Smallholder Farmers' Adoption of Radical Terraces and Their Effects on Food Production and Security in Nyamagabe District, Rwanda

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other university.

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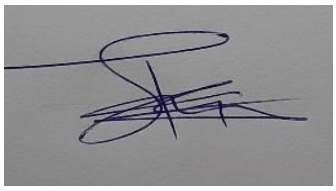
Signature:  Date: 02 September, 2023

DEDICATION

To the Almighty God

To the cherished memories of my late father, Jean Damascene Habiyambere, and my late mother Marthe Nyiraminani, my late stepmother Emerance Urayeneza and my late brothers and sisters.

To my beloved wife Odile Mukamutesi.

To my children Isingizwe S. Irénée, Ikuzwe S. Landry, Irakoze S. Ghislaine, Ihimbazwe S. Amedée and Iratwe S. Amelie.

To my brothers and sisters.

To my family and family-in-law; and

To all my friends, colleagues, and classmates,

With utmost respect and gratitude, this thesis is dedicated to each and every one of you.

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LIST OF ACRONYMS AND ABBREVIATIONS

AI	:	Agricultural Information
BDC	:	Belgium Development Cooperation
BPR	:	Banque Populaire du Rwanda
CAADP	:	Comprehensive Africa Agriculture Development Programme
CAC	:	Cell Agricultural Committee
CFSVA	:	Comprehensive Food security and Vulnerability Analysis
CIP	:	Crop Intensification Programme
CTB	:	Cooperation Technique Belge
DAC	:	District Agricultural Committee
DWCRA	:	Development of Women and Children in Rural Areas
EDPRS	:	Economic Development and Poverty Reduction Strategies
FAO	:	Food and Agriculture Organization
FBOs	:	Farmer-Based Organizations
FFS	:	Farmer Field Schools
FP	:	Farmer Promotors
FSD	:	Farming System Development
FUG	:	Fadama User Groups
FWUC	:	Farmer Water User Communities
GDP	:	Gross Domestic Product
HGS	:	Home Grown Solution
HIMO	:	Haute Intensité de la Main d'Oeuvre
IPMS	:	Improving Productivity and Market Success
KOAKUKI	:	Koperative y'Abahinzi b'Amaterasi ba Kibilizi, Uwinkingi na Kibumbwe
LODA	:	Local Administrative Entities Development Agency
LWH	:	Land-Husbandry, Water-Harvesting and Hillside Irrigation
MINAGRI	:	Ministry of Agriculture
MINECOFIN	:	Ministry of Economic planning and Finance
MINIPLAN	:	Ministère de la Planification
MINITERE	:	Ministère de la Terre
MOUCECORE	:	Mouvement Chrétien pour l'Evangélisation, le Counseling et la Réconciliation
MRA	:	Multi-Regression Analysis
NAEB	:	National Agriculture Export Board

NAP	:	National Agriculture Policy
NGO	:	Non-Governmental Organization
NISR	:	National Institute of Statistics of Rwanda
NNP	:	Nyungwe National Park
NPK	:	Nitrogen, Phosphorus and Potassium
PSF	:	Private Sector Federation
RAB	:	Rwanda Agricultural Broad
RoR	:	Republic of Rwanda
RSSP	:	Rural Sector Support Project
SAC	:	Sector Agricultural Committee
SACCO	:	Saving and Credit Cooperative
SC	:	Scheduled Caste
SEDO	:	Social and Economic Development Officer
SHPIs	:	Self-Help Promoting Institutions
SPSS	:	Statistical Package for Social Sciences
ST	:	Scheduled Tribe
SWC	:	Soil and Water Conservation
TRPA	:	Tahoe Regional Planning Agency
TV	:	Television
TVET	:	Technical and Vocational Education and Training
UNICOOPAGI	:	Union des Cooperatives Agricoles Integrees
UON	:	University of Nairobi
USAID	:	United States Agency for International Development
VUP	:	Vision 2020 Umurenge Programme

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Abstract

A national survey conducted in 2016 revealed that out of Rwanda's 1,963,975 households, 473,847 were food insecure, with 63,696 classified as severely food insecure, while 979,045 were marginally food secure. Rwanda, not only a small country covering 26,338 square km but also landlocked, is often called the “Land of a Thousand Hills” due to its hilly terrain. Additionally, it sustains a large population, estimated at 13,697,803 in 2021, with a population density of 525 persons/sq. Km (NISR, 2022). Around 80% of the population relies on agriculture, which contributes 34% to the GDP and remains a primary employer (Mbonigaba, 2013; Republic of Rwanda, 2014; World Bank, 2014, p. 2). However, agricultural growth has been declining over the years, significantly impacting food security. For instance, agricultural growth rates were 0.5% in the 1980s, 3.9% in the 1990s, 9% in the 2000s, 8% in 2010, and 7.8% in 2015 (NISR, 2017).

To address the declining food security situation, the Rwandan government introduced Radical terraces, an agricultural technology aimed at preserving soil and enhancing farming activities in the highland areas to increase agricultural production and ensure food security. Despite this initiative, many of the radical terraces are underutilized or abandoned by farmers, negatively impacting agricultural productivity and food security. In this context, this study sought to examine smallholder farmers' adoption of radical terraces and its effect on ensuring their food security.

The literature review covered food security, adoption of radical terraces, and factors influencing adoption, including farmers' characteristics, access to agricultural information, membership in self-help groups, outside support from agencies, and participation in decision-making related to radical terraces. However, limited attention has been given to the role of community participation in food production projects, like the adoption of radical terraces and its impact on food security. The study utilized the adoption and diffusion model of farm innovations and food security theoretical perspectives as the basis for its research.

The research design employed for the study was descriptive and correlational. Nyamagabe District was selected as the study site due to its adoption of radical terraces, despite being significantly affected by food shortages. Four sectors, Nkomane, Buruhukiro, Kibilizi, and Gatare, were purposively sampled from the district, along with eight cells and twenty-four villages within these sectors. The target population consisted of smallholder farmers who had adopted radical terraces, and data were collected through semi-structured interviews with the sampled farmers and interviews with nineteen key informants involved in the radical terraces project. Quantitative and qualitative data were collected and analysed using SPSS version 23 and thematic and narrative content analysis.

The main findings indicated a positive and significant correlation between food security and farmers' adoption of radical terraces. The regression model showed that 96.8% of food security could be explained by the adoption of the radical terraces variable ($R2 = 0.968$; $F (12, 179) = 446.775$, $p < 0.001$). Many farmers reported improved food security after adopting radical terraces, with an increase in the daily meals taken by their households. Furthermore, farmers' adoption of radical terraces was significantly correlated with their family size, reported seasonal income, and land size owned, explaining 72% of the overall relationship between these variables ($R2 = 0.720$, $F (14, 177) = 32.469$, $p < 0.001$). Similarly, farmers' adoption of radical terraces was significantly correlated with their access to information sources about farming and radical terraces, explaining 70% of the overall relationship ($R2 = 0.7001$, $F (9, 182) = 47.282$, $p < 0.001$).

Moreover, farmers' adoption of radical terraces was significantly correlated with their membership in self-help groups, outside support received from agencies, and participation in decision-making on radical terraces, explaining 68.5%, 68.1%, and 72.2% of the overall relationships, respectively ($R2 = 0.685$, $F (8, 183) = 49.824$, $p < .001$; $R2 = 0.681$, $F (9, 182) = 43.232$, $p < .001$; $R2 = 0.722$, $F (9, 182) = 52.632$, $p < .001$).

The study suggests that continued government sensitization and education on adopting and maintaining radical terraces is necessary to improve food production and security. Additionally, providing low-cost and affordable loans to farmers for investing in farming, including radical terraces, is recommended. Finally, the potential application of the Technology Characteristics-Users' Context model in adopting radical terraces in Rwanda warrants further research.

CHAPTER ONE: INTRODUCTION

1.0 Background to the Study

In 2016, the "Comprehensive Food Security and Vulnerability Analysis survey (CFSVA)" conducted in Rwanda revealed that out of the country's 1,963,975 households, 473,847 were classified as food insecure. Among these, 63,696 households faced severe food insecurity, while 979,045 were marginally food secure, implying a high risk of becoming food insecure (NISR, 2016).

Food, a fundamental human need, drives individuals to engage in activities exploiting the environment to produce it (Ndagi, 2017). Within the academic discourse, the term 'food security' embodies the state wherein individuals consistently possess physical and economic means to obtain ample safe and nourishing sustenance, thus satisfying their nutritional needs and culinary preferences to facilitate an active and healthy existence. This concept encompasses not only the presence and accessibility of food resources but also their effective utilization to meet dietary requirements (NISR, 2016). Fundamentally, the cornerstone strategy for upholding food security resides in the autonomous agricultural production by farmers, coupled with their capacity to acquire sustenance (Sen, 1999).

Rwanda, a small landlocked nation spanning an expanse of 26,338 square kilometres, has earned renown as the 'Land of a Thousand Hills,' predominantly due to its undulating landscape (Republic of Rwanda, 2015). Despite its modest dimensions and rolling topography, Rwanda sustains a considerable populace. As of 2021, the approximate total population reached 13,697,803, contributing to a population density of 525 individuals per square kilometre (NISR, 2022). This substantial populace heavily depends on agriculture, a promising expansion potential sector. However, although agriculture remains paramount in the Rwandan economy, it also presents formidable challenges (Republic of Rwanda, 2014).

Most Rwandan farmers engage in subsistence farming, cultivating small family plots. As stated by the World Bank, "Rwandan agriculture is characterized by small production units that average 0.33 hectares in size" (2014, p. 2). Like many developing nations, Rwanda's economic landscape maintains a steadfast agricultural orientation, wherein the lion's agricultural output originates from small-scale subsistence farmers (Republic of Rwanda, 2012). The agricultural domain is the chief wellspring of employment and contributes to 34% of the National Gross Domestic Product (GDP) (Mbonigaba, 2013; Republic of Rwanda,

2014). However, agricultural growth has fluctuated over time, with growth rates of 0.5% in the 1980s, 3.9% in the 1990s, 9% in the 2000s, 8% in 2010, and 7.8% in 2015 (NISR, 2017).

Agricultural production in Rwanda primarily hinges on smaller-than-average farm sizes, considered inadequate for household sustainability, and declining soil fertility. These combined factors hinder food production efforts (Alinda and Abbott, 2012). Rwanda's public policies and initiatives are dedicated to tackling these production hurdles, which result in food scarcity, impede children's growth, and contribute to malnutrition. There is a pronounced emphasis on implementing interventions designed to enhance farm productivity and cultivate growth within the agricultural sector.

Rwandan farming systems underscore the necessity of bolstering productivity while concurrently mitigating land degradation and soil erosion (Bizimana, 2011). However, the Republic of Rwanda (2004) highlights that "inappropriate farming practices have adverse impacts on both the environment and food production. Declining soil fertility and farmers' limited utilization of modern agricultural inputs adversely affect food production levels" (p. 6). Hence, for Rwanda to effectively meet its food demands, an increase in production hinges, among other factors, on strategies for soil erosion control and conservation. These strategies should be underpinned by national agricultural and nutrition policies that strongly advocate for the active involvement of local farmers and their leaders.

