resources a farmer may or may not have. The newly intensified farming technique challenges farmers on their financial capital by (1) the access to finance and (2) the materialisation of income.

- **Access to finance**

Access to finance is a challenge for smallholder farmers, as briefly touched upon in relation to the socio-economic factors. Access to finance is important to purchase all required items to start, continue farming or extend the farm activities. Almost half (48%) of the participants said not to have access to



finance or loans. When exploring the reason for not having access to finance, a surprising clarification came up, *“farmers fear to get a loan”* (Theoville, 27 years). This fear gets caused by the *“unstable market of potatoes and [which causes] fear not to be able to pay back [the loan]”* (Theoville, 27 years), *“information about loans is lacking”* (Wensisilas, 50 years) and *“the risk of losing land is high [land is the guarantee to receive a loan]”* (Xaverine, 48 years).

Especially due to the unstable potato market price, financial institutions are more hesitant to give out loans, but also farmers are aware of the risks that come with loans. Besides, *“limited land is not enough to get loan because your grant is too small, unstable price because when receiving loan bank start the count [unstable market price make bank hesitant] and when you can’t repay after harvesting the bank will sell your ground”* (Dative, 28 years). This financial risk makes farmers fear getting loans from the bank. As Dative explains, losing farmland to be able to pay off the loan is a reality and a smallholder farmer without farmland will not be able to sustain themselves.

The Government of Rwanda recognises the limited finance access of smallholder farmers (MINAGRI, 2018). The agricultural department of the Rwandan government reports that the limited access to finance restricts many smallholder farmers from buying inputs, animals, land, extension services, irrigation, insurance, and several other production factors. In fact, they refer to finance as the core of increasing agricultural productivity (MINAGRI, 2018). Kassie, Teklewold, Jaleta, Marenny & Erenstein (2015) claim that smallholder farmers who experience credit constraints are less likely to adopt an intensified method as most adoptions require purchased items. So, not having access to finance can be a bottleneck to the adoption of the introduced intensified farming technique to increase their agriculture productivity. Without finance, smallholder farmers rely on the limited funds to start or continue the intensification of their farm production.

- **Materialisation of income**

As a result of the intensification process of the new technique of farming, the smallholder farmers stated to have an increased income and profit (chapter 5.2). A growth in farmers’ income and profit means an increase in financial capital which can materialise to sustain a better livelihood for the smallholder farmer. However, it is up to the smallholder farmer how to spend the money.

Out of the farmers who experienced an increase in income, thanks to the new technique of cultivating potatoes, we asked about what they had decided to spend the extra money on. *Figure 16* points out where the participants chose to spend their increased income. The smallholder farmers spend the most money on the continuation of the farm, such as buying livestock, extending their farmland, and purchasing better-quality seeds. Smallholder farmers *“expect to get more profit when improving their farm more”* (Dative, 28 years). Besides, *“especially farmers who didn’t use manure because didn’t have [livestock], buying livestock helps good [to be able to sustain the farm and continue with the new method of farming]”* (Diana, 48 years). The Rwandan Government agriculture department (2018) reports that the cause of low levels of profitability and productivity of smallholder farmers is related to land fragmentation (small farm size). They state that *‘plots are often too small to produce a marketable surplus to invest in future production’* (MINAGRI, 2018). With the process of intensification and the increase of profitability, it explains that the smallholder farmer aims to increase their plot so the produces can increase and be more sustained for future production.

Overall, are households of the smallholder farmers highly heterogeneous in terms of their spending habits. Smallholder farmers spend the increased income on varied categories. There is no convincing anonymous answer to the choice how to spend the increased income.

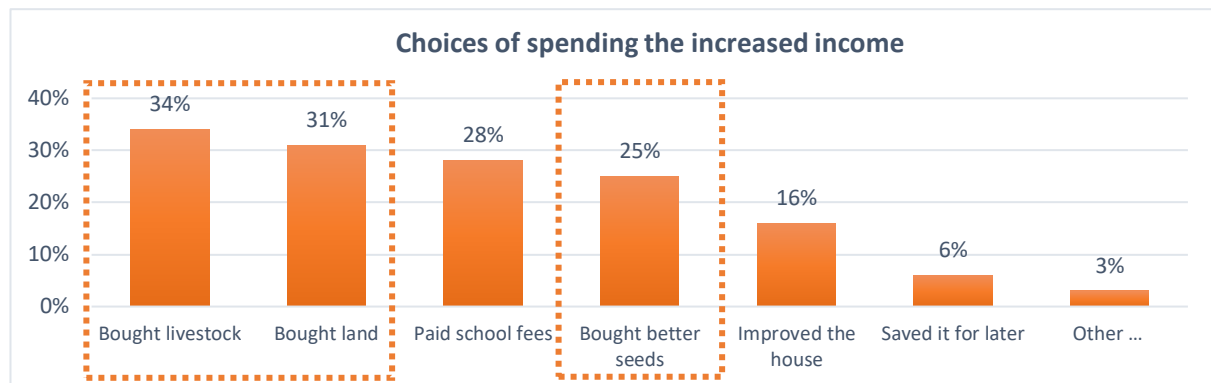


Figure 16. – The decision of smallholder farmers to spend the increased income on is presented in this figure. The frequency of the answers of the smallholder farmers represents the percentages. The circled information are the three variables all in line with improving the farm. (N = 37)

### 6.3 Physical capital

The third livelihood capital is physical capital. Physical capital captures all the required goods to enable farmers to function more productively and meet their basic needs. Inadequate assets can leave households in a vulnerable position. Farmers' physical capital gets affected by the new technique of farming when looking at (1) the diversification of the farm production, (2) the input of required items and (3) the access to the market.

- **Diversification of farm production**

While analysing the data of the questionnaires, it appeared that more than half of the smallholder farmers had changed their farm produce to less different produce, see *figure 17*. Also, there is a correlation between the following three variables: 'produce changes', 'the number of seasons involved in the project' and 'the number of seasons cultivated with the new technique'. Both variables connected to the change of produce have a negative correlation (*appendix IV, table 7*). In other words, this means that when the number of seasons involved in the project or the number of seasons cultivating with the new technique increases, the production of crops becomes less diversified.

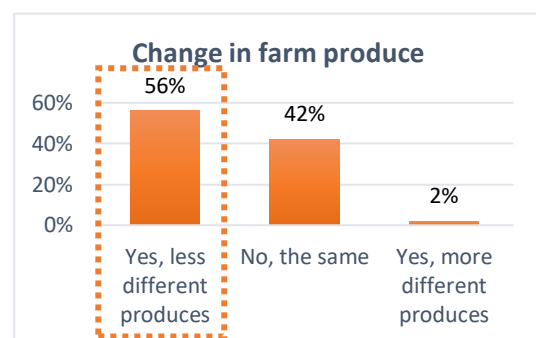


Figure 17. – The percentage of the change in farm produce reflects the frequency of the answers of the smallholder farmers. Most answers indicated a 'less different produce'. (N = 62)

In line with the above, when specifically looking at whether the 'field size of cultivating with the new intensified technique' influences the 'diversification of the farm produce', a similar interesting result occurs. There is a correlation between two variables with a significant negative level of .474 (*appendix IV, table 8*). In other words, this means that as the field size with the new technique increases, the farm produce becomes less diversified. Especially because over half of the smallholder farmers have mentioned to increase the plot size for the cultivation of potatoes (chapter 5.2).



Therefore, when the plot size for potatoes grows, there is less space for different crops which means the variety of produce decreases. This is in line with this analysis focusing on the decrease in the diversification of farm production.

When exploring the reason for this change in farm production, it became clear that most farmers were positive about the change to less diversified farm production. The smallholder farmers mentioned, *“they [the smallholder farmers] just want more money and more profit”* (Jean Bosco, 35 years) and *“more [potatoes] is good in this region as this region is known for [the potato production]”* (Theoville, 27 years). The participants refer to the financial benefits of earning more money. Besides, the North-West region in Rwanda is known for the cultivation of potatoes which is positive for the area when more potatoes get produced. These findings indicate that the potato farmers move toward a monoculture instead of diversified traditional farming. Hereby is modern knowledge leading and the traditional method less relevant. Also, other crops are needed *“at home for own consumption”* (Dative, 28 years) which eventually means that farmers purchase more products from other farmers.

Three farmers acknowledged the risk that comes with less diversified farming. They mentioned do *“not [put] all eggs in one basket”* (Patricia, 53 years) and *“just [focusing on] potatoes is risky as today you do get the [improved] yields but tomorrow maybe no”* (Wensisilas, 50 years). Converting to a more monoculture increases the risks of income stability (Liao & Brown, 2018); (Verlauwe, et al., 2014). This risk occurs when the harvest fails. Concentrating all efforts and resources on one crop can mean there is no other income source available which makes the farmers more vulnerable and could turn out in a disastrous result (Van Rijn, Burger, & Den Belder, 2012). On the other hand, the CIP of the Rwandan Government aims to install a shift in land use strategies from subsistence agriculture where farmers grow food crops for themselves to the production of monocropping selected for the export value (MINAGRI, 2011). Besides, within SSA there are studies performed in Malawi and Rwanda that report an increase in yields and improved biodiversity from intercropping compared to monoculture production (Isaac, Snapp, Chung, & Waldman, 2016); (Snapp, Blackie, Gilbert, & Kanyama-Phiri, 2010). Andres & Bhullar (2016) claim that the conventional process of intensification of monocultures is highly productive for the short-term however, lowering diversity can cause crop failure in the long-term. Despite the intercropping strategy is highly discouraged by the Rwandan Government as it is not commercially feasible (MINAGRI, 2011).

Another argument against the less diversified farm production is the impact on the soil quality. *“Big challenge who farms potatoes only [and who does not rotate] is that soil gets degraded, and the result is not to get more [potato yields] crops in the long-term. Better to do rotations at the farm [to keep the soil healthy]”* (Emmanuel, 50 years). The research of Dahal, Sitaula & Bajracharya (2007) in Nepal experienced land degradation and fertility losses due to the sustainable intensification of agriculture. Monocropping needs to include crop rotations to reduce the risk of land degradation (Dahal, Sitaula, & Bajracharya, 2007). In addition, *“farming more potatoes need [to] be matching with the market”* (Diana, 48 years). The potato market is already unstable at harvest due to the high increase of available potatoes. The potatoes production needs to get sold and farmers need to be aware of overproduction while the domestic market demand does not increase.

- **Inputs of required items**

The physical inputs, required to follow the new intensified farming technique, are a challenge for the smallholder farmers involved in the intensification process. The necessary items are quality seeds, pesticides, fertilisers, manure, and labour. As discussed in chapter 5.1, the required products cause a

socio-economic restriction adopting the new technique. Besides, these required items influence the physical capital of smallholder farmers as the input to the potato cultivation process has changed. *Figures 18* provide an overview of the change in the amount of the required inputs for the intensified farming method of cultivating potatoes. Verlauwe & Dobermann (2020) claim that sustainable intensification of agriculture in SSA typically includes an increase in input use and an increase in labour productivity.