The Rwandan government formulated the National Agricultural Policy (NAP) in 2004 to address these challenges, primarily promoting consistent economic growth by elevating farm incomes (Bizimana, 2011). A multitude of strategies were outlined for its implementation. Notably, one of the key pillars on which the NAP relied to ensure food security was the transformation and modernization of agriculture (Republic of Rwanda, 2004, p. 9). The principal goal of this policy was to empower rural communities to actively engage as stakeholders in the progress of the agricultural sector.

In tandem with the NAP, the Government of Rwanda initiated the Crop Intensification Program (CIP) in September 2007. As documented in the Republic of Rwanda Report (2012), the primary objective of CIP is to amplify agricultural productivity within regions with high potential for food crop cultivation, thereby securing food sufficiency and self-reliance for Rwandan communities.

Nevertheless, several factors posed potential constraints to the successful implementation of the NAP. These factors encompassed the lack of effective coordination between

administration and extension services provided by the Ministry of Agriculture (MINAGRI), diverse actors' varying interpretations of the policy, inadequacies in the extension system, and deficiencies in training and extension services. Additional limitations included insufficient training leading to ignorance (Ubujiji) and inadequate agricultural information for a segment of farmers, the absence of functional self-help groups, an imbalance between research and the transfer of technologies, a deep-rooted tradition of subsistence farming, and the scarcity of financial resources and external support (Republic of Rwanda, 2004). These cumulative factors contributed to the prevalence of household food insecurity.

One of the primary avenues to alleviate farmers' food insecurity involves their adoption of radical terraces. Adoption can be elucidated as the conscious decision to comprehend an innovation as the most suitable course of action. Moreover, it encompasses this innovation's recurrent and persistent integration into a farmer's ongoing practices (Peshin et al., 2014). According to Rogers (2003), the diffusion of innovation unfolds as a social process wherein farmers communicate and exchange agricultural knowledge, ultimately fostering communal comprehension.

In line with this perspective, the Republic of Rwanda (2012) underscores that the pivotal transformation of the agricultural sector would have the most significant influence on enhancing farmer self-sufficiency regarding food security and poverty reduction within Rwanda. Correspondingly, the Republic of Rwanda (2010) has emphasized the importance of Soil and Water Conservation (SWC) measures, encompassing techniques to restore and preserve agricultural land. This entails providing access to technical insights on soil conservation measures, such as radical terraces, representing fundamental approaches to bolstering food production.

In this study, our primary focus revolves around adopting radical terraces[1] as a fundamental method for transforming agriculture and ensuring a substantial increase in sustainable food production.

[1]Radical Terraces (Amaterasi y'indinganire), colloquially known as 'radical terracing' among the local population, constitutes a technique encompassing earth-moving activities. This approach entails the construction of reverse-slope bench terraces, wherein well-formed risers are established and fortified with vegetation such as grass or trees along the embankments to prevent any risk of collapse (WOCAT [2014] database reference: T_RWA003en Radical Terraces Rwanda).

Mupenzi et al. (2014) point out that “radical terraces had the potential to enhance farm productivity” (p. 53). However, starting from 1980, soil erosion has exerted a substantial influence on agricultural operations in Rwanda. The issue of land degradation due to erosion has arisen as a critical concern, impacting not only agricultural output and food security but also the environment and the overall well-being of resource-scarce farmers (Republic of Rwanda, 2010).

As indicated by the Republic of Rwanda (2014), the endeavour to counter food insecurity through adopting radical terraces demands a decentralized approach to the ownership of innovative farming technologies. This approach underscores the significance of local farmer ownership, active engagement, and cooperation within agricultural self-help groups. Furthermore, it stresses enhancing access to information and assistance from diverse extension agencies.

The primary focus of this research centres on household food security within Nyamagabe, a district located in Rwanda. Farm production's potential augmentation and food insecurity alleviation are closely associated with farmers' adoption of radical terraces. The inclination of farmers to embrace these terraces is anticipated to be shaped by various factors, encompassing their attributes, participation in terracing-related decision-making, and access to extension information and assistance facilitated through self-help groups and extension agencies.

1.1 The Radical Terraces Project: An Overview

In order to address the challenges above, diverse strategies were formulated and implemented with the primary objective of augmenting agricultural productivity. Radical terraces were employed among these strategies to safeguard land and enhance farm productivity (Mupenzi et al., 2014).

Historically, the concept of radical terraces was introduced in 1972 by Syrille Wieme, a religious figure in Rwanda’s Kisaro region, located in the Rurindo District of the North Province. By 1979, the Rwandan Government officially recognized and promoted the adoption of radical terraces among all Rwandan farmers, targeting numerous households for implementation (Bizimana, 2011). The implementation of radical terraces in the Nyamagabe District aimed to enhance soil fertility, increase food production, and ensure food security. Additionally, these terraces were designed to facilitate modern cropping operations, promote intensive land use on slopes, and reduce shifting cultivation (Republic of Rwanda, 2010).

Proper maintenance and protection of the newly constructed terraces were essential to realize increased agricultural production and food security.

Adopting radical terraces as a farming practice enables Rwandan farmers to cultivate in areas with hilly or mountainous terrain where traditional farming methods are not feasible. According to UNPD (2007), erosion in Rwanda leads to approximately 15 million tonnes of soil loss annually, resulting in a decline in the capability to feed around 40,000 inhabitants yearly sustainably. To address this concern, the radical terraces project was initiated to protect land and increase farm productivity for the highland population (Mupenzi et al., 2014).

Radical terraces are particularly well-suited for slopes with a gradient ranging from 13 to 55 per cent. Approximately 1,000,000 households possess agricultural land with the potential for radical terracing, representing a substantial portion of the country's farming population. The ambitious goal of the radical terraces project was to ensure the adoption and diffusion of this technique to 71 per cent of the entire farming community (Republic of Rwanda, 2012).

On the other hand, several barriers impede the successful implementation of radical terraces, including the limited availability of technical skills, a lack of comprehensive reference information, and challenges related to acceptance within local communities. Moreover, the vast arable land in Rwanda, amounting to 294,000 hectares, necessitates the widespread adoption of radical terraces to combat soil erosion. In light of this, between 2008 and 2012, 5,736 hectares of radical terraces were developed as agricultural technology, and an additional 1,500 hectares were constructed in the subsequent period from 2013 to 2018 in the Nyamagabe District (Nyamagabe District, 2018).

1.2 Statement of the Problem

By 2016, approximately 979,045 households in Rwanda were confronted with elevated vulnerability to encountering food insecurity, while 473,847 households were already labelled as food insecure. Within this group, 63,696 were grappling with severe food insecurity (NISR, 2016). A pivotal factor governing food security resides in the extent of production accomplished by households. To attain food security, a household must produce a certain quantity of food crops (RoR, 2014). This study measures the amount of food produced based on the total number of bags or kilograms obtained annually from the farmed hectares of radical terraces in each household or smallholder farmer's possession (NISR, 2016). The quantity of food produced

significantly influences the acceptance and adoption of new farming ideas and technologies. Considering Rwanda's topography, characterized by numerous hills, adopting modern technologies like radical terraces is imperative to combat soil erosion and enhance productivity. Consequently, radical terracing emerges as a critical approach to addressing food insecurity within the nation (Republic of Rwanda, 2021).

By adopting radical terraces as a farming practice, Rwandan farmers can cultivate on hilly or mountainous terrain that would otherwise prove challenging to farm conventionally. According to UNPD (2007), Rwanda experiences an annual soil loss of approximately 15 million tones due to erosion, leading to the loss of the capability to feed about 40,000 inhabitants each year sustainably. As a countermeasure to this concern, the radical terraces initiative emerges as one of the strategies directed towards safeguarding land and elevating farm productivity within the highland-dwelling populace (Mupenzi et al., 2014).

Radical terraces are best suited for slopes ranging from 13 per cent to 55 per cent steepness. It is estimated that approximately 1,000,000 households own agricultural land with the potential for radical terracing, representing a significant portion of the country's farming population. The ambitious goal of the radical terraces project was to ensure its adoption and diffusion among 71 per cent of the entire farming community (Republic of Rwanda, 2012). However, there are various barriers to its effective implementation, such as limited technical skills in terracing, insufficient reference information, and challenges related to acceptability within local communities.

Moreover, Rwanda's arable land, amounting to 294,000 hectares, necessitates the widespread adoption of radical terraces to combat soil erosion. From 2008 to 2012, agricultural technology encompassing 5,736 hectares of radical terraces was established, and a further 1,500 hectares were earmarked for development between 2013 and 2018 within the Nyamagabe District (Nyamagabe District, 2013).

The low adoption of new farming innovations like radical terraces has contributed to low food production and food insecurity, prompting the government to mobilize people to adopt radical terraces to ensure food security (Nyamagabe District, 2013; the Republic of Rwanda, 2014). Mupenzi et al. (2014) recognized the favourable influence of radical terraces on augmenting farm productivity and their contribution to advancing food security and sustainability.

Regrettably, a significant number of radical terraces are presently underutilized or left in a state of abandonment due to the absence of maintenance and revitalization efforts. This circumstance holds substantial implications for Rwanda's agricultural productivity and food security, culminating in pronounced food shortages in specific regions. This is particularly evident in the Nyamagabe District, where 42% of households experience food insecurity (NISR, 2016).

Various factors need to be considered to ensure the effective adoption of radical terraces, including farmer characteristics, access to extension sources of information, membership in self-help groups, participation in decision-making, and support from outside agencies. These factors have been discussed in detail in other studies, such as those conducted by Rogers (1981), Kinyangi (2014), Odini (2014), Sundaram (2012), and others. Farmer participation is crucial in identifying and addressing problems related to food security (Onyango, 2009), and community self-help groups that employ radical terraces can contribute significantly to food production and resource management (ILO, 2006).

Support from external sources, including government bodies, non-governmental organizations, and local administrations, holds a crucial significance in aiding farmers by providing financial resources, training opportunities, and adopting novel agricultural methods (Bandeth, 2010; Garnevska et al., 2011). This assistance is pivotal in facilitating the effective execution and acceptance of radical terraces, thereby contributing to realizing food security objectives.

1.3 Research Questions

1 What is the influence of farmer characteristics on the adoption of radical terraces?
2 To what extent do farmers have access to agricultural information when adopting radical terraces?
3 How does participation in self-help groups impact farmers' adoption of radical terraces?
4 How does external support influence farmers' decision to adopt radical terraces?
5 How does the involvement of smallholder farmers affect the adoption of radical terraces?
6 What impact does adopting radical terraces have on enhancing household food security?

1.4 Objectives of the Study

1.4.1 General Objective

The primary aim of this study was to examine farmers' adoption of radical terraces and their influence on establishing food security within the Nyamagabe district of Rwanda.

1.4.2 Specific Objectives

The specific objectives of the study were:

a) To assess farmers' level of adoption of radical terraces and its effect on their food security.
b) To evaluate how farmer attributes impact their decision to adopt radical terraces.
c) To investigate the extent of farmers' accessibility to agricultural information and its impact on their adoption of radical terraces.
d) To determine the role of farmers' involvement in self-help groups in relation to the adoption of radical terraces.
e) To gauge the effect of external assistance on farmers' choice to adopt radical terraces.
f) To scrutinize the effect of smallholder farmers' engagement on adopting radical terraces within the Nyamagabe district.

1.5 Justification for the Study

The information gathered from this research will prove valuable to other researchers interested in conducting similar or related studies, as it offers valuable insights into radical terraces and related agricultural programs. Additionally, the study's findings will provide crucial insights to policymakers, planners, and implementers, including local leaders, to aid them in their future agricultural development. Through an analysis of the root causes behind the underutilization of radical terraces and their impact on farm production, this study will offer guidance to leaders, decision-makers, and planners on strategies to enhance the effectiveness of the terraces project, leading to increased farm production and improved food security.

1.6 Scope and Limitations of the Study

This study is centred on the agricultural program known as 'Radical terraces,' which is currently being implemented in the Nyamagabe district of Rwanda. Despite farmers' adoption of extensive hectares of radical terraces in the district, it still grapples with severe food shortages. The primary aim of this research is to analyze the extent of farmers' acceptance of the radical terraces program, pinpoint the factors that either promote or hinder this adoption process and subsequently shed light on the persisting issue of food insecurity within the district. In terms of methodology, this study adopts a rural sociological approach to investigate how farmers adopt and diffuse innovative farming practices, like radical terraces, using an adoption-diffusion model.

1.7 Definitions of Key Concepts

Smallholder Farmer: This term refers to an agricultural operator accessing farming land between 0.2 and 12 hectares (Kithu, 2012).

Smallholder farmer characteristics: This term encompasses a range of characteristics of smallholder farmers, encompassing elements such as age, gender, educational background, marital status, family size, occupation, primary source of income, seasonal income, and extent of land ownership.

Farmer Participation: It signifies the engagement of farmers in decision-making processes related to adopting radical terraces for food production. This involvement encompasses activities such as accessing information, seeking consultations, engaging in collaborative decision-making, working collectively, and mutually supporting one another's interests associated with adopting radical terraces. This study emphasises farmer involvement in decision-making related to radical terraces projects, including initiation, planning, implementation, monitoring, and evaluation. Additionally, the study examines the frequency of meetings attended by farmers, their contribution to the decision-making process (e.g., information sharing, consultation, collective decision-making, joint action, and support), and the types of contributions made by farmers to the adoption of radical terraces (e.g., labour, materials, land, cash, and ideas).

Access to agricultural information: This pertains to the reception of information concerning agricultural production activities from diverse channels and extension methods, including extension services (training, advisory support, visits, demonstrations, and guidance on seasonal tasks), mass media, and agricultural research. The study examines the various sources of information accessed, the extent of access to these sources, and the advantages gained from obtaining agricultural information.

Level of access to agricultural information: This term describes the intensity at which messages related to agriculture are acquired, categorized as very high, high, medium, or low at local and national levels. The availability of agricultural information fosters interpersonal connections between agricultural extension professionals and farmers, enriching farmers' understanding of information, knowledge, and awareness regarding contemporary

agricultural developments. This, in turn, encourages the adoption of radical terraces and contributes to the enhancement of food production (Odongo, 2014).

Self-help Group: This denotes a group of individuals who offer reciprocal assistance, addressing shared challenges, goals, and ambitions while collectively taking on responsibilities (Oka T. & Borkman, T., 2000). Within this study, significant facets connected to self-help groups encompass the duration of farmers' membership, the leadership roles farmers undertake, and the advantages farmers accrue through their participation in self-help groups, particularly concerning radical terraces.

Outside Support: This term refers to the support or assistance provided to farmers by external agencies, such as the government, local authorities, non-governmental organizations, and private sector federations. This support can take various forms, including technical, financial, and material aid (Bandeth, 2010). The study focuses on the types of agencies providing support to farmers, the amount of support offered, and how farmers utilize the support or credit received.

Adoption: Adoption is the deliberate choice to employ innovation as the most optimal strategy. Lionberger (1970) characterises adoption as integrating innovation into a farmer's ongoing practices, achieved through repeated and sustained utilization (Peshin et al., 2014).

Diffusion: This concept relates to how individuals within a community embrace innovation. This process aims to transform the conventional mindset of insular rural communities towards advancement using innovative approaches (Bonye et al., 2013). Diffusion also encompasses the gradual dissemination of innovation among the constituents of a social system over time (Rogers, 1983), as cited by Masinde (2009). Currently, it concerns how community members, particularly smallholder farmers, accept and disseminate radical terraces as new farming technology and continuously use it.

Radical terraces: Radical terraces constitute a form of adaptive technology that transforms inclined land into a series of gradually receding, flat surfaces resembling steps. This design is aimed at mitigating runoff and soil erosion. Constructed on sloped areas susceptible to erosion, these terraces segment the steep gradient into more level segments upheld by modest retaining walls. These levelled portions reduce the overall length of the slope (Republic of Rwanda, 2012).

Adoption of radical terraces: This phrase alludes to transforming sloped terrain into a series of successive platforms to diminish runoff and soil erosion. Radical terraces play a role in conserving soil moisture and fertility, streamlining contemporary farming practices, encouraging intensive land utilization, and establishing permanent agriculture on inclines, thereby minimizing shifting cultivation (FAO, 2009; TRPA, 2014). Metrics indicating the adoption and application of radical terraces encompass the duration of experience in constructing such terraces, the area (in square meters) dedicated to radical terraces, the extent of upkeep for these terraces, the cultivation of fodder on radical terraces, and the utilization of such fodder.

Food Production: Food production refers to the number of crops produced within a household to achieve food security. Household food production is measured by the total number of bags or kilograms of crops produced annually by a household from the hectares of radical terraces cultivated (RoR, 2014). This study assesses two types of food production: food crop production and livestock production. Food crop production indicators include planted food crops, seedbed preparation, types of seeds planted, use of chemical fertilizers, use of farm yield manure, clean weeding, and crop yield. Livestock production indicators include the type of livestock kept (local or improved), milk production yield, and sales of farmer's livestock.

Food Security: Food security signifies a state in which every individual consistently possesses both physical and economic means to access an ample, safe, and nourishing food supply that caters to their nutritional requisites and dietary preferences, thus promoting a robust and vigorous life. It encompasses guaranteeing the presence of food and ensuring its accessibility and effective utilization (NISR, 2016).

1.8 Thesis Outline

This thesis is organized into six chapters as outlined below:

Chapter One: Introduction

This section offers an overview of the research, including its contextual background, problem statement, research inquiries, and objectives. It also substantiates the importance of the study, outlines its boundaries and constraints, explicates essential terms, and proposes the thesis framework.

Chapter Two: Literature Review and Theoretical Framework

This chapter presents an all-encompassing assessment of pertinent literature, focusing on subjects such as community engagement, access to agricultural information, external assistance, and self-help groups. Additionally, the chapter explores the theoretical viewpoints related to community involvement, adoption and diffusion, food production and security.

Chapter Three: Research Methodology

This segment delves into the research methodology applied, covering elements like the description of the study location, research design, sampling methods, data collection, and analytical techniques. Moreover, the chapter addresses any encountered research challenges and ethical considerations.

Chapter Four: Data Analysis, Presentation, and Interpretation

Chapter four provides a thorough analysis and presentation of the collected data, presenting descriptive statistics to offer insights.

Chapter Five: Analysis of Relationship between Study Variables

Chapter five delves into the interrelations between study variables and employs regression analysis to examine how predictor variables impact response variables.

Chapter Six: Summary, Conclusions and Recommendations

The concluding chapter scrutinizes the research's theoretical assumptions, highlights key findings, deduces conclusions from the study's outcomes, proposes policy recommendations, and points out potential avenues for further research.

CHAPTER TWO: LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.0 Introduction

This chapter reviews relevant literature, which serves as a foundation for the present study. The literature encompasses the response variable of the research, namely food production and security, along with the intervening variable of the adoption of radical terraces and the predictor variables, including farmer household characteristics, community participation, membership in Self-Help Groups, access to agricultural information, and the support provided by outside agencies to farmers. Additionally, we present insights from other countries' experiences with radical terraces.

The chapter also explores the theoretical viewpoints linked to community engagement, the uptake and spread of radical terraces, and food production and security. Furthermore, we lay the foundation for the conceptual framework and offer precise definitions for the variables scrutinized within this study. The literature review is systematically structured, following thematic lines and concentrating on the central subjects addressed in this investigation.

2.1 Food Production and Security

Food production pertains to the quantity of cultivated food crops generated within a household, aiming to attain food security (RoR, 2014). This study gauged food production by the cumulative count of bags or kilograms of crops harvested annually from the acres of cultivated radical terraces within a household or smallholder farmer's domain. The Food and Agriculture Organization (FAO, 1996) and the National Institute of Statistics of Rwanda (NISR, 2016) delineate food security into three dimensions: availability, accessibility, and utilization.

Research conducted by Limnirankul et al. (2015) in the highland regions of Northern Thailand underscored the significance of tailored technological interventions that align with the specific circumstances of farmers in order to heighten the productivity of food crops. Their findings indicated that "technological interventions that fit farmers' circumstances need to be programmed in partnership with farmers to improve the productivity of food crops" (Limnirankul et al., 2015).

Likewise, in a study by Gathaara et al. (2011) conducted in Kenya's Machakos District, the significance of gender and soil conservation was examined, revealing the impact of educational attainment on adopting agricultural technologies and innovations to enhance food production. They reported that "educational level had a function in adopting farming technologies and innovations for producing food" (Gathaara et al., 2011).

Karplus (2014) investigated "post-development theory and food security in Swaziland" and identified ineffective and outdated agricultural practices as contributors to food insecurity in the country. Karplus (2014) states, "At least some of Swaziland's food insecurity was caused by ineffective and archaic agricultural practices and customs."

In addition to these factors, smallholder farmers in the studied context face challenges in accessing agricultural loans. Musabanganji et al. (2015) researched "determinants of access to agricultural credit for small-scale farmers in the Southern Province of Rwanda," revealing limited access to formal financial services for smallholders, hindering their ability to invest in agricultural activities. They found that "access by smallholders to formal financial services was still limited, preventing them from having enough financial resources to invest in agricultural sector activities" (Musabanganji et al., 2015). Moreover, farmers' educational background significantly affected their access to agricultural credit.

While the studies under review have predominantly centred on soil and water conservation, agricultural financing, and educational attainment as significant determinants impacting food production, they tend to disregard smallholder farmers' contribution in embracing novel farming methodologies like radical terraces and the subsequent implications for food security. To bridge this void, the current study examines the degree of food security achieved by adopting radical terraces.

2.2 Factors Influencing Adoption and Food Security

2.2.1 Farmer Household Characteristics

Numerous factors have been identified as influencing the integration of novel farming practices and technologies. As outlined by Kinyangi (2014), these factors, such as farmer attributes, farm configuration, institutional aspects, and managerial structure, can be broadly classified. Furthermore, some studies categorize them within social, economic, and physical dimensions. This research examined a variety of characteristics pertaining to farmers,

including but not limited to age, sex, educational background, marital status, size of the family, source of income, vocation, periodic profits, and extent of land ownership.