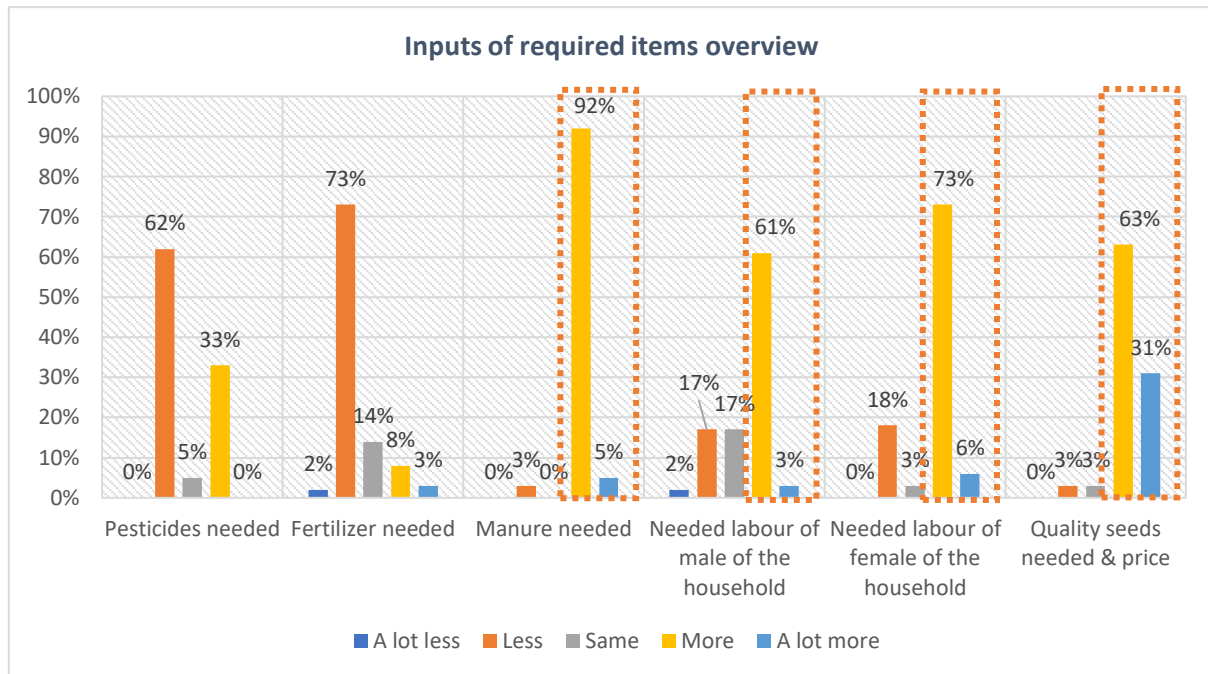


Figure 18. – The change in required product inputs with the intensified farming technique is measured on a Likert scale. The percentage reflect the change in input provide by the smallholder farmers. The dotted circles indicate the items which require ‘more’ or ‘a lot more’ input. (N = 37)

Smallholder farmers experience challenges when looking at the collective results. The newly introduced farming technique requires an increased need for better seeds, an increased need for labour and an increased need for manure (see *figure 18*). When exploring the reason behind the increase in the quality seeds, it became clear that the smallholder farmers experience a challenge with getting access to quality and new potato seeds, “good seeds are expensive and hard to find” (Wensisilas, 50 years). The main reason for the high price and difficult access is because the “producers of potatoes seeds are only a few” (Diana, 48 years) and in addition it is a “monopoly market for SPF” (Jean Bosco, 35 years). The company named SPF (Seed Potato Fund), partly owned by the Rwandan government, has a monopoly on the potato seeds supply in Rwanda. SPF seeds are not available in all districts as the location of the greenhouses, where seeds are produced, stored, and sold, are limited. This means the distance between quality seeds and farmers increases, predominantly the rural locations. For these farmers, quality seeds from SPF are inaccessible and expensive. In fact, almost half of the smallholder farmers (49 percent) find it challenging to find good quality seeds and over 60 percent of the smallholder farmers want to learn how to produce new seeds.

Besides, the new technique of farming potatoes needs more manure. For farmers with livestock, this is not a challenge. On the other hand, farmers “without livestock [it is a] big challenge [to get] manure” (Xaverine, 48 years). Manure can be bought from other farmers, but it depends on the region if there is enough available and how costly it is. Besides, smallholder farmers mentioned





that because *“agro-dealers [farmer shops] are empty of fertilisers so price goes up too of the manure”* (Wensisilas, 50 years). So, the price of manure is affected by the shortage of fertiliser as it is used as a replacement by farmers. When fertiliser is not accessible, the demand for manure increases, and so does the price. Efficient use of external inputs can increase crop production, but Verlauwe & Dobermann (2020) mention that farmers can also get addicted to the use of products. Other agricultural development all over the globe demonstrate that during the first two decades of agriculture intensification crop, production was largely driven by using fertilisers. However, according to the Integrated Soil Fertility Management (ISFM), external inputs are site-specific, and using organic input can result in better soil dynamics (Vanlauwe & Dobermann, 2020). As the findings suggest, the intensified method requires more manure, an organic resource, and less inorganic fertiliser which helps to maintain soil fertility (Cassman & Grassini, 2020).

Furthermore, for the new technique of intensified farming is more labour required. *“Labour is easy to find but cost money”* (Xaverine, 48 years). *“Price [of labour] depends on season and sometimes expensive”* (Emmanuel, 50 years). Thus, the price fluctuates and during the weeks when farmers require extra labour, during planting or harvest, the demand for labour increases and so does the price. Dahlin & Rusinamhodzi (2019) point out that the process of sustainable intensification of agriculture often experiences a serious challenge due to a lack of labour in SSA, plus most smallholder farmers do not have access to labour-saving technologies. Fortunately, Rwanda is densely populated which ensures sufficient access to labour.

In contrast to the increase in the use of manure, labour, and seeds, decreased the use of pesticides and fertilisers (see *figure 14*). Unfortunately, there are *“no fertiliser on the market, the few that is there is very expensive”* (Diana, 48 years) and *“access [to pesticides] is okay but higher price, [the market] doubled it”* (Deborah, 55 years). The interviewees explained that Rwanda depends on the import of pesticides and fertilisers and does not manufacture them domestically. Besides, the regulations on the import of pesticides and fertilisers are strict and only a few types are allowed in the country. With less availability, the price increases and the farmers cannot explain why it is unavailable. Some farmers guessed that the *“price [is] high because of Ukraine war maybe”* (Isaac, 65 years).

Overall, is there a decrease in the use of inorganic inputs (pesticides and fertilisers, see *figure 14*). Schut & Giller (2020) highlight that smallholder farmers in SSA often overuse inputs and overload the system by using inappropriate nutrients in the fertilisers or eroding the soil fertility by ‘soil mining’. The findings suggest that the smallholder farmers were indeed overusing fertilisers and pesticides as the use has decreased. The project transfers knowledge to local agronomists who know a suitable and balanced composition for proper field management. The field management has improved as the smallholder farmers use fewer inorganic inputs and more organic inputs.

- **Access to the market**

Farmers need market access to purchase the required inputs and sell their crops. When focusing on where potatoes get sold, 51 percent of the respondents said to sell their harvest to the cooperative. *“Cooperative [is the one] who buys potatoes and sells them elsewhere”* (Diana, 48 years). So, the cooperative finds markets to sell the potatoes. Especially for *“small farmers need to collect for cooperative, big farmers take the crops to Kigali themselves. Kigali is best market [to sell potatoes for a good price]”* (Jean Bosco, 35 years). This collective organisation searches for the best market, which is often further away, to ensure a better price for the smallholder farmer who is financially not able to organize it by himself or herself. Harris (2019) reported this constraint of accessing the market as the



main constraint for smallholder farmers to achieve sustained adoption. As farmer cooperatives are very common in Rwanda this constraint is nullified.

As briefly mentioned before, the unstable potato price is a challenge for the smallholder farmer. This is caused by the *“market here [in Rwanda] is just consuming market. Unstable price is more potatoes compare to demand”* (Isaac, 65 years). Overall, the lack of industry in Rwanda able to process the potatoes all year round and the high crop release on the market after harvest, where the demand stays the same, are the main reasons for the price fluctuations. Potatoes need to be consumed or processed in weeks after harvest as they cannot be stored for months. One of the focuses of the Rwandan Government is to increase private sector investment in the agricultural sector, like agri-food processors (MINAGRI, 2018). Besides, Rwanda aims to minimize post-harvest losses which are currently between 15 percent to 50 percent depending on the value chain (MINAGRI, 2018). This also shows the mismatch between demand and available crops.

#### 6.4 Social capital

The fourth capital is social capital. Social capital includes the availability of social networks and relationships of trust through which households gain access to other resources and assets. The newly intensified farming technique affects farmers' social capital by (1) resistance to the newly introduced technique and (2) through gender dynamics.

- **Resistance to the new technique**

Smallholder farmers, in the process of sustainable intensification of their agricultural land, experience a barrier to successfully adopt the new technique of farming. The survey and the interviews reported farmers' resistance to change. In addition to the farmers' profile characteristics, are farmers reluctant to accept a new method of farming. Smallholder farmers are used to their traditional method of farming. *“Farmers are very resistant to new technique as they have farmed in a way for a long time. Whoever would tell them otherwise, they would be difficult [would experience resistance]”* (Jean Bosco, 35 years).

There is a new practice of farming, which increases yields when applied in line with the advice of the local agronomist. Yet, many farmers find it difficult to step away from the traditional practices, out of this research it became clear that the social barrier based on local knowledge and beliefs has large influence. The smallholder farmers have farmed with the traditional method for generations. Farmers highlight that the extrinsic factor of seeing the improved outcome drives the adoption rate. This is in line with the outcome of Kiptot & Franzel (2015) research, they report that participants learn more when seeing others implementing a new method, they mentioned that 'seeing is believing' for most farmers. So, being confronted with the improved progress and seeing the improved outcome with their own eyes can convince farmers to adopt the new farming technique. One smallholder farmer stated: *“Demo plot is the example, and they [the smallholder farmers] want to see it first. To invest requires patience and after seeing it [the intensified technique of farming] decide if you want to invest [adopt]. Can spend the money just once”* (Francois, 55 years).

Meijer, Catcutan, Ajayi, Silieshi & Nieuwenhuis (2015) state that resistance among rural smallholder farmers in SSA also relates to a general lack of confidence in science because of bad experiences in the past with newly introduced innovations. So, the resistance to change is a social barrier which is partly trust related. The lead farmers described it as *“most farmers decide after seeing result and they learn, and they need prove; build trust”* (Emmanuel, 50 years), *“see if it is true what has*

*been said*" (Diana, 48 years) and *"just to see first result of the demo plot if the results are what has been told [improved productivity]"* (Dative, 28 years).

The main indicator for smallholder farmers is to identify the improvement in productivity in terms of yields. So, *"most farmers decide after seeing result [improved productivity]"* (Emmanuel, 50 years) and *"people need proof if the new way is better [more productive]. Need to see and manage the [financial] risk to start a new technique"* (Deborah, 53 years). Research shows that face-to-face training and demonstrations improve implementation rates of new farming techniques (Yigezu, et al., 2018); (Shikuku, 2019). However, projects focusing on intensification services often have insufficient financial resources and staff to carry out extensive field visits and demonstrations. Consequently, the advice and practice skills do not reach households in rural areas (Feder, Anderson, Birner, & Deininger, 2010); (Taylor & Bhasme, 2018). Fortunately, the project in North-West Rwanda has the financial resources and staff to perform demonstrations and training days to install an extensive reach in the four different districts. By implementing a demo plot and seeing the results with their own eyes, farmers face proof of the improved productivity after the training they have received. As Francois describes, the new technique requires an investment and to secure their financial input, they must be convinced about the improved yields and that they can recoup the money.

- **Gender dynamics**

Besides the resistance to change, gender dynamics also affects the process of sustainable intensification of agriculture. Gender is embedded in society and its institutions where agriculture is part of. This complex dimension gets growing acknowledgement of understanding of how gender work within agriculture (Öborn, et al., 2017). Gender dynamics will be discussed in relation to control over resources, participation in agriculture production and the decision-making power of women.

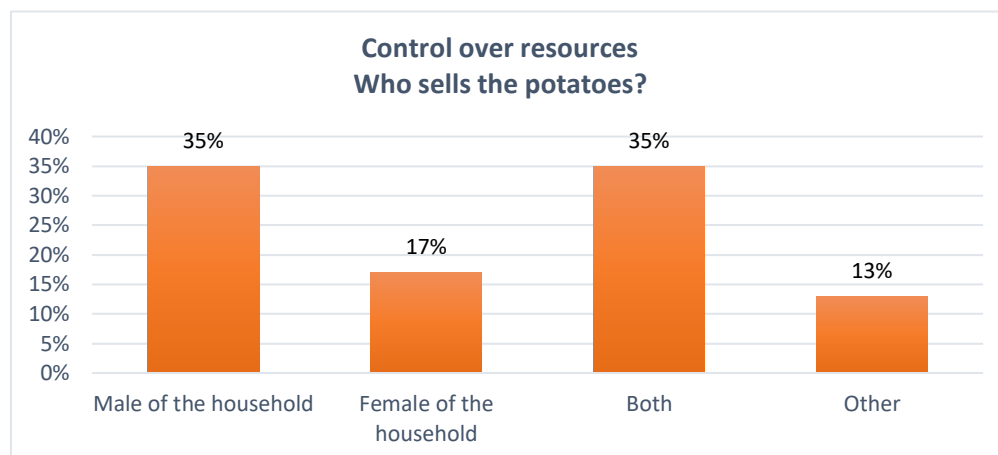


Figure 19. – Selling potatoes is divided by the head of the household. The percentage represents the frequency of the answers of the smallholder farmers. (N = 62)

While analysing the findings regarding control over resources, it becomes clear that gender dynamics influence this control. In all regions in the world and Africa particularly, women experience restrictions regarding the control and access to resources such as agricultural inputs, land, and extension services (Seebens, 2011). The survey pointed out a solid gendered component when focusing on the control over the post-harvest potatoes. Correlation with a significant level of .007 between 'household role' and 'who sells the potatoes' claims that the household role influences who sells the potatoes (*appendix IV, table 9*). In fact, mostly the male head of the household, the father, sells the potatoes (*see figure 19*). The MINAGRI (2019) has also observed this division. The MINAGRI



states that Rwandan women are constrained to benefit economically from the potato harvest as they are not in control over the cash crops. Women tend to take responsibility for the cultivating process and men manage post-harvest (MINAGRI, 2019). This gendered aspect of agriculture results in a social barrier for women. Out of the interviews, it became clear that men selling potatoes is culturally driven. The *“man is head of the farm and sells potatoes, the way God said”* (Deborah, 53 years) and *“letting men sell the potatoes is a way of showing him respect”* (Theoville, 27 years). Referring to God and respect makes the link to the local culture clear. Furthermore, MINAGRI (2019) elaborates on the gender roles in the Rwandan culture, they report that men are the breadwinner of a Rwandan household. This is interpreted and confirms that men remain in charge of the income of crop production (MINAGRI, 2019). On the other hand, some more practical reasons why men mostly sell the crops were mentioned: *“men [are] more common to sell [potatoes] because knowledge of men is better to sell potatoes”* (Dative, 28 years) and *“mostly men sell. When they sell, they weigh the sack ladies [are] not familiar with the weight [weighing process]”* (Wensisilas, 50 years). The findings agree with the claim of Bezner Kerr (2008) and Grabowski et al. (2020) that men disproportionately control resources for agriculture and receive a large share of benefits. On the other hand, some participants did express concerns when men sell potatoes, *“they [men] put money on the side for their own business”* (Xaverine, 48 years), *“men always think they want to keep money aside to use in own affairs”* (Diana, 48 years). Overall, it is tolerated that females sell potatoes; however, it is less common. Ingabire et al. (2018) reported a similar outcome, Rwandese women rarely participate in the selling process of potatoes except when the husband is unavailable or works in a different sector. These findings on the control of agricultural crops and income reveal a gender gap framed by the local culture. Females experience therefore, a social barrier to agricultural production and income.

In fact, strong gender roles also reoccur within the production activities of potato cultivation. Most hours of work on the farm get carried out by the female head of the household (see figure 20). This translates into a higher participation rate of the female of the household compared to the male of the household. The reason for a higher workload on the farm could be caused by *“the occupation of the men, men can also find labour to do the work in his place [work in another sector]”* (Emmanuel, 50 years), *“can be cause by two reasons, irresponsible men who don’t help their wife or the*

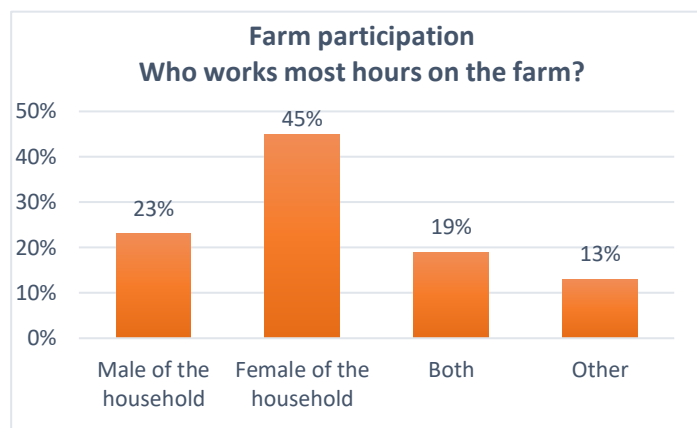


Figure 20. – Farm participation is divided per head of household. The percentage illustrates the frequency of the answers of the smallholder farmers. The female of the household works most hours on the farm. (N = 62)

*occupation of the men [work in another sector]”* (Francois, 55 years). Other participants were more critical and stated that *“common in this region [women working more hours on the farm], women are strong and work hard”* (Dative, 28 years) and *“women are most likely to work more on the farm because ladies are strong more than men that is needed in the farm. Farm work is heavy work”* (Dative, 28 years). MINAGRI (2019) also observed that in farm households in Rwanda, women tend to do most of the production process. Women execute 66 percent of the agricultural workforce (MINAGRI, 2019). It is not without reason that African women are seen as the key role in farm work and carry the responsibility of the family food security and home production (Meinzen-Dick, et al., 2010).



Another interesting outcome is the correlation between ‘who works most hours on the farm’ and ‘who sells the potatoes’ with a significant level of .050 (*appendix IV, table 10*). In other words, when the male of the household sells potatoes, the female works most hours on the farm. This relates to gender roles and has links with the local culture. More conservative families tend to stick to the more traditional gender roles of men managing the income and females participating more hours on the farm. Clay & Zimmerer (2020) report that social inequalities are often deeply rooted in societies.

When focusing on the decision-making power of women two indicators stand out, the ‘decision to join the project plus trainings’ and the ‘decisions taken at the farm’. The household role correlates with ‘who made the decision to join the project’ and ‘who joined the training’, both on a significant level of <.001 (*appendix IV, table 11*). This indicates that the one who provides the answers is most likely to join the project and the training. It is therefore important to speak to both males and females involved in the research, as it correlates who provides the answers and who makes decisions. An interesting fact that came forward while analysing was that male respondents would almost always answer that they took all decisions. On the other hand, female respondents also confessed that the male of the household took decisions. In other words, none of the male participants mentioned that the female of the household took decisions. This confirms the traditional gender roles and the low control of females over the agriculture business. That the decision-making is gender-related is very likely but cannot be confirmed by this study. The interviewees state that decisions regarding the farm are taken “*together between husband and wife*” (Dative, 28 years). Deciding together “*shows respect to each other*” (Theoville, 27 years) and “*two heads know more than to one head*” (Wensisilas, 50 years). Meanwhile, MINAGRI (2018) states that Rwandan women experience limited decision-making power due to unequal relations. This questions the reliability of the answers of the participants on the decision-making process. As it regards a sensitive topic, it could be that desirable answers were given.

By way of contrast, the Rwandan land rights are very gender equal. In government policies, males and females have equal land rights and from the interviews, it became clear that females have equal land ownership and rights compared to males. The overall decision-making power of women is still questionable. Due to contradicting findings, it is impossible to conclude if women experience equality. Besides, the male of the household could experience peer pressure to avoid not losing face. As the topic regards a sensitive issue in the communities, the finding might be influenced by it.

## 6.5 Natural capital

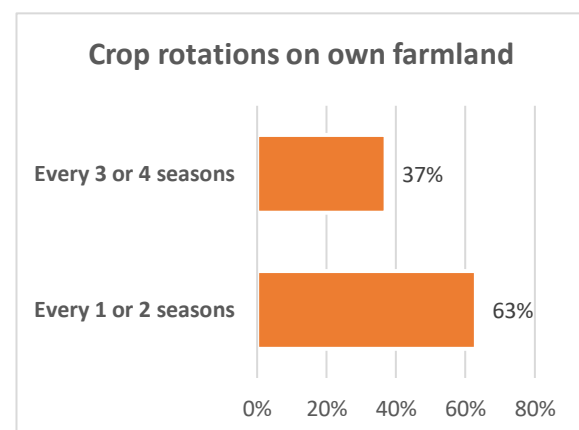
The last out of the five livelihood capitals is natural capital. Natural capital includes the quality and quantity of the basic ingredients for agriculture activities like accessible land, water, and biodiversity. The natural capital of the smallholder farmers changes with the new technique of farming when looking at soil quality.

Soil conservation is of great importance for farmers and they depend on their soil quality. Besides expanding knowledge about the technique of cultivating potatoes, there is extra emphasis on the importance of soil conservation during the training days. According to internal documentation of Delphy (2018), the project promotes regular crop rotation, the use of natural manure, teaches farmers about preventing erosion, and about the use of chemical pesticides. These practices are beneficial for the soil quality of the farmland of the smallholder farmers (Vanlauwe & Dobermann, 2020). The interviews confirmed the outcomes of the survey that “*modern [farming is] better for the soil, applying manure [is] healthy for soil: protection of soil*” (Diana, 48 years) and “[the new method] *affects soil in*



*a good way better than traditional way, just rotation is good, reducing quantity of fertiliser with manure added, lines of plants too*” (Theoville, 27 years). A direct result of better soil quality is good quality potatoes and fewer detected pests and diseases in the soil and crops. The Likert scale results out of the survey shows that the quality of potatoes has increased (8% ‘same’ quality, 70% ‘more’ quality, 22% ‘a lot more’ quality) and the pest and diseases detected in potatoes and potato plants have decreased (100% ‘less’ pest & diseases). In addition, there is a positive correlation between the ‘quality of potatoes’ and the ‘improved output’ (more yields, more income, and more profit) with a significant level of .040 (*appendix IV, table 12*). This indicates that the quality improves together with the yields, income, and profit with the intensified technique of cultivating potatoes. The reasons for better potato quality gets explained by *“reduces fertiliser when using manure”* (Emmanuel, 50 years), *“protect land from erosion by making the lines [planting in so the water get distributed elsewhere without destroying the planting beds]”* (Wensisilas, 50 years), *“learn about rotation”* (Dative, 28 years), *“better protected by spraying [pesticides]”* (Xaverine, 45 years), *“no interaction with fertiliser and manure which could damage the seeds”* (Wensisilas, 50 years), *“give distance to potatoes [seeds when planting], and they can grow bigger and multiply”* (Jean Bosco, 35 years) and *“harvesting to keep [select] the good seeds”* (Theoville, 27 years). Pretty & Bharucha (2014) state that the combination of ‘sustainable’ and ‘intensification’ remains controversial to them. However, by reducing the potential overuse of inorganic fertiliser and pesticides plus achieving higher production, the attempt at sustainable intensification is largely successful. Using fewer fertilisers and pesticides and more manure has a positive effect on the soil quality (Köninger, et al., 2021).

When looking at the number of crop rotations, numbers show that farmers are aware of the need to rotate their crops. Crop rotations have a significant impact and are more effective in maintaining soil quality (Aziz, Ashraf, Mahmood, & Islam, 2011). *Figure 21* implies that all participating farmers rotate their crops. More importantly, rotating in Rwanda is mandatory by the Rwandan government and farmers are even locked into specific crop rotations based on location (Clay & Zimmerer, 2020). For example, pyrethrum is a crop which grows particularly well in Nyabihu region, and the government made it mandatory for farmers to cultivate pyrethrum every second season to ensure enough pyrethrum was available on the market. Clay & Zimmerer (2020) report that 75 percent of all Rwandan households said that decisions about cropping were made by the government.



*Figure 21. – All (100%) of the smallholder farmers rotate their crops in their own farmland. The percentage shows the frequency of the answers of the smallholder farmers. (N = 62)*

The last effect on soil quality is when looking at erosion. Based on the interviews, it became clear that the new farming technique *“protect land from erosion by making the lines [ditches]”* (Wensisilas, 50 years). These ‘ditches’ distribute the water and prevent the planted beds from getting destroyed. See photos of the two different planting methods in *appendix VIII*. Farmers shared that the big beds of the traditional method got damaged by heavy rainfall more regularly.