Age is recognized to moderate technology adoption, with younger individuals typically displaying greater adeptness in adopting technology compared to their older counterparts (Wairiuko, 2018). Nevertheless, older farmers are often credited with accumulated wisdom and experience over time, rendering them more capable of scrutinizing technical information (Mwangi and Kariuki, 2015). For instance, Chitere (1980) discovered that age did not elucidate variances in the quality of crop management amongst farmers in Kenya's Kakamega district. In this study, age did not necessarily correlate with superior crop management among younger farmers compared to their older counterparts (Chitere, 1980). Our investigation categorizes age into three groups: young (below 29 years), middle-aged (30-49 years), and elderly (50 years and above).

Gender equally influences the integration of technology (Wairiuko, 2018). However, research investigating the impact of gender on technology adoption has generated mixed outcomes. Several studies suggest that female farmers have a diminished likelihood of obtaining resources such as land, credit, or vital information required for the comprehensive adoption of technology (Kariuki, 2013; CIMMYT, 1993). In contrast, Morris and Doss (1999) established no significant connection between gender and the uptake of enhanced maize varieties in Ghana. Similarly, Masinde (2009) did not unearth any gender-associated effect on adopting Integrated Pest Management (IPM) technologies. Within our study, we explored the influence of gender on technology adoption.

The level of educational achievement has been recognized as a crucial element influencing the integration of agricultural technologies and advancements aimed at augmenting food production (Gathaara et al., 2011). Those with higher educational levels are commonly considered to have a greater propensity for embracing innovative technologies compared to those with restricted educational backgrounds (Wairiuko, 2018). A correlation exists between education and the swifter integration of innovations, as individuals with lengthier educational experiences tend to be more receptive to adopting new technologies than those with fewer years of education (Chitere, 1980). For this study, we classified education into four tiers: none, primary, secondary, and beyond, along with TVET/CERAI qualifications.

Marital status similarly exerts an influence on technology adoption. For instance, married individuals might exhibit increased engagement in community development endeavours due to their diverse family responsibilities, including childcare (Kariuki, 2016). However, Mango et al. (2018) uncovered that specific subcategories of marital status, such as formal employment and small-scale business, could negatively impact the embrace of small-scale irrigation farming. Farmers in these occupations often dedicate more attention to their work and businesses, leading to reduced enthusiasm for adopting novel technologies (Mango et al., 2018). Our study categorized marital status into three groups: single, married, and widowed.

As a gauge of available labour, family size significantly influences the adoption trajectory. Larger households may possess a labour-oriented advantage when introducing fresh technology (Mwangi and Kariuki, 2015). Farmers hailing from sizable families typically adopt new technologies more than those with smaller households (Muya et al., 2016). The underlying logic is that farmers with larger families anticipate that technology adoption will bolster farm productivity and better fulfil their family's needs (Sseguya, 2009). Our study segmented family size into three brackets: 1 - 3, 4 – 9, and above 10 members.

Occupation, denoting the primary economic endeavour undertaken by the head of the household, can influence the uptake of technology. As an illustration, Mango et al. (2018) discerned that specific occupational subcategories, such as formal employment and small-scale business, were negatively affected by adopting small-scale irrigation farming. Household heads immersed in these vocations often accorded precedence to their professional commitments and small businesses over embracing novel technologies (Mango et al., 2018). In the scope of our research, all participants assumed the position of farmers, and their vocation was categorized as either engaging in farming on a full-time or part-time basis.

The chief source of income is another determinant shaping technology adoption. An inquiry into agricultural technology adoption in Ethiopia unveiled that adopters reaped a favourable and substantial impact on farm income, rendering them more prosperous than non-adopters (Aynalem et al., 2018). Certain studies propose that farmers with a more commercial orientation, selling a greater proportion of their harvest, exhibit an enhanced propensity to adopt specific agricultural technologies (CIMMYT, 1993). In our study, we categorized the principal sources of income into crops and livestock, with income corresponding to the agricultural season.

Lastly, farm size, representing the cumulative land owned by the household, stands as a foundational agricultural production unit and a gauge of affluence within rural communities. Greater farm extents correlate with a heightened likelihood of technology adoption, particularly when the adoption entails procured inputs (CIMMYT, 1993). More affluent farmers are often more disposed to undertaking risks and boast improved access to extension information and credit, enabling them to explore new methodologies (CIMMYT, 1993). Our study stratified land size into two categories: less than 0.9 ha and above 1 ha.

2.2.2 Community Participation

Participation signifies the engagement of community members in developmental initiatives that pertain to and impact them. It denotes the community's capacity to initiate and carry out development undertakings that align with its specific needs (Ouma, 2017). Community participation encompasses active involvement across all dimensions of agricultural development, including contributing unpaid labour, utilizing locally accessible resources, and participating in decision-making, project formulation, execution, oversight, and assessment (Mwendwa, 2012; Wairire, 2009).

Within the scope of this study, farmer participation pertains to how farmers engage in decision-making processes related to adopting radical terraces for food production. It encompasses farmers' active participation in acquiring information, seeking advice, collectively arriving at decisions, taking action, and fostering mutual support in adopting radical terraces.

Typically, two prevailing approaches to implementing projects are bottom-up and top-down methods. Abatena (1995) investigated the "importance of community self-help initiatives in advancing social development in Ethiopia," highlighting the effectiveness of bottom-up development within the Tula case study. This approach underscored the successful mobilization of grassroots communities in the development process (Abatena, 1995). Similarly, Jimu (2008) examined community participation in Malawi, stressing that efforts to enhance agricultural productivity can only prosper when farmers embrace modern farming technologies and other inputs advocated by government extension agents. Overcoming various challenges, encompassing structural, administrative, and social factors, is crucial to ensure food security (Mutagoma, 2006).

Ouma (2016) investigated the factors that affected community participation in implementing agricultural projects within the Kimira-Oluch Smallholder Farm Improvement Project in

Homa Bay County, Kenya. The study found limited community engagement in project activities, indicating a lack of ownership. The author recommended adopting a participatory approach from the project's initiation to involve the local community effectively. Similarly, Miseda (2014) identified funding as a critical determinant of project longevity. The study underscored the necessity for the community to voluntarily contribute resources, whether financial, skill-based, ideational, or labour-related, to bolster a sense of ownership and dedication to the projects (Miseda, 2014). Ogunleye-Adetona C. I. & Oladeinde, C. (2013) reported that income incentivized citizens to partake in self-help community initiatives. Local farmers invested capital in the projects while also providing labour.

These existing studies lack a comprehensive examination of the extent of community involvement in smallholder farmers' communities concerning the adoption and spread of agricultural innovations and related projects, particularly within the context of radical terraces. The impact of community members' participation on the long-term viability of projects has been overlooked, and the sociological dimension of community engagement remains insufficiently addressed. Therefore, adopting a sociological standpoint, this study investigates the impact of smallholder farmers' participation on adopting radical terraces for food production and security. Through an analysis of farmers' engagement in decision-making processes, information access, consultations, and mutual support regarding adopting radical terraces, this research seeks to uncover the sociological factors that influence the success and sustainability of such agricultural initiatives. Understanding the degree of community participation in smallholder farmers' adoption of radical terraces can furnish policymakers and stakeholders with valuable insights for effectively enhancing food security initiatives.

2.2.3 Membership in Self-Help Groups

Sundaram (2012) defines Self-Help Groups (SHGs) as a method of mobilizing resource-poor and marginalized individuals to address their problems collectively. In line with this, Chitere's (2018) study revealed that Self-Help Groups serve as a platform for individuals to pursue their goals and aspirations while providing mutual support to one another. These groups have been actively involved in soil conservation, crop cultivation, livestock keeping, and trading activities.

Similarly, Reddy K. R. & Reddy C. S. (2012) argue that in food production projects, landless individuals often contribute their labour force to exploit the land owned by wealthier

individuals. In this context, members of SHGs are considered small, economically homogenous entities where the poor and the rich collaborate for effective agricultural service.

A study by The International Labour Organization (ILO) 2006 revealed that SHGs serve as a mechanism for poor people to pool their savings. Beyond economic and financial support, these groups also provide emotional support. Consequently, community self-help groups adopting radical terraces could qualify as contributors to food inputs and outputs. The role of self-help groups may extend to managing food products and agricultural resources in utilizing radical terraces for food production (ILO, 2006).

Jussi et al. (2009) studied ten women self-help groups in three former provinces of Kenya, namely Nyanza, Central, and the Rift Valley. The study highlighted various challenges faced by SHG members, including limited government support, low education levels of members, poor leadership, lack of commitment, limited resources, and issues related to gender discrimination. In Rwanda, these challenges may impact the adoption of radical terracing, as gender equality and equal participation in development projects are essential in the agricultural sector.

The literature review indicates that self-help groups are commonly perceived as small, economically similar entities with vulnerable individuals who pool their savings. However, this perspective fails to recognize these groups' significant social and emotional support in addressing food security challenges. Moreover, existing research has not explored the role of support groups in terms of their contributions to both the inputs and outputs of food production, which constitutes the primary focus of this study. Notably, there is a gap in sociological research regarding the involvement of self-help groups in adopting root terraces for food production and security at the county and national levels. Hence, this study investigates how much self-help groups contribute to implementing radical terraces to enhance food security. By considering the sociological dimensions of self-help groups and their influence on farmers' adoption of innovative agricultural techniques, this research sheds light on their role in augmenting food production and ensuring food security.

2.2.4 Access of Farmers to Agricultural Information Sources

Smallholder farmers need information to enhance their decision-making in planning and achieve sustained growth in agricultural productivity, the market economy, and, subsequently, food security, as Odini (2014) posits. This highlights the crucial role of agricultural information in improving smallholder agricultural production and connecting

enhanced productivity to profitable markets, thus promoting rural welfare, food production, and security, as observed by Siyao (2012). Consequently, agricultural information is widely acknowledged as a crucial component in agricultural development programs, and its sources vary.

In the context of agricultural extension in India, Glendenning, Babu, and Asenso-Okyere (2010) found that other farmers (16.7%) and agriculture input dealers (13.1%) serve as the primary sources of agricultural information. Similarly, Yaseen et al. (2016) reveal that self-experience constitutes the primary source of agricultural information for 24.4% of farmers.

Shifting the attention to farmers in Nigeria, Sokoya et al. (2014) point out that they acquire agricultural information tailored for specific purposes through channels such as mass media, agricultural extension agents, social networking, folk tales, and interpersonal connections. In a study centred on rural farmers in Maharashtra, India, Bachhav (2012) highlights that a significant portion of farmers seeks information primarily about seed availability (74.3%) and crop production (70.8%).

When considering the implications of these research findings for the present study, it becomes evident that enhancing access to information concerning radical terraces is paramount for their successful adoption and the subsequent enhancement of farm productivity among smallholder farmers. However, it is important to acknowledge that the studies above do not explicitly concentrate on the accessibility of agricultural information related to adopting and disseminating radical terraces to ensure food security. This research endeavour aims to bridge this gap in sociological exploration by scrutinizing how smallholder farmers access agricultural information in the context of adopting radical terraces and advancing food security.

2.2.5 External Support by Development Agencies

Bandeth (2010) researched "participatory irrigation management and the factors influencing the success of Farmer Water User Communities (FWUC) in Cambodia." The findings underscored that the FWUC received significant financial support from governmental entities, Non-Governmental Organizations (NGOs), and municipal bodies. Nonetheless, constraints in governmental resources impeded substantial investments in the agricultural domain. This aligns with the findings of ActionAid (2015), which revealed that African governments were inadequate in allocating resources to agriculture to fulfill the prescribed levels of expenditure in their policy and implementation strategies, thus falling below the

commitment of allotting 10% of the national budget to the agricultural sector. The majority of the agricultural budget frequently found allocation toward recurring expenditure such as personnel salaries and administrative costs.

To tackle the obstacles farmers confront, Yuliatia Y. & Iskaskara, R. (2016) explored a strategy to "enhance the participation of women farmers in several Districts of Java," strongly emphasizing providing nourishing sustenance for families. This corresponds with the observations of Garnevska et al. (2011), who noted that the development of cooperatives in Northwest China was ascribed to government-sanctioned strategies that encompassed cost-free registration, training, and simplified access to capital and financial support. Anandajayasekeram et al. (2008) established that the widespread adoption of the Training and Visit (T&V) program in nations across East Africa served as a mechanism to promote the establishment of government-initiated extension services for farmers. This underscores the dynamic involvement of governments in propelling the progress of small-scale agricultural growth, incorporating the provision of inputs and subsidies. Similarly, Musabanganji et al. (2016) highlighted a significant upsurge in the utilization of inputs by smallholder farmers in Rwanda, propelled by the introduction of subsidies for fertilizers and higher-quality seeds. These findings underscore the importance of government backing and policies in the agricultural sector.

This current research delves into the interplay between external aid and indigenous small-scale farmers in the adoption of radical terracing methods to enhance food security in the Nyamagabe District of Rwanda. The primary objective of the study is to investigate how external assistance enhances the ability of local smallholder farmers to achieve food security without compromising their autonomy. Through an assessment of how external aid influences the uptake of radical terracing techniques among farmers, this study seeks to address existing gaps in understanding and shed light on the complex intricacies underlying agricultural advancement and food security within the locality.

2.3 Lessons on Radical Terraces from other Countries

A number of scholars have underscored the importance of radical terracing techniques in contemporary cultivation practices, advocating for the intensified exploitation of land and the establishment of enduring agricultural systems on sloped terrain in mountainous areas. Simultaneously, this aids in diminishing the practice of rotational farming (FAO 2009, Bizimana 2011, Rwanda Agriculture Board 2014, TRPA 2014). Asian countries such as the

Philippines, Indonesia, Vietnam, China, and India widely employ terracing for rice production in mountainous areas. Acabado (2010) specifically studied Ifugao agricultural terraces in the Philippines and Southeast Asia, using Geographic Information Systems technology, archaeological excavations, and ethnographic research. He found that terraces symbolize humanity's accomplishment in modifying the environment for food production, with their presence not limited to Asia but found worldwide in America, Europe, and Africa. Similarly, radical terraces have been implemented in Spain, Morocco, Swaziland, and Ethiopia to address soil erosion and promote intensive farming (Lasanta et al., 2001).

Posthumus (2005) conducted a study on terrace adoption in the Peruvian Andes, providing concrete evidence of increased agricultural output on terraced farms, especially on gentle, steep, sloping land. Similarly, Castonguay et al. (2016) examined the resilience and adaptability of rice terraces in Banaue, Philippines, revealing a concerning trend of declining interest in agricultural activities among the youth due to expanding employment and educational opportunities in urban areas, potentially resulting in the widespread abandonment of the rice terraces.

These findings highlight the vital role of terraces in enhancing agricultural productivity and emphasize the urgency for sustainable strategies to preserve traditional farming practices amidst the challenges of urbanization and changing demographics. Nevertheless, despite the substantial research on radical terraces, a significant knowledge gap persists concerning their adoption as a strategic approach to food security. Existing studies have primarily concentrated on their role in preventing soil erosion, leaving the potential contribution of radical terraces to address food insecurity largely unexplored. This study aims to decisively fill this research gap by examining the adoption of radical terraces as a proactive means to ensure food security in Nyamagabe District, Rwanda.

2.4 Summary of Knowledge Gaps

To summarize, the preceding studies did not adequately address various pivotal elements, including farmer engagement, affiliation with Self-Help Groups, entry to agricultural insights, external assistance, and the connection between food output and security vis-à-vis the implementation of radical terrace initiatives. The scarcity of attention directed towards the adoption of ground breaking terrace projects and their implications on the food security of farmers is particularly evident. In Rwanda, limited documented knowledge exists regarding community participation, membership in self-help groups, access to agricultural information,

outside support for adopting radical terraces, and its implications for food security. Moreover, there has been no investigation into the significance of smallholder farmers' integration of radical terraces within food production initiatives and its direct repercussions on ensuring food security.

Thus, this study assumes significance as it seeks to provide a sociological analysis of the community members' adoption of new farm innovations, particularly focusing on local projects for sustaining their food security, emphasising radical terraces. Additionally, the research examines the level of food security among local farmers, local leaders, and other development partners involved in food production projects in Nyamagabe District, Rwanda. This comprehensive examination aims to fill the existing research gaps and offers valuable insights into the region's dynamics of agricultural innovation, food security, and community development.

2.5 Theoretical Framework

This section elucidates the theoretical perspectives utilized in this study, namely community participation, adoption and diffusion, and food production and security. These viewpoints present a suitable analytical structure for grasping the intricacies associated with the acceptance of radical terracing practices by smallholder farmers, along with its ramifications for both food output and security within the examined region.

2.5.1 Community Participation Theory

The issue of sustainability in community projects has been a subject of concern, particularly when development and transformative organizations take a top-down approach in their interventions. Mulwa (2010) observes that many community-level projects suffer collapse shortly after the handing-over ceremony by donors, primarily due to factors like low or non-community participation in decision-making. Onyango (2009) asserts that participation should encompass all community members, regardless of their living conditions, without discrimination. Mobilizing active participation from local communities is deemed the most crucial process in any development project, as it enables the identification of problems, constraints, and local aspirations (Mamburi, 2014). Participation allows individuals to engage in collective actions to address specific community development projects.

Moreover, community participation has become integral in planning and implementation theory and practice. While project planning and implementation were once predominantly

government-led and bureaucratic endeavours by technical experts, recent trends signify a shift towards a more inclusive and participatory model (Onyango, 2009). Community participation plays a vital role in problem identification and devising solutions, particularly in the context of food security. According to Harvey and Reed (2007), involving the target population in the decision-making process fosters a sense of ownership among local community members. Wairire (1999) highlights four forms of people's participation in decision-making: participation in planning and decision-making, implementation of decisions, distribution, and sharing of benefits, and evaluation of the impact of the development activity. During participation, community members contribute their views, suggestions, money, materials, and labour on different levels, ranging from voluntary to required, negotiated, and indifferent.

Arnstein (1969) proposed a ladder or model of community participation, which delineates eight levels of participation, including manipulation, therapy, informing, consultation, placation, partnership, delegated power, and citizen control. The degree of non-participation corresponds to a lack of power for farmers, who are passive in the decision-making process, indicating low participation. Tokenism denotes symbolic participation, while medium participation entails farmers reacting quickly to decisions. Real participation occurs when farmers are fully engaged in the decision-making process. Figure 1 illustrates Arnstein's ladder of participation.

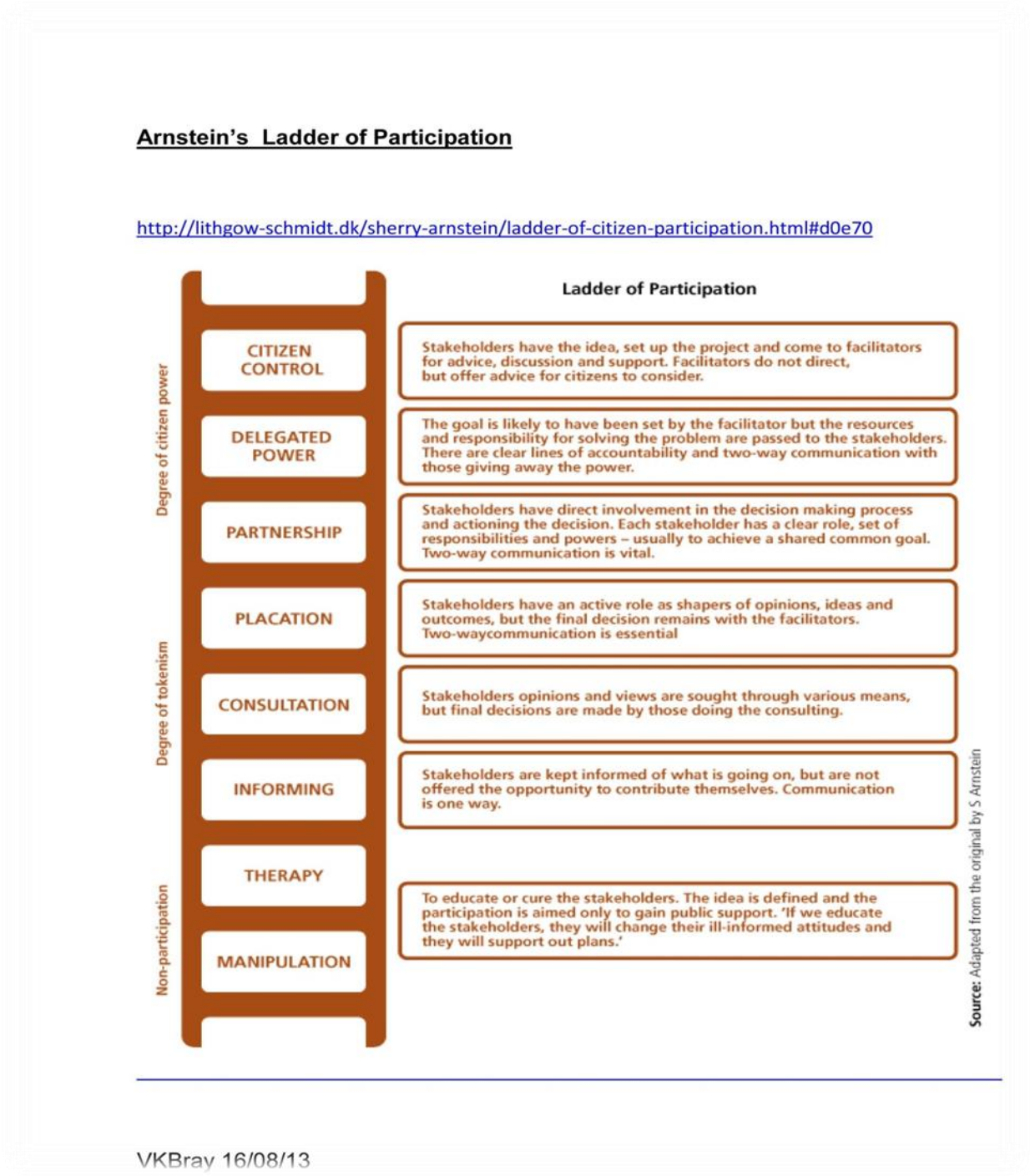


Figure 1: Arnstein's Ladder of Participation

The community participation model above holds particular relevance for this study, as it offers valuable insights into understanding how farmers adopt radical terracing as a novel farming technique and how this practice influences food security through the adoption of radical terraces. By employing this model, the study effectively examined the participatory framework of farmers in decision-making processes related to adopting radical terraces.