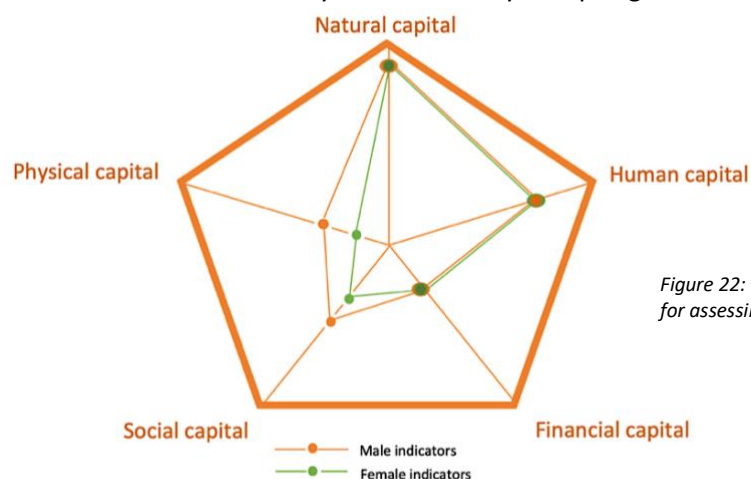
### 6.6 Conclusion remarks

The analysis of livelihood enhancement provides an extensive overview of the effects on each livelihood capital. The findings indicate a different impact on each livelihood capital. *Table 5* presents an overview of the outcomes and effects on the livelihood of smallholder farmers. In sum, based on data gathered through questionnaires and interviews, livelihood enhancement while in the process of sustainable intensification of agriculture points to several barriers. The physical, social, and economic barriers prevent smallholder farmers from starting and continuing farming with the intensified farming technique. Besides the barriers, beneficiary assets also arise when looking at the gained knowledge and the improvement in soil quality. But livelihood is broader than just the capital. When focusing on the transforming structures and processes, it becomes clear that the Rwandan Governments’ vision of the agricultural sector has implications for the Rwandan smallholder potato farmers. The mandatory rotation, set cultivation of specific crops and seed monopoly gave insights to the influence of the government on the smallholder farmers. These top-down measures decrease the autonomy of smallholder farmers. Decisions of the government have direct impact on the livelihood outcomes of smallholder farmers. The government’s agricultural mission is to make the sector more commercial with monocropping, locked crop cultivation and rotation, government-managed seed distribution, and strict import rights have a negative impact on the autonomy and resilience of the farmers involved.

*Table 5: Livelihood enhancement overview*

Livelihood capital	Outcomes	Effect
<i>Physical capital</i>	<ul style="list-style-type: none"> <li>- Diversification of farm produce</li> <li>- Required input (price and availability)</li> <li>- Access to the market</li> </ul>	Physical barrier
<i>Social capital</i>	<ul style="list-style-type: none"> <li>- Resistance to change</li> <li>- Gender dynamics</li> </ul>	Social barrier
<i>Financial capital</i>	<ul style="list-style-type: none"> <li>- Access to finance</li> <li>- Materialisation of income</li> </ul>	Economic barrier
<i>Human capital</i>	<ul style="list-style-type: none"> <li>- Knowledge</li> </ul>	Cognitive asset
<i>Natural capital</i>	<ul style="list-style-type: none"> <li>- Soil conservation</li> </ul>	Natural asset

*Figure 22* presents the capital pentagram, bringing various people’s assets and inter-relationships to life. Based on this research, the livelihood pentagram for males and females are differently shaped due to gender dynamics. When specifically focusing on gender differences, females experience more barriers regarding physical capital and social capital. Mainly due to traditional gender roles in society, women have less agency. On the other hand, males and females are equal when concentrating on the gained cognitive and natural assets and experiencing the same economic barrier. Overall, gender differences matter during the process of sustainable intensification of agriculture, mainly in the restricted agency and resources like access to markets, farm participation and farm management which are determined culturally and defined by unequal gender roles.



*Figure 22: Pentagram with indicators for assessing livelihood enhancement*

## 7. Discussion

The results of this research presented the effect of sustainable intensification of agriculture in a Rwandan context concerning a specific project focused on the intensification of the potato value chain. The research demonstrated that most farmers experienced improved outputs due to the process of intensification of their farmland, but at the same time, this process brought unanticipated consequences along. The data has contributed to a comprehensive understanding of the research context. The analysis of the survey and interviews provided an extensive overview of the effects on the lives of the participants. It examined their views regarding the effect of the intensified farming technique. This discussion chapter aims to connect the insights from the previous analysis to a broader literary context. The three central concepts within this chapter are sustainability, land tenure, and gender equality.

### 7.1 Sustainability

The project aims to make the potato sector more sustainable in terms of food security, nutrition, and agricultural growth (Delphy, 2018). For smallholder farmers in Rwanda, this concept of sustainable intensification is a pathway to reduce the yield gaps on their existing agricultural land to increase productivity. The components 'sustainable' and 'intensification' are intertwined concepts and can cause a mismatch in the field (Struik, Kuyper, Brussaard, & Leeuwis, 2014). For example, farmers' decisions to intensify crop production using fertilisers can have a negative effect on the environment and results in an unsustainable adoption in the long-term (Silva, et al., 2021). A commonly used definition for 'sustainability' is described by the Brundtland Commission Report as *"meeting the needs of the present without compromising the ability of the future generations to meet their own needs"* (Brundtland report, 1987). Sustainability is a broad concept which also translates into sustainable adoption and relates to the present needs of the smallholder farmers while in the process of sustainable intensification. Sustainable practices in agricultural systems can get reflected in their economic, environmental, and social sustainability (Rodriguez, Molnar, Fazio, Sydnor, & Lowe).

Several findings of the analysis contribute to the sustainability aspect of sustainable intensification. *Figure 23* shows an overview of the effects of the case study on sustainability by sustainable intensification of agriculture. Based on the findings, the improvement in soil was realised by using fewer fertilisers and pesticides. Silva et al. (2021) claim that lowering the use of inputs improves environmental sustainability. On the other hand, findings indicate a negative influence on the sustainability aspect. Economically disadvantaged farmers experience challenges regarding access to finance and markets. Besides, the inaccessibility of required items reduces their economic sustainability (Haggard, Lamboll, Nelson, &

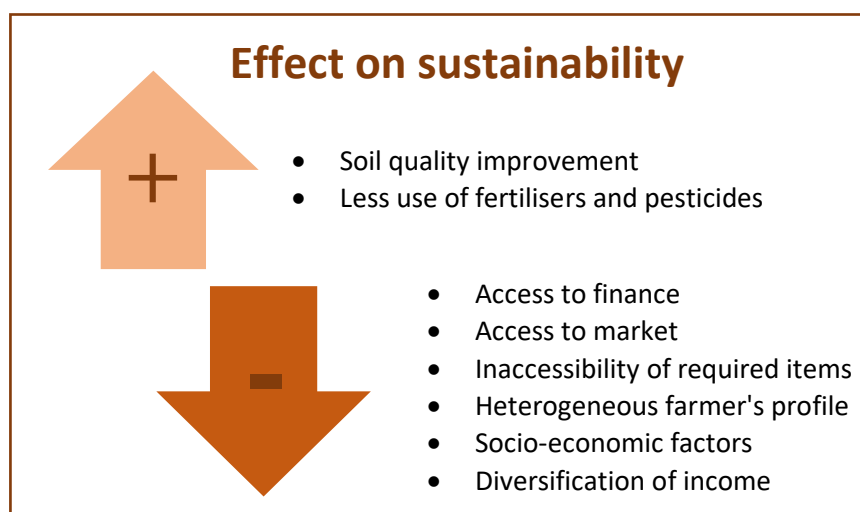


Figure 23: Overview of the effects on sustainability by sustainable intensification of agriculture



Rodenburg, 2020). These challenges make it close to impossible for smallholder farmers to achieve a sustainable adoption of the intensified farming method. The heterogeneous nature of the involved smallholder farmers evolves into an unequal adoption that depends on the farmer's profile and their socio-economic factors. The differences between smallholder farmers in the community can decrease social sustainability (Mohammed, 2009). Lastly, the diversification of farm produces decreases environmental and economic sustainability as it contributes to a more dependent livelihood, risks of income instability, land degradation and fertility losses (Liao & Brown, 2018); (Dahal, Sitaula, & Bajracharya, 2007).

In addition, a critical part of the project relies on the transfer of knowledge about the intensified way of farming potatoes. According to project lead partner Delphy, new knowledge and skills need to increase farmers' production (Delphy, 2018). They state that the yield gap exists due to a lack of sustainable agricultural practices. Mohammed (2009) mentions sustainable agriculture as a knowledge-intensive system. The intensified practice is a new kind of agricultural knowledge to the smallholder farmers as the project transfers modern knowledge. Mohammed (2009) claims that agriculture extension services are gradually shifting to knowledge-share concepts where smallholder farmers are more contributing to the learning process. In contrast, the potato value chain project uses a conventional system to transfer modern knowledge. The project applies a collective and voluntary approach with group sessions, demonstrations, and shared information in networks of farmers. Still, the current system is characterised by top-down learning styles (Allahyari & Chizari, 2008). According to Mohammed (2009), conventional systems cannot achieve sustainability in agriculture as social issues and specific environmental implications are not part of the process.

Sustainable intensification is a shift in agricultural practice rather than a short-term solution. According to internal documents of Delphy (2018), the priority is to ensure an increase in crop production with a focus on long-term sustainable income and becoming more resilient to stresses and/or shocks. Concludingly, can be stated that the broader reality of sustainable development with this intensified farming method brings along unpredicted and complex challenges that reduce the level of sustainability for the smallholder farmers involved.

## 7.2 Land tenure

As discussed, Rwanda is challenged by high population density, a rapidly growing population, land degradation, and land scarcity. These challenges influence land use strategies of farmers and government policies (Clay & Zimmerer, 2020). Introducing sustainable intensification of agriculture to improve productivity, results in the implementation of the land use consolidations. By improving the smallholder farmers' knowledge, farming practices affect land tenure. In regions where land is scarce and the farming practice intensified, the value of land increases (Otsuka & Place, 2014). But the Rwandan government's vision goes beyond improving productivity and has implications for the distribution of land tenure. The CIP of the Rwandan Government aims to optimise land use systems and transform the land use of rural areas (MINAGRI, 2011). Under the CIP program, the Rwandan Government plans to synchronise crop cultivation in consolidated lands and rearranged into larger, more commercial holdings (MINAGRI, 2011). Overall, using land efficiently is key when land is scarce. Therefore Otsuka & Place (2014) argue that land of less productive producers needs to reallocate to more productive producers. The end goal of this state-led commitment is to turn Rwanda into a middle-income country (Cioffo, Ansoms, & Murison, 2016).



Based on the findings, smallholder farmers with larger plots of land (>1 ha) are likelier to adopt the intensified farming technique. Additionally, a larger plot of land makes smallholder farmers more eligible to have access to finance. Owning land can serve as collateral to get a loan. These findings indicate that larger land tenure provides smallholder farmers with a capacity to adapt and be more resilient compared to the marginalised groups with little land. Clay & Zimmerer (2020) have also recognised the value of land tenure while in the process of sustainable intensification of agriculture. They call for risk management as a central policy of intensification programs, as intensification can bring along further risks to the most vulnerable, little land smallholder farmers (Clay & Zimmerer, 2020). Sustainable intensification programs are often a ‘one-size-fits-all’ solution where larger, wealthier households are able to adopt and achieve a higher income through more commercial agriculture (Bizoza, 2021); (Clay & Zimmerer, 2020). Small farmers have less or no access to finance and inputs, which shows the inequitable distribution of opportunities and income levels (MINAGRI, 2011).

Scarcity of valuable land results in competition between individuals (Otsuka & Place, 2014). As mentioned in chapter 3, land scarcity in Rwanda is recognised to cause potential instability and even conflict (Abbott, Mugisha, & Sapsford, 2018). The unequal distribution of opportunities linked to the size of farmland and the vision of the Rwandan Government to commercialise smallholder production systems according to the priorities of the state, reveals the vulnerability of the impoverished segment of farmers in Rwanda. While Rwanda still deals with land tenure struggles after the genocide, other turmoil surrounding land competition increases in society. Only time will tell how Rwandan land tenure will change while the tension rises.

### 7.3 Gender equality

The proposal of the project expresses the vision, goals, and principles of the project (Delphy, 2018). The project aims to promote or achieve gender equality in the potato value chain. Delphy (2018) announced that the project specifically targets women to make sure training and other benefits are equally distributed by sex. The outcomes of this research confirmed the existence of persistent gender inequality in the potato value chain in Rwanda, as outlined in the project proposal (Delphy, 2018) and the Gender and Youth Mainstreaming Strategy rapport of the Rwandan Government (MINAGRI, 2019). Several gendered patterns were identified based on the narratives of the smallholder farmers. The farm participation, control over resources, adoption rate of the intensified farming technique, and decision-making power of females are influenced by gender patterns. These findings comply with studies of Bezner Kerr (2008), Grabowski et al. (2020) and MINAGRI (2019), which identified similar challenges facing women in agriculture in general and specifically in Rwanda. Through the interviews with smallholder farmers, these challenges were linked to the Rwandan culture and the present gender roles in society. These findings are supported by Clay & Zimmerer (2020), who state that social inequalities are deeply rooted in Rwandan society.

Interestingly, Rwanda ranked 7th in the Global Gender Gap Report of 2021 of the World Economic Forum (2021). Rwanda made it to the top 10 most gender-equal countries in the world and was one of the best-performing countries concerning the political empowerment of women. Nonetheless, the report identifies remaining gender gaps in the informal sector, low-wage occupations, and managerial roles (World Economic Forum, 2021). This top 10 ranking of Rwanda opposes Debusscher & Ansoms (2013), Abbott & Malunda (2016) and Kubai & Ahlberg (2013), who all refer to gender inequalities being deep-rooted in social norms and practices in Rwanda. The top-down



gender policy programs of the Rwandan Government lacks grassroots participation and therefore face resistance on community level (Abbott & Malunda, 2016). Despite the progress on gender equality through legal reforms and policies, the attitude toward women empowerment in Rwanda remains negative in everyday social practices, especially in rural areas (Debusscher & Ansoms, 2013). Overall, Debusscher & Ansoms (2013) and Abbott & Malunda (2016) conclude that political representation of women in parliament has not led to a change in the lives of Rwandan women living in rural areas.

The project aims to target women by including them in the project. Similarly, to the Rwandan Government including women in parliament. Both have the intention to close the gender gap in society. However, by just including women, the deeply rooted social norms and practices do not get challenged nor changed. Both the potato value project and the Rwandan Government will need to include more grassroots acknowledgement to have an influence on the existing gender gap. For now, achieving real gender equality in Rwanda still seems a long way to go.



## 8. Conclusion and recommendations

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This research aimed to identify how the process of sustainable intensification of the potato value chain affects the livelihood and gender dynamics of smallholder farmers in North-West Rwanda. The analysis of the survey and interviews with smallholder potato farmers, who are involved in the process of intensification of their farmland, contributed to the growth of a comprehensive understanding of the contextual embedding of the research. Based on this combined analysis of quantitative and qualitative data on the overall impact can be concluded that the outputs improve. However, the smallholder farmers do experience economic, cognitive, and social barriers while adopting the method of sustainable intensification of their agricultural land. Furthermore, livelihood of the smallholder farmers faces physical, social, and economic barriers which constrain farmers from cultivating with the intensified technique. Furthermore, there are assets that enhance livelihood with gained knowledge and improved soil quality. Moreover, the gender roles are culturally unequal in the agricultural sector, and this influences the involvement of women in the process of sustainable intensification of agriculture. Diverse influencing factors reoccurred throughout analysing the data, such as the required inputs, access to finance, and the unstable market price. These factors correspond to the improved outputs of the smallholder farmers and their livelihood enhancement.

Findings of the research point out that the Rwandan government's vision has far-reaching implications for the smallholder farmers in North-West Rwanda. The state-led agricultural intensification pathway to economic growth grants development organisations like Delphy to work alongside a set of rural development policies. This top-down approach affects the autonomy of smallholder farmers and could result in undesirable practices which are poorly suited for the farmer's ability. In contrast to this top-down rural transformation, the project is participatory-based and designed for voluntary adoption. However, this does not take away the fact that all involved smallholder farmers likely experience pressure from powerful entities and the government's agenda. The adoption rate of the intensified method is high, but at the same time, livelihood diversification levels decrease. This suggests a more dependent livelihood that comes with great risks, especially when the level of resource access is poor. These adverse effects particularly impact the more impoverished farmers, who have less land and financial capital. As a result, many participants override the aims of a sustainable practice.

As the Rwandan case demonstrates, the process of intensification is successful in the sense that most smallholder farmers have received financial remuneration. Yet, the long-term impact remains unknown. The intensified technique has improved the soil quality. However, the access (in terms of availability and price) of resources and finance questions the possibility of long-term sustainable adoption. Especially when resources are inaccessible, how fair and reasonable is it to transfer knowledge about practices that are not accessible to these farmers? Additionally, the Rwandan potato market functions poorly and is highly unstable. Financial benefits are key for smallholder farmers to get involved with sustainable intensification. Therefore, potential financial risks are a bottleneck to the adoption of the intensified technique and even to the continuation of cultivation potatoes. However, this chance is close to zero as the Rwandan Government locked farmers into potato production based on regional targets. According to the participants, achieving improved productivity is desirable, even when the market is unstable.





Even though the adoption rates indicate otherwise, findings claimed resistance to the newly introduced intensified farming method. The project puts much emphasis on face-to-face knowledge transfers and visible practice. This resulted in a decreasing social barrier and a high adoption rate. The new intensified practice is based on modern knowledge where traditional practices, local knowledge and beliefs are not included. Still, smallholder farmers are free to choose whether to adjust their way of cultivating potatoes and to buy in on the intensified farming technique. The project transfers knowledge on a voluntary basis by local agronomist at a location near the smallholder farmer. The lead farmer invites smallholder farmers in the area to join the training sessions and demonstrations to witness the intensified farming method. Findings show that the participants have gained knowledge plus the adoption rate is high. Both indicate that the modern knowledge transfer has been successful.

The findings provide insights on the influence of gender roles on adoption decisions and barriers when in process of sustainable intensification of agriculture. Gender roles are embedded in society and mainly defined by culture. Women tend to have less agency and control over resources. The achievements are related to participation in agriculture production and the decision-making power of women. Altogether, gender dynamics negatively restrict women in their physical and social capital. Often, it comes at the cost of other dimensions of livelihood, like uneven distribution of the financial capital. By aiming to include women in the intensification project, the gender dynamics do not get affected. Consequently, the outcomes of the project reflect the present unequal culturally defined gender roles in society.

The preceding empirical chapters, where the findings are critically discussed with academic literature, have presented the answers to the sub-questions. In this chapter, the main question is answered. Overall, the effects of sustainable intensification of agriculture are very diverse and are, therefore, in line with the highly heterogeneous nature of smallholder farmers. But above all, it can be stated that, even though Rwandan smallholder farmers do not have full authority over their decisions, this study examined that the effects of the potato value chain program are positive when focusing on productivity. The unanticipated consequences may reduce the chance of a sustainable long-term adoption and decrease the resilience of most smallholder farmers.

### **Recommendations for project development purposes:**

- The project should consider **addressing the existing gender social norms and practices** as part of the project. By just aiming to include women in the project, existing barriers are challenged nor changed. Educating women and men on equal treatment throughout the project is essential to achieve the aim to empower women.
- The issues that arose during data collecting regarding **access to inputs and finance** need to be addressed and resolved in cooperation with all project partners, including the MINAGRI. The aim is to find a solution for the unavailable inputs and inaccessible loans. The preferred outcome is that the project assists in providing smallholder farmers with the inputs and finance opportunities.
- The potato value chain intensification project should prepare a plan specifically to **protect the more impoverished segment** of smallholder farmers from the unanticipated consequences on their livelihood. This segment faces higher risks and are seriously in need of the benefits of sustainable intensification of agriculture.



- To ensure sustainability and risk management of smallholder farmers' livelihood, it is necessary to **teach farmers about the importance of diversification** of their production and the risks connected to a less diversified production. The results show that most smallholder farmers are unaware of these risks.

#### **Recommendations for future research:**

- To better understand the implications of these results, future research could address the effect on livelihood of other projects in SSA to get a better scientific understanding of the impact of sustainable intensification of agriculture.
- Further research is needed focusing on a specific livelihood capital to determine the specific causes and effects. Livelihood is a broad concept, but while focusing on one dimension, a deeper understanding occurs of that particular aspect of livelihood.
- Based on the conclusion, development organisations need to consider the impact of gender dynamics in society. Conducting specific research on the impact of gender inequality and ways to improve gender equality while in the process of sustainable intensification of agriculture, will provide more insights. The outcomes would be an enrichment of development policies and intensification programs on how to identify gender dynamics and how to include these in the process of intensification so none of the genders involved will not be influenced by the process negatively.
- Research how to effectively incorporate more traditional knowledge in sustainable intensification projects. Development projects often bypass traditional knowledge. Conducting research on traditional knowledge in the area, before starting a sustainable intensification program, could be highly beneficial for future projects in agriculture.



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## Appendix

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Appendix I	:	Questionnaire
Appendix II	:	Participation list for survey sample
Appendix III	:	Overview of questionnaire participants
Appendix IV	:	SPSS outcome
Appendix V	:	Interview guide
Appendix VI	:	Overview of interview participants
Appendix VII	:	Code tree
Appendix VIII	:	Different farming methods



I. Questionnaire

HOUSEHOLD QUESTIONNAIRE					
<b>District</b> :		<b>Date</b> :			
<b>Sector</b> :		<b>Time</b> :			
<b>Cell</b> :		<b>Present team members:</b>			
Farm and farmer characteristics					
Name respondent:					
Household role of the respondent:					
Agricultural role of the respondent:					
Members of the family:					
Estimated field size:					
% modern farming field:					
Involved in a cooperative:					
How old are you?					
Livelihood activities					
1. How did you join the potato project?	Asked myself	My cooperative	A lead farmer	Through SPF/HGT	Other ...
2. Main reason for joining the potato project?	Increase of income	Increase of yields	Gain knowledge		Other ...
3. For how many seasons have you been part of the potato project?	1	2	3	...	
4. For how many seasons have you cultivated potatoes in the modern way?	1	2	3	...	
5. Who of the family decided to join the potato project?	Father of the household	Mother of the household	Together		Other ...
6. How many trainings were attended?	1	2	3	...	
7. Who in the household attended the trainings?	Father of the household	Mother of the household	Other ...		
8. What are the sources of family income?	Farming	Livestock	Contract work	Other ...	
9. What is the <u>main</u> source of family income?	Farming	Livestock	Contract work	Other ...	



10. What does your farm produce?	Potato	Beans	Banana	Maize	Pyrethrum	Other ...	
11. What is the <u>main</u> produce of your farm?	Potato	Beans	Banana	Maize	Pyrethrum	Other ...	
12. Did the farm produce change after joining the project?	Yes, focused on <u>less</u> different produces	No, stayed the same		Yes, focused on <u>more</u> different produces	What changed?		
13. How often do you rotate the crops?	Every 1 – 2 seasons	Every 3 – 4 seasons	Every 5 – 6 seasons	never			
14. Do you lease the farmland?	Yes	No	Other ... (owner of the land / partly)				
15. Who works most hours on the farm?	Father of the household	Mother of the household	Other ...				
16. Who sells the potatoes?	Father of the household	Mother of the household	Other ...				
17. Where do you sell the potatoes?	Locale market	Sold by cooperative	Sold by trader	Processor			
18. Do you keep track on your expenses?	Yes, I keep a quick book	My husband/ man household	With the cooperative	No, we don't			
19. Do you have access to finance/loans?	Yes	No	Other ...				
20. Compared to the traditional way, what is different in the modern way?	Applying fertiliser and manure underneath the seed + cover is with soil	Measuring distance between planted seeds	Planting in lines of small hills	Spraying	Rotation	Selection quality seeds	Other
<b>Current changes after joining the program</b>							
<i>Intended outcome, project aims (modern compared to traditional)</i>							
	<b>A lot less</b>	<b>Less</b>	<b>Same</b>	<b>More</b>	<b>A lot more</b>		
21. Potato yields	< -50.000	-50.000 - 0	0	0 – 100.000	> + 100.000		
22. Income from potato farming	< -200.000	-200.000 – 0	0	0 – 200.000	> +200.000		
23. Profit from potato farming (Income – all expenses)	< -50.000	-50.000 - 0	0	0 – 50.000	> +50.000		
<i>Unexpected outcome (modern compared to traditional)</i>							
	<b>A lot less</b>	<b>Less</b>	<b>Same</b>	<b>More</b>	<b>A lot more</b>		
24. Needed labour from the father of the household							



25. Needed labour from the mother of the household					
26. Needed assisted labour of children					
27. Did the plot of land for potatoes production change in size after starting the project?					
28. Pest and diseases in the potatoes					
29. Pesticide needed					
30. Needed fertiliser					
31. Needed manure					
32. Quality of the potatoes					
33. Market price for potatoes					
34. Market price of the seeds					
35. Knowledge of the father of the household about farming potatoes					
36. Knowledge of the mother of the household about farming potatoes					
37. In case of an increased income, what did you do with the increased income?	<i>Saved it for later / bought more land / paid school fees / paid off dept(s) / other...</i>				
<b>Looking back and into the future</b>					
38. Will you continue to farm potatoes in the modern way?	Yes	No	Not sure		
39. Please elaborate your answer ...					
40. What did you like about the modern	More yields	More money	The trainings	Other ...	



way of farming potatoes?				
41. If you want to fully adapt the modern way of farming potatoes, what needs to be improved? What is challenging in the modern way of farming?	Need more knowledge	Access to finance	Need better seeds	Other ...
42. Next time, what would you like to learn more about?	<i>(More about the seeds, irrigation, pesticides, rotation, diseases, etc.)</i>			
43. Would you recommend the modern way of farming potatoes to others?	Yes	No	Not sure	
44. Please elaborate your answer ...				