2.5.2 Adoption and Diffusion Theory

In this study, adoption pertains to the deliberate choice to accept innovation as the most suitable way forward. This concept is further clarified as the integration of innovative methods into a farmer's ongoing practices, distinguished by repeated and consistent usage (Peshin et al., 2014). The theory of Adoption and Diffusion of Innovations, championed by notable scholars including Everett M. Rogers (1995), Gabriel Tarde (1962), Eugene Wilkening (1953), and Bruce Ryan and Neal Gross (1943), played a central role in agricultural extension endeavours from the post-World War II period through the 1970s. This theory experienced significant evolution during the 1980s, particularly amid the eras of "agricultural productivity" and the "green revolution." It retains its relevance in contemporary agricultural extension efforts, especially when adopting specific techniques or technologies. Everett M. Rogers, acknowledged as the progenitor of the adoption and diffusion of innovations theory (Tomas-Simin & Jankovic, 2014), characterized the diffusion of innovation as a societal process centred on interpersonal communication. In this process, participants collaboratively generate and exchange information to establish a shared comprehension. The adoption-diffusion model represents a distinctive form of communication concerning novel concepts (Tomas-Simin & Jankovic, 2014).

Chimoita (2017) delineates the diffusion and innovation theory as disseminating new ideas within a community over a defined period, emphasizing elements of awareness, knowledge, attitude change, and decision-making processes that culminate in the adoption or non-adoption of an innovation. Rogers (1995) identifies several determinants influencing the adoption and diffusion of innovations among society members, encompassing the innovation-decision process, adopter categories, attributes of the innovation, and communication channels. The innovation-decision process comprises five stages: awareness, where a farmer encounters a new idea and becomes acquainted with it; interest, when the farmer develops a curiosity about the idea and seeks further information; evaluation, when the farmer weighs the advantages and disadvantages of the new idea; trial, when the farmer tests the idea on a small scale; and adoption, when the farmer integrates the idea into ongoing farming practices (Peshin et al., 2014). These stages assessed the various phases of smallholder farmers' adoption of radical terraces for food production in the Nyamagabe District.

The notion of adopter categories delineates the time community members take to adopt an innovation. These categories include innovators (2.5%), early adopters (16.7%), early

majority (34%), late majority (34%), and laggards (16.5%). Innovators are the initial adopters, possessing resources and access to information about novel ideas. The early majority also possess resources and exhibit leadership qualities, often serving as reference points for other farmers. Conversely, the lower class lack resources and are the final adopters, often exhibiting scepticism towards novel concepts. The early and late majority fall in between.

Attributes of innovations encompass relative advantage, perceived by users as a superior alternative yielding beneficial outcomes. Compatibility with prevailing values and practices among farmers also influences the success of innovation adoption. Complexity refers to the simplicity of using the technology. Turner et al. (2010) underscored that farmers are more inclined to adopt ideas perceived as straightforward than innovations demanding acquiring new skills and knowledge. Ogunleye-Adetona C. I. & Oladeinde, C. (2013) examined the "adoption and diffusion theory," underscoring the potent impact of awareness of ideas and innovation among community members, influencing its propagation within the community. Figure 2 illustrates the comprehensive principles of adoption and diffusion, as Rogers (2003) embraced.

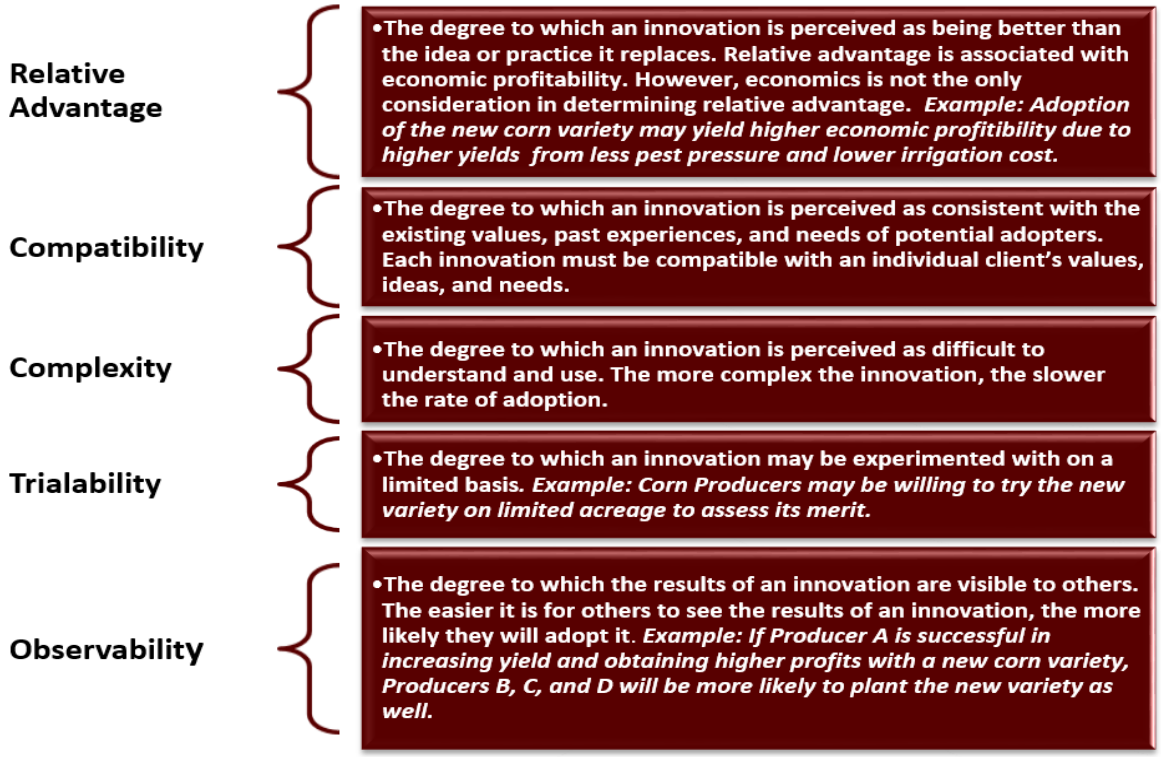


Figure 2. Everett Rogers adoption-diffusion principles (Rogers, 2003).

Figure 2: Everett Rogers adoption-diffusion principles (Rogers, 2003)

Communication channels encompass both mass and interpersonal media. Mass media, such as radio and TV, can reach a large audience, but their effects are often short-lived, primarily creating awareness. On the other hand, interpersonal media, though more costly and involving face-to-face communication, can have a more profound and lasting impact. In contemporary times, social media accessed through mobile phones and computers, such as Facebook, WhatsApp, and email, enable people to share information more efficiently.

The rationale for integrating the Adoption and Diffusion theory into this study stems from its proposition that farmers grappling with obstacles in embracing novel farming methods, like radical terraces, might be incentivized by the aspiration to mitigate risk and minimize endeavour through active engagement in constructing and utilizing such terraces. This active involvement can potentially optimize the benefits of incorporating radical terraces. In terms of methodology, this theory provided a framework for appraising agricultural extension services and interpersonal exchanges among farmers as they embrace innovative farming techniques to address food requirements and establish sustainable food security within Nyamagabe District.

2.5.3 Food Production and Security Perspective

Food security originated in the 1970s amidst a worldwide food crisis. In its early stages, the delineation of food security predominantly centred on concerns of food provisioning linked to its availability (FAO 2006). Sen (2014, p.1870) defined food security in his study on "perspectives on food security" as "a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life." Numerous scholars have illustrated that the examination of food security can be delineated into three fundamental dimensions: the presence of food, its reachability, and its effective utilization (Bashir et al., 2014; Karplus, 2014; Sneyd, 2014; Kithu, 2012; and Muthoka, 2010). Muthoka (2010) employed the systems theory of management to probe into the factors influencing food security initiatives in Kenya. The research explicates food security as an outcome of a chain of interconnected and mutually dependent events and actions that influence food production. The state of food security was contingent upon the interactions between individuals and institutions within a regional or national system.

Within the Rwandan context, NISR (2016) linked food security to the production of food crops in a mixed farming system, encompassing rain-fed root and tuber crops (Irish potatoes, sweet potatoes, and cassava), cereals (maize and sorghum), dry beans, bananas, traditional

livestock rearing, and vegetable cultivation. Roughly 71% of all harvested crops were utilized within households, while only 23% were traded in the market. Food crops earmarked primarily for domestic consumption included cereals, roots, tubers, beans, and cooking bananas. Predominantly, the cultivated crops were annual (84%), with the remaining 16% perennial. A majority of farming households cultivated beans (88%), followed by maize (49%) and sweet potatoes (45%). On average, households cultivated a combination of three distinct crops (NISR, 2016). Despite the availability of food items in markets, NISR (2016) reported that half of the households (50%) encountered difficulties accessing food at some point during the year. Food security was also evaluated based on the duration of harvested crop availability. According to the Republic of Rwanda (2016), the ability of farmer households to access food was contingent upon whether they possessed sufficient food or financial resources to procure food within the preceding 12 months. Altogether, fifty per cent of households experienced challenges accessing food at certain times during the previous year.

A significant hurdle to food security, as underscored by Karplus (2014), pertains to the usage of outdated agricultural methodologies and land allocation policies. Moreover, the lack of inclusive engagement of target populations in the decision-making processes of development agencies concerning food security interventions contributed to the issue. An estimated 75% of Swazi Nation land cover suffered from degradation caused by soil erosion, resulting in impaired soil structure, diminished soil nutrients, and decreased crop yields.

In this study, the food production and security theory served as a guiding framework for investigating the level of food requirements concerning their availability, accessibility, and utilization within households and the broader community. Households were categorized as secure or insecure and further stratified into low, moderate, and high groups. The evaluation of agricultural production, storage, and consumption also formed the basis for measuring food security within this study.

2.6 Conceptual Framework

The conceptual framework of this study delineates the relationships between its different variables. Food security is the dependent variable while adopting radical terraces is the intervening variable. The predictor variables encompass household characteristics, self-help group membership, agricultural information access, outside support, and farmers' participation. Figure 3 illustrates the conceptual framework, depicting the connections among

these study variables. It is posited that the predictor variables impact farmers' acceptance of radical terraces, subsequently influencing their state of food security.