Something else to mention:





## II. Participation list for survey sample

Example participation list of lead farmer J.M.V. in Rubavu with 40 support farmers.

Last names (in Rwanda written before the first name) and part of the phone numbers have been blanked for confidentiality reasons.

Source: Holland Greentech attendance list Farmer Field Day

Summary of participants

Male	Female	Lead farmer	and
>30 / <30	>30 / <30	KABUTURA J.M.V	tech
13 / 8	7 / 12		
21	19		
40 Total Money paid 44000F			

Sector: BUWESIII  
 Date: 25/11/2021  
 Event/ Activity: Farmer field day and  
 Lead farmer: [redacted] J.M.V.

#	Names	Male		Female		Phone	Signature
		>30	<30	>30	<30		
01	[redacted] cent			✓		0786568	[redacted]
02	OLSHAYAMU		✓			0782144	[redacted]
03	[redacted]		✓			0780339	[redacted]
04	[redacted]		✓				[redacted]
05	[redacted]				✓	0782208	[redacted]
06	[redacted]	✓				0787661	[redacted]
07	ERA Angélique				✓		[redacted]
08	[redacted]	✓				0782722	[redacted]
09	[redacted]	✓				0786520	[redacted]
10	LANA J.M.V	✓				0787597	[redacted]
11	[redacted]	✓				0782465	[redacted]
12	[redacted]				✓	0780452	[redacted]
13	[redacted]				✓	0785458	[redacted]
14	[redacted]				✓	0787597	[redacted]
15	[redacted]				✓	0786568	[redacted]
16	Jeanine				✓	0782468	[redacted]
17	FOROBAMG				✓	0785755	[redacted]
18	[redacted]				✓	0789818	[redacted]
19	[redacted]				✓	0784701	[redacted]
20	HERA INOCA		✓			0786523	[redacted]

5 4 5 6



### Event attendance

SDGP Project I CYEREKEZO

District: RUBAVU

Sector: BUGESHI

Date: 25/11/2021

Event/ Activity: ... Farmers field day two

Lead farmer: [redacted] J.M.V

#	Names	Male		Female		Phone	Signature
		>30	<30	>30	<30		
01	[redacted] NE		✓			0782473	[Signature]
02	Polvestina			✓		0786240	[Signature]
03	[redacted] J.M.V	✓				0781150	[Signature]
04	HUNZIO Daniel		✓			0784456	[Signature]
05	SHOMA Christian			✓		0780533	[Signature]
06	ANYE Jerome		✓			078656	[Signature]
07	NAFORO RANSE			✓		-	[Signature]
08	Antoine Guston	✓				0781176	[Signature]
09	[redacted] J.M.V	✓				078071	[Signature]
10	Elizabeth	✓				07807	[Signature]
11	Yc-rajabilit	✓				07823	[Signature]
12	NYONA EBUJEM			✓		078086	[Signature]
13	[redacted] Innocent		✓			078154	[Signature]
14	E JBERCHIMAS	✓				078205	[Signature]
15	YANA USTHUC			✓		078276	[Signature]
16	YANA EMEANA			✓		078252	[Signature]
17	YANA APOSE			✓		07844	[Signature]
18	[redacted] 1964	✓				0782	[Signature]
19	YANA [redacted]			✓		0782	[Signature]
20	[redacted]	✓				078335	[Signature]

8 4 2 0



### III. Overview of questionnaire participants

<b>Nr.</b>	<b>Name</b>	<b>Age</b>	<b>Sex</b>	<b>District</b>	<b>Farmer/ lead farmer</b>	<b>Seasons involved</b>
1	Zikamwanahari	>60	Male	Nyabihu	Farmer	3
2	Edith	41-60	Female	Nyabihu	Farmer	3
3	Emmanuel	41-60	Male	Nyabihu	Lead Farmer	2
4	Amnestat	41-60	Male	Nyabihu	Farmer	2
5	Amos	26-40	Male	Nyabihu	Farmer	2
6	Jean Pierre	41-60	Male	Nyabihu	Farmer	3
7	Nadine	26-40	Female	Rubavu	Farmer	2
8	Ruth	26-40	Female	Rubavu	Lead Farmer	2
9	Innocent	26-40	Male	Rubavu	Farmer	2
10	Liberatha	26-40	Female	Rubavu	Farmer	3
11	Bosco	26-40	Male	Rubavu	Farmer	2
12	Angelique	41-60	Female	Rubavu	Farmer	3
13	Leonard	41-60	Male	Musanze	Lead Farmer	3
14	Jean Baptise	<25	Male	Musanze	Farmer	2
15	Dative	41-60	Female	Musanze	Farmer	2
16	Angelique	41-60	Female	Musanze	Farmer	3
17	Bosco	26-40	Male	Musanze	Farmer	3
18	Esperance	41-60	Female	Musanze	Farmer	3
19	M. Grace	41-60	Female	Musanze	Farmer	1
20	Casirnir	26-40	Male	Musanze	Farmer	1
21	Odette	41-60	Female	Musanze	Farmer	1
22	Elizabeth	26-40	Female	Musanze	Farmer	1
23	Berancille	41-60	Female	Musanze	Farmer	1
24	Emmanuel	41-60	Male	Musanze	Lead Farmer	1
25	Agnes	41-60	Female	Musanze	Farmer	1
26	Providence	26-40	Female	Musanze	Farmer	1
27	Celine	41-60	Female	Musanze	Farmer	1
28	Ester	41-60	Female	Musanze	Lead Farmer	1
29	Samuel	<25	Male	Musanze	Farmer	1
30	Damien	>60	Male	Musanze	Farmer	1
31	Leontine	41-60	Female	Burera	Lead Farmer	1
32	Alexis	<25	Male	Musanze	Farmer	1
33	Alphonsine	41-60	Male	Burera	Farmer	1
34	Deo	26-40	Female	Burera	Lead Farmer	2
35	Jean Paul	41-60	Male	Burera	Farmer	1
36	Mariane	<25	Male	Burera	Farmer	2
37	Isidore	41-60	Female	Burera	Lead Farmer	2



<b>38</b>	Dusabe	>60	Male	Nyabihu	Farmer	3
<b>39</b>	Furaha	41-60	Female	Nyabihu	Farmer	2
<b>40</b>	Beatrice	41-60	Female	Nyabihu	Farmer	1
<b>41</b>	Odile	41-60	Female	Nyabihu	Farmer	2
<b>42</b>	Ancille	>60	Female	Nyabihu	Farmer	2
<b>43</b>	Mukankusi	41-60	Female	Nyabihu	Farmer	1
<b>44</b>	Innocent	41-60	Female	Nyabihu	Lead Farmer	2
<b>45</b>	Cyporien	41-60	Male	Musanze	Farmer	1
<b>46</b>	J pierre	>60	Male	Musanze	Farmer	2
<b>47</b>	Elyse	41-60	Male	Musanze	Lead Farmer	2
<b>48</b>	Claudine	<25	Male	Musanze	Farmer	1
<b>49</b>	Jeanne	41-60	Female	Musanze	Farmer	2
<b>50</b>	Jean de Dien	41-60	Female	Musanze	Farmer	2
<b>51</b>	Delange	26-40	Female	Rubavu	Farmer	2
<b>52</b>	Emelance	26-40	Male	Rubavu	Farmer	1
<b>53</b>	Delange	41-60	Female	Rubavu	Farmer	2
<b>54</b>	J. Paul	<25	Male	Rubavu	Farmer	2
<b>55</b>	Generouse	26-40	Female	Rubavu	Farmer	1
<b>56</b>	Protais	41-60	Female	Rubavu	Lead Farmer	2
<b>57</b>	Bonifirda	41-60	Female	Nyabihu	Farmer	1
<b>58</b>	Jonus	<25	Male	Nyabihu	Farmer	2
<b>59</b>	Marie Chantal	<25	Female	Nyabihu	Farmer	1
<b>60</b>	Jacqueline	<25	Female	Nyabihu	Farmer	2
<b>61</b>	Patrick	41-60	Male	Nyabihu	Farmer	1
<b>62</b>	Jonus	41-60	Male	Nyabihu	Lead Farmer	2

#### IV. SPSS outcome

The questionnaires are analysed with SPSS and the outcomes are presented in this appendix. To present the outcomes, the same layout as the result chapters is used. All references in the main text are found in this appendix.

##### List of the tables in appendix IV:

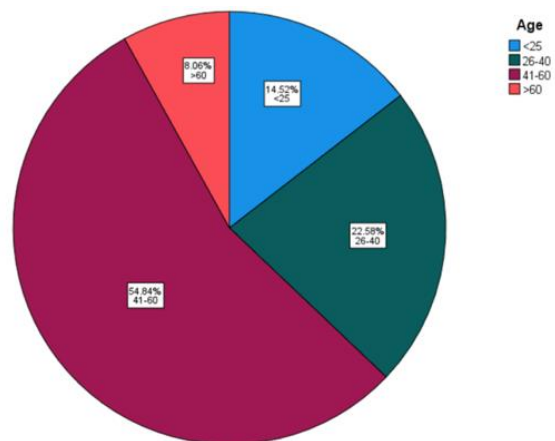
- Table 1: Correlation Spearman’s Rho on total field size, gender, seasons cultivated modern, modern size, and seasons involved in project.
- Table 2: Outcome reliability analysis SPSS, modern size, season involved in project, season cultivated modern & age.
- Table 3: Challenges in the modern way of farming potatoes
- Table 4: Correlation Spearman’s Rho on finance and loans.
- Table 5: Outcome reliability analysis SPSS, potato yields, income from potato farming & profit from potato farming.
- Table 6: Correlation Spearman’s Rho on plot size for potatoes, potato yields & income from potato farming.
- Table 7: Correlation Spearman’s Rho on produces change, seasons involved in the project & seasons cultivated modern.
- Table 8: Correlation Spearman’s Rho on modern size farmland & change in produce.
- Table 9: Correlation Spearman’s Rho on control over resources.
- Table 10: Correlation Spearman’s Rho on participation in agriculture production
- Table 11: Correlation Spearman’s Rho on decision making power
- Table 12: Correlation Spearman’s Rho on quality of the potatoes & intended outcome

##### General information

Out of the 62 participants of the survey, the largest group is between 41 - 60 years old. With this data is not possible to perform a parametric test as the variables are not normally distributed. A non-parametric test provides more accurate assumptions and conclusions. For that reason, the non-parametric Spearman’s rho tests whether the different variables correlate.

For these Likert scale variables, a Cronbach’s Alpha analyses is suitable, and the level of the Cronbach’s Alpha needs to be higher than 0.7 to be regarded reliable.

All questionnaire participants depend on the income out of farming potatoes and all participants cultivate potatoes as their main crop. This shows that they are heavily relying on the cultivation of potatoes.



Circle diagram with age of the participants





**Improved output**

• **Adoption**

Adopting the new farming technique to instigate the intensification of cultivation is the first intended outcome. A correlation has been found between seasons involved in the project, seasons cultivated in the modern way of farming and by the modern size of land applied (see *table 1*). This correlation means that when the number of seasons involved in the project increases, the seasons cultivated modern, and the modern size of the land also increase. The adoption of the new farming technique increases when participants are longer involved in the project.

*Table 1: Correlation Spearman’s Rho on total field size, gender, seasons cultivated modern, modern size, and seasons involved in project.*

			Total field size	Gender	Seasons cultivated modern	Modern size	Seasons involved in project
<b>Spearman’s rho</b>	Total field size	Correlation Coefficient	1.000	-.034	<b>.280*</b>	<b>.296 *</b>	.054
		Sig. (2-tailed)	.	.792	<b>.028</b>	<b>.020</b>	.679
		N	62	62	<b>62</b>	<b>62</b>	62
	Gender	Correlation Coefficient	-.034	1.000	-.077	-.167	-.018
		Sig. (2-tailed)	.792	.	.552	.195	.891
		N	62	62	62	62	62
	Seasons cultivated modern	Correlation Coefficient	<b>.280*</b>	-.077	1.000	<b>.871**</b>	<b>.668**</b>
		Sig. (2-tailed)	<b>.028</b>	.552	.	<b>&lt;.001</b>	<b>&lt;.001</b>
		N	<b>62</b>	62	62	<b>62</b>	<b>62</b>
	Modern size	Correlation Coefficient	<b>.296 *</b>	-.167	<b>.871**</b>	1.000	<b>.529**</b>
		Sig. (2-tailed)	<b>.020</b>	.195	<b>&lt;.001</b>	.	<b>&lt;.001</b>
		N	<b>62</b>	62	<b>62</b>	62	<b>62</b>
Seasons involved in project	Correlation Coefficient	.054	-.018	<b>.668**</b>	<b>.529**</b>	1.000	
	Sig. (2-tailed)	.679	.891	<b>&lt;.001</b>	<b>&lt;.001</b>	.	
	N	62	62	<b>62</b>	<b>62</b>	62	

\*. Correlation is significant at the 0.05 level (2-tailed).

\*\*. Correlation is significant at the 0.01 level (2-tailed).

To find out whether the variables modern size, seasons involved, seasons cultivated modern, and age reflect internal consistently and measure the construct a reliability analyses was carried out. A Cronbach’s Alpha analyses is suitable, and the level of the Cronbach’s Alpha needs to be higher than 0.7 to be regarded reliable. In *table 2* the outcome of the reliability analyses is shown. The Cronbach’s Alpha is 0.690 which is almost 0.7 which can be regarded as reliable. In the table *Item-Total Statistics* can be seen that three out the four items correlate with the overall questionnaires score as they all score >0.3 when looking at *Corrected Item – Total Correlation*.

*Table 2: Outcome reliability analysis SPSS, modern size, season involved in project, season cultivated modern & age.*

**Reliability Statistics**

Cronbach’s Alpha	N of items
.690	4

**Item-Total Statistics**

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach’s Alpha if Item Deleted
<i>Modern size</i>	5.31	3.265	.612	.524



Season involved in project	5.53	4.122	.608	.562
Season cultivated modern	6.31	3.068	.732	.429
Age	4.73	5.448	.063	.844

The challenges of the new technique of farming are visible in *table 3*. The amount of pesticides used became less, however the price went up. While fertilisers get used more and became more expensive. Manure was also more used in the new farming technique.

*Table 3: Challenges in the modern way of farming potatoes*

		Responses		Percent of cases
		N	Percent	
More challenging in modern farming	Access to finance	24	14.5%	39.3%
	In need of better seeds	30	18.1%	49.3%
	More labour required	32	19.3%	52.5%
	More manure required	37	22.3%	60.7%
	Pesticides more expensive	20	12.0%	32.8%
	Fertiliser more expensive	21	12.7%	34.4%
	Other	2	1.2%	3.3%
Total		166	100.0%	272.1%

Out of the survey it appears to be difficult to get access to finance. Almost half of the farmers (48.39%) said they do not have access to finance. Besides, there is correlation between the challenge of not have access to finance and want to learn how to get access to finance with a significant level of .049 (*table 4*). Which means when access to finance is a challenge the number of people who want to learn about finance increases.

*Table 4: Correlation Spearman's Rho on finance and loans.*

		Access to finance/ loans	[More challenging in modern way of farming potatoes] Access to finance	[Want to learn more about next time] Getting finance
<b>Spearman's rho</b>	Correlation Coefficient	1.000	.181	.053
	Sig. (2-tailed)	.	.159	.682
Access to finance/ loans	N	62	62	62
	Correlation Coefficient	.181	1.000	<b>.251*</b>
[More challenging in modern way of farming potatoes] Access to finance	Sig. (2-tailed)	.159	.	<b>.049</b>
	N	62	62	<b>62</b>
[Want to learn more about next time] Getting finance	Correlation Coefficient	.053	<b>.251*</b>	1.000
	Sig. (2-tailed)	.682	<b>.049</b>	.
		N	<b>62</b>	62

\*. Correlation is significant at the 0.05 level (2-tailed).



- **Increased yields, income, and profit**

The second intended outcome of the intensification of agriculture is the increase in yields, income, and profit. To find out whether these variables reflect internal consistently and measure the construct a reliability analyses was carried out. For these Likert scale variables, a Cronbach’s Alpha analyses is suitable, and the level of the Cronbach’s Alpha needs to be higher than 0.7 to be regarded reliable.

In *table 5* the outcome of the reliability analyses is shown. The Cronbach’s Alpha is 0.910 and thus the three Likert scale variables of more yields, more income and more profit can be regarded as reliable. In the table *Item-Total Statistics* can be seen that all items correlate with the overall questionnaires score as they all score >0.3 when looking at *Corrected Item – Total Correlation*. Besides, the Cronbach’s Alpha will not increase if one of the items were deleted (*Cronbach’s Alpha if Item Deleted*). All variables will be included in the further research results.

Table 5: Outcome reliability analysis SPSS, potato yields, income from potato farming & profit from potato farming.

Reliability Statistics				
Cronbach’s Alpha	N of items			
.910	3			

Item-Total Statistics				
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach’s Alpha if Item Deleted
Potato yields	8.32	1.781	.804	.890
Income from potato farming	8.49	1.590	.880	.823
Profit from potato farming	8.65	1.401	.805	.900

Another interesting result is the change in plot size for potatoes together with potato yields and income from potato farming. All are significantly correlated; however, the correlation coefficient is not very strong (see *table 6*). This means that when the plot size for potatoes increases the potato yields go up and the income increases too.

Table 6: Correlation Spearman’s Rho on plot size for potatoes, potato yields & income from potato farming.

			Plot size for potatoes	Potato yields	Income from potato farming
<b>Spearman’s rho</b>	Plot size for potatoes	Correlation Coefficient	1.000	<b>.432**</b>	<b>.380*</b>
		Sig. (2-tailed)	.	<b>.008</b>	<b>.020</b>
		N	37	<b>37</b>	<b>37</b>
	Potato yields	Correlation Coefficient	<b>.432**</b>	1.000	<b>.821**</b>
		Sig. (2-tailed)	<b>.008</b>	.	<b>&lt;.001</b>
		N	<b>37</b>	37	<b>37</b>
	Income from potato farming	Correlation Coefficient	<b>.380*</b>	<b>.821**</b>	1.000
		Sig. (2-tailed)	<b>.020</b>	<b>&lt;.001</b>	.
		N	<b>37</b>	<b>37</b>	37

\*. Correlation is significant at the 0.05 level (2-tailed).

\*\* . Correlation is significant at the 0.01 level (2-tailed).



## Livelihood enhancement

- **Physical capital**

*Table 7* indicates that all variables correlate with a significant level. The variables produce change and seasons involved in project have a negative correlation of 0.233 and produce change and seasons cultivated modern has a negative correlation of 0.491. As the correlation is closer to 0 than to 1, both correlations are not very strong. This means when the number of seasons increase of being involved in the project or cultivating modern, the produce of crops becomes less diversified.

*Table 7: Correlation Spearman's Rho on produces change, seasons involved in the project & seasons cultivated modern.*

			Produce change	Seasons involved in project	Seasons cultivated modern
<b>Spearman's rho</b>	Produce change	Correlation Coefficient	1.000	-.233*	-.491**
		Sig. (2-tailed)	.	.034	<.001
		N	62	62	62
	Seasons involved in project	Correlation Coefficient	-.233*	1.000	.668**
		Sig. (2-tailed)	.034	.	<.001
		N	62	62	62
	Seasons cultivated modern	Correlation Coefficient	-.491**	.668**	1.000
		Sig. (2-tailed)	<.001	<.001	.
		N	62	62	62

\*. Correlation is significant at the 0.05 level (1-tailed).

\*\*. Correlation is significant at the 0.01 level (1-tailed).

When specifically testing whether the modern field size has influence on the produce change in the farm, a similar interesting result occurs. *Table 8* shows correlation between the two variables with a negative significant level of .474. This means that as the modern size field increases the produces become less diversified.

*Table 8: Correlation Spearman's Rho on modern size farmland & change in produce.*

			Modern size	Produce change
<b>Spearman's rho</b>	Modern size	Correlation Coefficient	1.000	-.474*
		Sig. (2-tailed)	.	<.001
		N	62	62
	Produce change	Correlation Coefficient	-.474*	1.000
		Sig. (2-tailed)	<.001	.
		N	62	62

\*\*. Correlation is significant at the 0.01 level (2-tailed).



- **Social capital**

Correlation is found between household role and who sells the potatoes with a significant level of .007 (*table 9*). Gender is not correlated to who sells the potatoes.

*Table 9: Correlation Spearman's Rho on control over resources.*

			Gender	Age	Household role	Sells potatoes
<b>Spearman's rho</b>	Gender	Correlation Coefficient	1.000	.144	.459**	-.182
		Sig. (2-tailed)	.	.266	<.001	.158
		N	62	62	62	62
	Age	Correlation Coefficient	.144	1.000	-.461**	-.249
		Sig. (2-tailed)	.266	.	<.001	.051
		N	62	62	62	62
	Household role	Correlation Coefficient	.459**	-.461**	1.000	<b>.340**</b>
		Sig. (2-tailed)	<.001	<.001	.	<b>.007</b>
		N	62	62	62	<b>62</b>
	Sells potatoes	Correlation Coefficient	-.182	-.249	<b>.340**</b>	1.000
		Sig. (2-tailed)	.158	.051	<b>.007</b>	.
		N	62	62	<b>62</b>	62

\*\* . Correlation is significant at the 0.01 level (2-tailed).

The two variables of who works most hours on the farm correlate with who sells the potatoes on a significant level of .050 (*Table 10*). Although the correlation is not strong, closer to 0 than to 1.

*Table 10: Correlation Spearman's Rho on participation in agriculture production.*

			Works most on the farm	Sells potatoes
<b>Spearman's rho</b>	Works most on the farm	Correlation Coefficient	1.000	<b>.250*</b>
		Sig. (2-tailed)	.	<b>.050</b>
		N	62	<b>62</b>
	Sells potatoes	Correlation Coefficient	<b>.250*</b>	1.000
		Sig. (2-tailed)	<b>.050</b>	.
		N	<b>62</b>	62

\*\* . Correlation is significant at the 0.05 level (2-tailed).



While analysing the decision-making power of women something interesting came up. The household role correlates with who made the decision to join the project and who joined the training, both on a significant level of <.001 (table 11). Which indicates that who provides the answers is also most likely to make the decision to join the project and joined the trainings.

Table 11: Correlation Spearman’s Rho on decision making power.