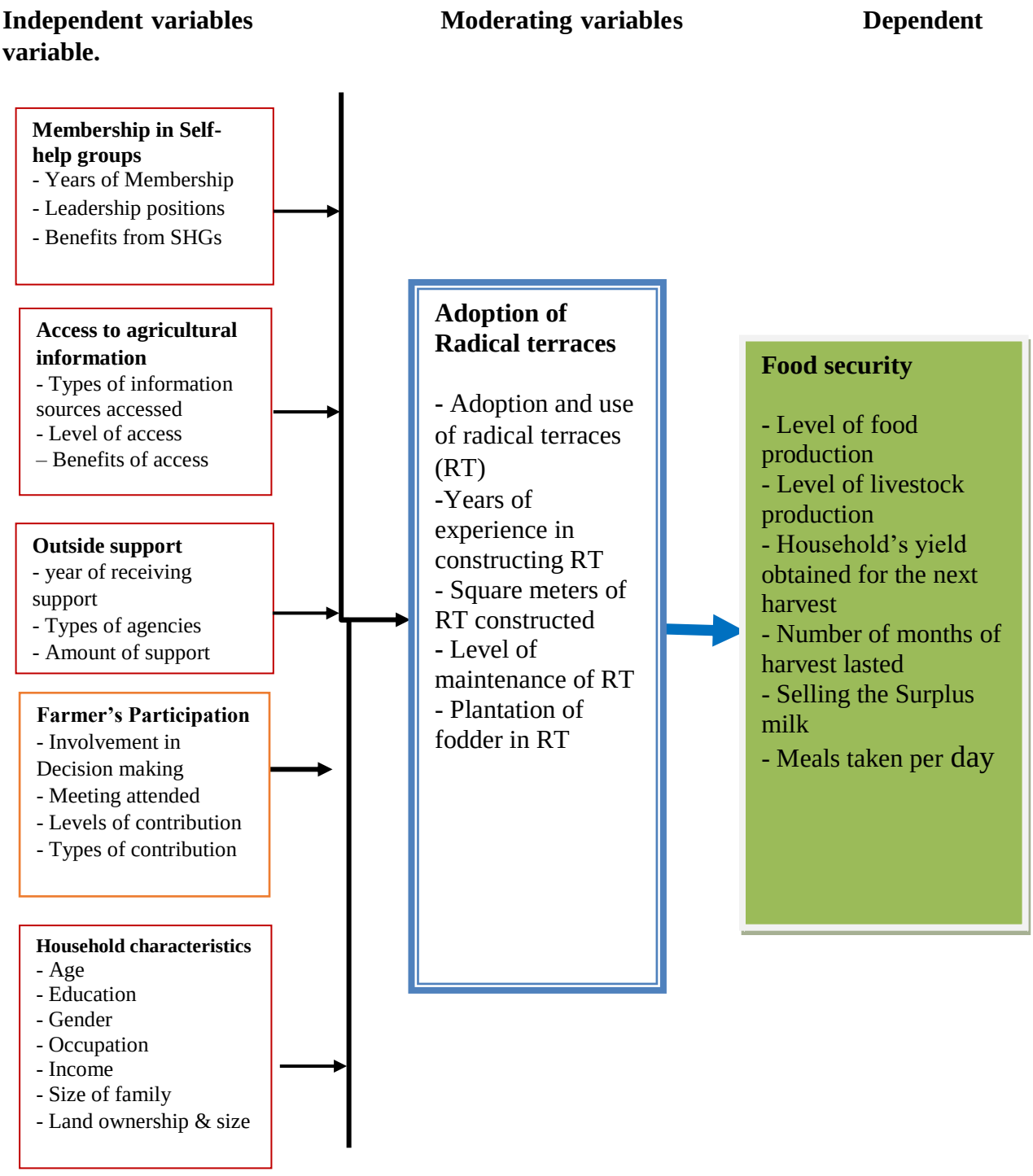


Figure 3: Conceptual framework of the study

Source: Researcher (2018)

2.7 Operationalization of the Study Variables

Food security is the dependent variable while adopting radical terraces is the intervening variable. The predictor variables encompass household characteristics (such as farmers' age, education, gender, occupation, income, family size, and land ownership), membership in self-help groups (indicated by years of membership, leadership positions, and benefits derived), access to agricultural information (evaluated based on types of information sources accessed, level of access, and benefits obtained), outside support (noted by the year of receiving support, types of agencies, and amount of support provided), and farmer's participation (measured by involvement in decision-making, meeting attendance, and level of contributions).

Various indicators were used for food security, including crop yield, harvest duration, surplus milk production, sales, and the number of meals taken per day. Additionally, crop and livestock production, types of crops planted, acreage planted for food crops, yield of food crops harvested, and use of improved farm inputs and practices were considered indicators of food security. The adoption and use of radical terraces (RT) were indicated by years of experience in constructing the RTs, the square meters of RTs constructed, the level of maintenance of the RTs, and the planting of fodder on RTs.

Household characteristics encompassed farmers' age, education, gender, occupation, income, family size, and land ownership. Membership in self-help groups was indicated by the years of membership, leadership positions held in the groups, and the benefits derived from the SHGs. Outside support was identified by the year of receiving support, the types of agencies involved, and the amount of support provided to the farmers. Access to agricultural information was assessed based on the types of information sources accessed, the level of access, and the benefits obtained from accessing these sources. Farmer's participation in decision-making was measured by evaluating their involvement in decision-making processes, attendance of meetings, and the level of contributions they made.

The operational definitions of the variables are summarized in Table 1.

Table 1: Operationalization of the study Variables

Variables	**Nature**	**Indicators**	**Scale Measure**
Characteristics of the Sampled Households	Independent variable	Age	Interval
		Gender	Nominal
		Education Level	Ordinal
		Marital status	Nominal
		Family Size	Ratio
		Occupation	Nominal
		The main income source	Interval
		Seasonal income	Interval
		Size of Land owned	Interval
Access to Agricultural Information	Independent variable	Types of information sources accessed	Nominal
		Level of access to information sources	Ordinal
		Benefits of access to information sources	Nominal
Membership in Self-Help Groups	Independent variable	Years of farmer's Membership in SHGs	Interval
		Farmer's Leadership Position in SHGs	Nominal
		Benefits Farmers Gained from SHG	Nominal
Outside Support	Independent variable	Types of Agencies Providers of Support to the Farmers	Nominal
		Amount of support	Nominal
		Farmers' Use of the Support or Credit	Nominal
Farmer's Participation in Decision Making Process	Independent variable	Farmer's Involvement in Decision Making of Radical Terraces Projects (initiating, planning, implementing, monitoring, and evaluation).	Nominal
		Frequencies of the Meetings Attended by Farmers	Ordinal
		Farmer's contribution to the decision-making process (information, consultation, decision-making, acting together, supporting each other's interest).	Nominal
		Types of farmers contribute to adopting radical terraces (labour, materials, land, cash, ideas).	Nominal
Adoption of Radical Terraces	Intervening variable	- Adoption and use of radical terraces	Interval
		-Years of experience in constructing radical terraces	Interval
		- Square meters of radical terraces constructed	Interval

		- Level of maintenance of radical terraces	Ordinal
		- Plantation of fodder in radical terraces	Nominal
		- Use of fodder	Nominal
Food Security	Dependent variable	Level of food production (Planted food crops, seedbed preparation, types of seeds planted, chemical fertilizers and manure used, clean weeding, and yield of crop production)	Ordinal Nominal Interval
		Level of livestock production (Types of livestock keeping, Yield of milk production, sales of farmer's livestock)	Ordinal Nominal Interval
		Household's yield obtained for the next harvest	Interval
		The number of months of harvest lasted	Interval and ratio
		Selling the Surplus milk	Interval
		Meal taken per day after the adoption of radical terraces	Ratio

2.8 Research Hypotheses

The study examined several hypotheses at the 0.05 significance level, formulated based on the study's variables. The intervening variable, the adoption of radical terraces, was hypothesized to impact the dependent variable, food security. Simultaneously, the predictor variables—farmer characteristics, membership in SHGs, access to agricultural information sources, farmer's participation, and outside support—were hypothesized to influence the adoption of radical terraces, affecting food security. The specific hypotheses are presented below:

Household Characteristics versus Adoption of Radical Terraces

H1: A favourable correlation exists between household attributes and the integration of radical terraces.

HO: No correlation exists between household attributes and the incorporation of radical terraces.

Membership in Self-Help Groups versus Adoption

H1: Membership in self-help groups positively influences the adoption of radical terraces.

HO: No association exists between membership in self-help groups and adopting radical terraces.

Access to Sources of Agricultural Information versus Adoption

H1: There is a positive association between farmers' access to sources of agricultural information and their adoption of radical terraces.

HO: There is no association between farmers' access to sources of agricultural information and their adoption of radical terraces.

External Support and Adoption of Radical Terraces versus Adoption

H1: The adoption of radical terraces by farmers is positively impacted by external support received from various agencies.

HO: There is no significant relationship between farmers' adoption of radical terraces and the support they received from external agencies.

Participation in Decision Making on Radical Terraces versus Adoption

H1: Farmers' participation was significantly related to adopting radical terraces.

HO: Farmers' participation did not influence their adoption of radical terraces.

Exploring the Link between Farmers' Adoption and Food Security

H1: There is a statistically significant relationship between farmers' adoption of radical terraces and their level of food security.

HO: The adoption of radical terraces by farmers has no significant impact on their food security status.

CHAPTER THREE: RESEARCH METHODOLOGY

3.0 Introduction

This section delineates the research methodology employed to attain the study aims, encompassing respondent selection, data collection, analysis methods, and result generation. Quantitative and qualitative methodologies were applied in both data gathering and analysis processes. This chapter provides comprehensive discussions concerning the chosen study locations and units of investigation, the strategy and steps taken for sampling, and the methodologies adopted for data analysis.

3.1 Description of the Study Site

The research was conducted within the Nyamagabe District in the Southern Province of Rwanda. It shares boundaries with Ruhango and Karongi districts to the northern side, Huye and Nyanza to the eastern side, Nyamasheke and Rusizi to the western side, and Nyaruguru to the south (as shown in Figures 4 and 5). Nyamagabe District comprises 17 administrative sectors, 92 cells, and 536 villages (Nyamagabe District, 2011). The population of the district is approximately 342,112 individuals, with women comprising 53% (180,472) and men comprising 47% (161,640) (Nyamagabe District, 2013). Historically, Nyamagabe District faced considerable challenges related to persistent hunger and enduring famine. Nonetheless, recent years have seen notable advancements in terms of socioeconomic growth. The selection of this district as the study site was grounded in its elevated terrain, agricultural significance, ecological factors, and active participation in soil and water conservation endeavours. Additionally, Nyamagabe District was one of the areas where the radical terraces project was being implemented, providing a valuable opportunity to study farmers with substantial experience in terracing practices.

3.2 Research Design

The research utilized a descriptive and correlational framework, integrating quantitative and qualitative methodologies. As explicated by Orodho (2004), a descriptive survey approach entails collecting empirical data through surveys or interviews with selected individuals. This method is advantageous in eliciting insights into individuals' viewpoints, sentiments, patterns, and interpretations of diverse societal matters. The adoption of this framework was predicated on its capacity to establish a sturdy structure for collecting and examining comprehensive data concerning smallholder farmers' adoption of radical terraces, food

production, and security. Furthermore, this approach facilitated an exploration of the influencing factors from a qualitative and quantitative perspective.