		Gender	Household role	Who decided to join the project	Who joined the trainings	
<b>Spearman’s rho</b>	Gender	Correlation Coefficient	1.000	<b>.459**</b>	-.003	.029
		Sig. (2-tailed)	.	<b>&lt;.001</b>	.992	.821
		N	62	<b>62</b>	62	62
	Household role	Correlation Coefficient	<b>.459**</b>	1.000	<b>.568**</b>	<b>.571**</b>
		Sig. (2-tailed)	<b>&lt;.001</b>	.	<b>&lt;.001</b>	<b>&lt;.001</b>
		N	<b>62</b>	62	<b>62</b>	<b>62</b>
	Who decided to join the project	Correlation Coefficient	-.003	<b>.568**</b>	1.000	<b>.493**</b>
		Sig. (2-tailed)	.992	<b>&lt;.001</b>	.	<b>&lt;.001</b>
		N	62	<b>62</b>	62	<b>62</b>
	Who joined the trainings	Correlation Coefficient	.029	<b>.571**</b>	<b>.493**</b>	1.000
		Sig. (2-tailed)	.821	<b>&lt;.001</b>	<b>&lt;.001</b>	.
		N	62	<b>62</b>	<b>62</b>	62

\*\* . Correlation is significant at the 0.01 level (2-tailed).

- **Natural capital**

The quality of the potatoes become better and the pest and diseases in the potatoes decrease when in the process of intensification. Besides, there is a correlation between the quality of potatoes and the intended outcomes (more yields, more income, and more profit) with a significant level of .040 (table 12).

Table 12: Correlation Spearman’s Rho on quality of the potatoes & intended outcome.

		Quality of potatoes	Intended outcome	
<b>Spearman’s rho</b>	Quality of potatoes	Correlation Coefficient	1.000	
		Sig. (2-tailed)	.	
		N	37	
	Intended outcome	Correlation Coefficient	<b>.340*</b>	1.000
		Sig. (2-tailed)	<b>.040</b>	.
		N	<b>37</b>	37

\*. Correlation is significant at the 0.05 level (2-tailed).



## V. Interview guide

Present team members:  Date:  No. of interview:  Start time:  End time:	District:  Household role of respondent:  Age:  Seasons involved in the project:  % of modern farming:	
<p><i>Introduction:</i></p> <p>My name is Claudy and this is Emmanuel, he will translate everything into Kinyarwanda. I would like to ask you some questions about your experience of being involved in the SDGP project of the potato value chain. I am conducting this research for my master’s course at the University of Utrecht in the Netherlands and the interview will take around 45 minutes. The purpose of the interview is to get an insight on your own perspective and overall understanding of the impact of the SDGP project to farmers. Everything you tell me will only be used for this research project and will not be shared with anyone outside the research team. Also, your name will not be used, to make sure that no one can identify your answers.</p> <p>Are you willing to participate in this interview?</p> <p>Is it okay if I record the interview? Do you have any questions before we begin?</p> <p><i>Thank you for participating!</i></p>		
MAIN SUBJECT	SUBSUBJECT	QUESTION
Opening questions		1. How did you got involved in the project? 2. Why did you decided to join the project? 3. How many seasons have you applied the modern way of farming potatoes? 4. Why did you decided (not) to start farming the modern way?
<b>Theme 1:</b> Intended outcome	<ul style="list-style-type: none"> <li>• Adoption of modern technique</li> <li>• More yield, income &amp; profit</li> </ul>	5. Why do most farmers start applying the modern way from the second season involved? (trust, prove of improved yields) 6. What is needed for a farmer to confidently adopt the new farming technique? (After seeing results demo plot, having enough land, hearing from other members, cooperative, family) 7. What are the main obstacles from fully adopting the new farming technique? (Finance, too risky, labour, seeds) 8. Do you think you and the other trained potato farmers will continue farming with the new technique? (Why, how to sustain it, make it sustainable) 9. Almost all farmers experienced an increase in yields with adopting the new farming technique. However, this did not always translate to an increase in profit. How can you explain this?





		10. Do you think less profit will play a role for farmers not to adopt the modern technique of farming potatoes?
<b>Theme 2:</b> Unintended outcome	<ul style="list-style-type: none"> <li>Change production system</li> </ul>	<p>11. What are reasons for a farmer to decide to change their farm production?</p> <p>12. Most farmers mentioned to focus more on potatoes after starting the project. Do you think it is good or bad to be more focused on potatoes? (Why?)</p> <p>13. Do you know any negative effects of cultivating more potatoes and less different crops? (More depended on one crop/vulnerable)</p> <p>14. Do you know factors that could influence the soil health and structure?</p> <p>15. Does the new technique of farming influence the soil health and structure? (good/bad, what influences, fertiliser/manure/pesticides)</p> <p>16. In the potato farming, which technique do you think costs more money? (Traditional/modern, explain this)</p> <p>17. In potato farming, which technique have you experienced results in the best quality potatoes? (Traditional/modern/same, why)</p>
<b>Theme 3:</b> Unintended outcome	<ul style="list-style-type: none"> <li>Materialisation of income</li> </ul>	<p>18. Did you experience an increase in profit? If yes, what did you primarily spend it on? (Why, who makes that decision)</p> <p>19. Most farmers chose to spend the extra money on their farm by buying land, livestock, or better seeds. What do you think of this decision?</p>
<b>Theme 4:</b> Unintended outcome	<ul style="list-style-type: none"> <li>Sustainable adoption</li> </ul>	<p>20. What types of support have you been offered by the project? What did you think of the support? (Effective, why good/not good, improvements suggestions)</p> <p>21. Describe your collaboration with SPF/HGT agronomists.</p> <p>22. How have you been assisted and prepared to host a FFD?</p> <p>23. What are factors which influence you and other farmers to adopt the steps out of the trainings? (The agronomist, the outcome, the costs)</p> <p>24. Do you remember all the steps of the modern way/new way of farming taught by the lead farmer and agronomist?</p> <p>25. Do you and other farmers apply all the steps taught during the FFD (Farmer Field Days) by the lead farmer and agronomist? (Why yes/no)</p> <p>26. How accessible are good potato seeds? What about the price? (Why, how?)</p> <p>27. What can be done to improve the access to seeds?</p>



		<p>28. How accessible are fertilisers? What about the price? (Why, how?)</p> <p>29. How accessible are pesticides? What about the price? (Why, how?)</p> <p>30. How accessible is manure? What about the price? (Why, how?)</p> <p>31. How accessible are third-party labour? What about the price? (Why, how?)</p> <p>32. How accessible are markets to sell the potatoes?</p> <p>33. Are there improvements needed regarding access to the above items? (Seeds, fertiliser, pesticides, manure, labour)</p> <p>34. Some farmers do not have access to finance. What is the main reason for not having access to finance?</p> <p>35. How can access to finance be improved?</p>
<b>Theme 5:</b> Unintended outcome	<ul style="list-style-type: none"> <li>Gender differences</li> </ul>	<p>36. Can you describe a day in your life that shows the different roles of you and your partner? (In the household and at the farm)</p> <p>37. Do you think the role has changed after starting the new technique of potato farming?</p> <p>38. In your community, do women have the same land rights as man? (Same to legal rights, why yes/no)</p> <p>39. What do you think of a wife who works more hours on the farm compared her husband?</p> <p>40. Is it common for females to sell potatoes? What are your thoughts about this?</p> <p>41. In your household, who takes decisions about the farm? (Husband/wife, why, whether to adopt the new technique)</p>
<i>Fading-out questions</i>	Project specific questions	<p>42. Looking at the future, what are your expectations of the new technique of potato farming?</p> <p>43. Besides the FFD, are you still in contact with the support farmers? (If yes, about what and when?)</p> <p>44. What do you think of your role as a lead farmer?</p>

*Thank you so much again for participating in this interview!*

***Reflect on the interview together with the translator***

*Body language of the participant during the interview:*

*Surrounding/atmosphere while conducting the interview:*

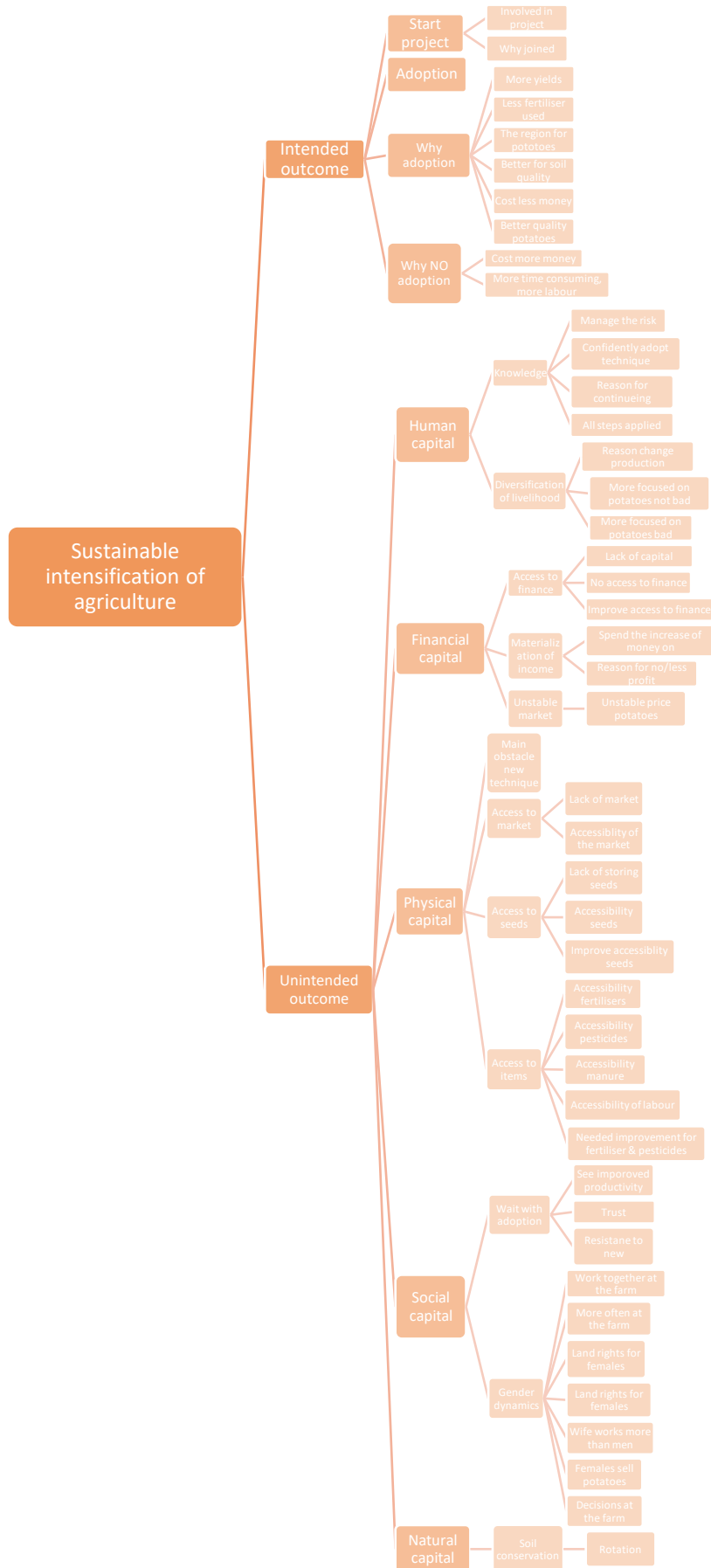


## VI. Overview of interview participants

<b>Nr.</b>	<b>Name</b>	<b>Age</b>	<b>Sex</b>	<b>District</b>	<b>Seasons involved</b>
<b>1</b>	Theoville	27	Male	Rubavu	2
<b>2</b>	Wensisilas	50	Male	Rubavu	2
<b>3</b>	Xaverine	45	Male	Rubavu	2
<b>4</b>	Deborah	55	Female	Nyabihu	2
<b>5</b>	Diana	48	Female	Nyabihu	2
<b>6</b>	Emmanuel	50	Male	Nyabihu	2
<b>7</b>	Patricia	42	Female	Musanze	2
<b>8</b>	Jean Bosco	35	Male	Musanze	2
<b>9</b>	Francois	55	Male	Musanze	2
<b>10</b>	Dative	28	Female	Musanze	2
<b>11</b>	Isaac	65	Male	Musanze	2



VII. Coding tree



## VIII. Traditional versus intensified farming method

- **Traditional method of farming potatoes**

There are multiple higher 'beds' with holes. The seeds and fertiliser go in the hole. The hole with seed and fertiliser gets covered with soil.



Source: personal photo

- **Intensified method of farming potatoes**

The fertiliser, manure is added to the line and covered with soil. The seeds go on top with 10 cm distance between each seed. The seeds get covered with soil and one higher line is constructed.



Source: personal photo