3.3 The Target Population of the Study

The target population of this study consisted of smallholder farmers, also known as agricultural operators, who owned less than 5 hectares of land. According to the NISR (2013) agricultural household statistics in Nyamagabe district, there were 26,882 agricultural households categorized as smallholder farmers, having adopted modern agricultural practices using terraces in their farming activities. Additionally, another target group comprised key informants, including local leaders, government officials, and staff from other agencies working at the district, sector, and cell levels (NISR, 2016).

3.4 Units of Analysis and Observation

This research's focal point of analysis was the incorporation of radical terraces by smallholder farmers and their impact on food security. The entities under scrutiny were smallholder farmers' households who had initiated and embraced radical terraces within the Nyamagabe district.

3.5 Sample Size and Sampling Procedures

3.5.1 Selection of Sub-Sites and Farmers

This research focuses on one agricultural program in Rwanda, known as 'Radical Terraces,' which is currently being implemented in the Nyamagabe district. This district was purposefully chosen as the study site due to its extensive adoption of radical terraces despite significant food shortages. Among the 17 sectors in the district, four sectors (Nkomane, Buruhukiro, Kibilizi, and Gatare) were purposively selected as they had undertaken initial construction and utilization of radical terraces. Within each of these four sectors, two cells were purposefully sampled. Within each cell, three villages were purposively chosen, resulting in eight cells and twenty-four villages being selected. At the village level, the committee helped compile a list of households that owned land and had constructed radical terraces. This list employed systematic sampling to draw a sub-sample of farmers. The number of households listed varied from one village to another; hence proportionate sub-samples of eight heads were drawn from each village. A total of 192 farmers were sampled.

Once the sampling process was completed, each village's village leader assisted the researcher in identifying the sampled household heads for interviews. Each sampled farmer

had radical terraces, but their levels of maintenance and utilization varied. Some farmers actively maintained and exploited radical terraces for food crop farming, while others were not fully engaged. Table 3.1 provides information on the sampled units.

Table 2: Farmers Sampled

No	**Sectors**	**Cells**	**Villages**	**Number of households**	**Number of households owned RT (> 5 ares)**	**Sampled Farmers**
1	Nkomane	Nyarwungo	Marambo	96	24	8
			Rutoyi	153	41	8
			Bisharara	110	32	8
		Nkomane	Ruhinga	235	58	8
			Banda	233	67	8
			Mugari	201	75	8
2	Gatare	Mukongoro	Kagano	220	76	8
			Rukereko	169	58	8
			Gikungu	139	61	8
		Gatare	Rwamakara	345	131	8
			Gashasha	126	64	8
			Murembo	92	37	8
3	Kibilizi	Uwindekezi	Karumbi	192	160	8
			Mugote	152	66	8
			Kigarama	130	88	8
		Bugarama	Munazi	129	42	8
			Kabarera	122	85	8
			Kivumu	151	87	8
4.	Buruhukiro	Kizimyamuriro	Gikungu	198	156	8
			Gishwati	262	168	8
			Tantamara	249	193	8
		Munini	Gitovu	219	103	8
			Uwinzovu	220	115	8
			Munini	183	87	8
Total	**4**	**8**	**24**	**4326**	**2074**	**192**

3.5.2 Key Informants

The chosen Key Informants for this investigation consisted of individuals with both direct and indirect involvement in implementing radical terraces. A total of nineteen (19) Key Informants were purposefully selected from various administrative tiers, including districts, sectors, and cells. The positions covered by the Key Informants encompassed a diverse range: Mayor of the district (1), District Vice Mayor responsible for economic development (1), District Agronomist (1), District planner (1), Representative of RAB at Nyamagabe Station (1), Representatives of NGOs operating in the agriculture sector (2), Sector Agronomists (4), Farmer Field School personnel at cells (4), and Agricultural cooperative representatives (4).

The rationale behind selecting these Key Informants hinged on their profound understanding and proficiency in matters related to the adoption of radical terraces and food security within the study district. Given their close involvement in the radical terrace initiative, their perspectives and insights were essential to this research.

3.6 Data Collection

3.6.1 Interview of Farmers and Key Informants

This study employed two sets of research tools to gather the necessary data. The field data collection was carried out by a team composed of the researcher and three field enumerators, spanning June 2019 to October 2019. The research instruments utilized encompassed a semi-structured interview schedule designed for smallholder farmers and an interview guide tailored for key informants.

The semi-structured interviews for smallholder farmers comprised various question types, including multiple-choice, closed-ended, semi-structured, and open-ended queries. Before commencing the interviews, the researchers obtained consent from the farmers and scheduled individual interview sessions. The interviews were conducted in Kinyarwanda or French, accommodating the respondents' linguistic preferences. All insights extracted from the interviews were meticulously documented using modern IT tools such as tablets and smartphones alongside traditional recording devices, strictly following the interview guide and schedule. These interviews transpired at the respondents' residences, offices, or any other convenient locations for the participants.

3.6.2 Observations

To gain comprehensive insights into the farmers' abilities and capacity to transform their community through their choices and participation, the study employed the non-participant technique of non-controlled direct observations, utilizing a checklist of questions. The researcher conducted visits and interviews with the farmers while also making observations of their radical terraces. During the observation process, the practices related to their adoption of radical terraces were carefully noted and recorded in shorthand notebooks.

The observation of the terraces focused on several parameters, including the types of construction material used for the cuts of radical terraces, the level of exploitation and use of radical terraces, the types of crops planted or harvested in the terraces, the level of maintenance of the radical terraces, and the land use activities and food storage or utilization practices associated with the terraces.

3.6.3 Documentary Sources

This study employed document review to amass pertinent information for literature review and reinforce theoretical underpinnings and discussions. The data acquired through this review also enhanced the insights from the field. The documentary data sources encompassed a range of materials, including textbooks, reports, scholarly articles, official government documents and plans, electronic resources, and visual aids such as figures, charts, and photographs. These materials pertained to farmers' food production and security, adopting radical terraces, participation in self-help groups (SHGs), access to agricultural information, engagement in decision-making, household attributes, and external support. Integrating documentary sources proved to be a valuable complement to the information gleaned from direct interviews with the study participants.

3.7 Data Analysis and Techniques

After data collection, the amassed information was processed and entered into a computer system for subsequent analysis. The initial stage encompassed coding, refining, and refining the data for accuracy. Qualitative data from interviews and observations were methodically coded and organized, streamlining their content for comprehensive analysis. Notably, concepts and themes linked to the involvement of smallholder farmers in radical terracing were meticulously identified and elucidated.

The Express Scribe Transcription Software and Express Scribe Dictation Software were both effectively employed to facilitate transcription and content analysis.

A combination of descriptive and inferential statistics techniques was adopted for the quantitative data analysis. Responses from questionnaires were assigned numerical codes and subsequently entered into a Microsoft Excel spreadsheet of version 2016, enabling systematic analysis and data cleaning. The amassed quantitative data was then imported into Statistical Package for the Social Sciences (SPSS) software of version 23.0, which enabled further comprehensive analysis.

The descriptive statistics approach encompassed frequency tables and percentages, offering a succinct data summary. Contingency tables (cross-tabulation) were generated to provide descriptive insights into the collected data. Additionally, the Pearson correlation method was utilized to scrutinize the relationships existing among the dependent, intervening, and predictor variables inherent to this study. Moreover, multiple regression analysis was employed to unravel multifaceted relationships among the predictor variables.

3.7.1 Descriptive Statistics

Within this investigation, the data were systematically structured and succinctly condensed through the synergistic application of descriptive statistical methods. The descriptive analysis procedure encompassed utilising statistical mechanisms, including frequency distributions, as tools to encapsulate the quantitative variables succinctly. Notably, even variables such as income, family size, and age, albeit measured on a ratio scale, were strategically grouped and classified for the descriptive analysis. Moreover, cross-tabulations, or contingency tables, were judiciously employed to delve into the interrelationships within the categorical data, unearthing connections among variables. The outcomes were adeptly presented through frequency tables alongside graphical representations like figures and charts, fostering a lucid and succinct portrayal of the data.

3.7.2 Inferential Statistics

Categorical analysis was carried out for all pivotal variables, yielding ordinal data. To enhance the capacity for more advanced analysis, all data assessed on a nominal scale were translated into numeric representations using dummy variables. According to William M.K. Trochim (2008), a dummy variable is “a numerical variable used in regression analysis to represent subgroups of the sample in a study, assuming only a finite number of values (such as 0 or 1) to identify different categories of qualitative variables.” Hence, dummy variables lack quantitative numerical values. The remaining variables that were gauged on an interval scale were incorporated within the regression model.

The potential predictors underwent definition and examination through bivariate analysis using the Chi-square distribution. This examination was conducted between the response variables concerning adopting radical terraces and among the various predictor variables. Predictors that demonstrated non-collinearity (Pearson correlation $r < 0.5$) with the response (p-value < 0.1) were retained for the construction of the multivariate model. Correlation was also employed to gauge the strength of the interrelation between the study variables. Additionally, a multivariate regression analysis (MRA) was carried out to ascertain the linkage between the predictor (independent) variables and the response (dependent) variables, accompanied by 95% confidence intervals. The MRA aimed to prognosticate or elucidate the impact of the predictor on the response variables.

Furthermore, for this study, chi-square statistics were chosen to assess whether a significant connection existed between each nominal (categorical) predictor and the response variable. The data were presented in a contingency table where each row represented a category for one variable, and each column symbolized a category for the other variable. The Chi-square statistic was applied to scrutinize the null hypotheses of the study. According to this test, variables were deemed independent if the distribution of one variable remained uniform regardless of the distribution of the other variable. This evaluation was achieved through the utilization of observed and anticipated frequencies. The observed frequencies denote the frequencies present in the sample, while the anticipated frequencies represent the frequencies that would manifest if the null hypothesis held. The expression of the chi-square statistic is as follows:

$$\chi^2 = \sum \frac{(O_i - E_i^2)}{E_i},$$

Where: O_i = Observed frequencies and E_i = expected frequencies

The null hypothesis holds if the distribution follows an approximate pattern similar to the distribution with k-r degrees of freedom. Pearson's chi-square statistic was applied to evaluate the potential interdependence among the nominal (categorical) variables. In the presentation of the chi-square, the value is denoted along with its associated degrees of freedom and the significance value at a 5% significance level, along with 95% confidence intervals.

Once a connection was established, correlation analysis was conducted to quantify the magnitude of the connection. Pearson's correlation coefficient r was employed to gauge the intensity of the relationship. Correlation values range from -1.00 to 1.00. A value of 1.0 signifies a perfect correlation, which may be either negative or positive, whereas a value of 0 indicates a lack of correlation or association. The calculation of the correlation coefficient is accomplished through the following equation:

$$r = \frac{\mathrm{cov}_{xy}}{s_x s_y} = \frac{\sum (x_i - \tilde{x})(y_i - \tilde{y})}{(N-1)s_x s_y},$$

Where s_x represents the standard deviation of the variance for the first sample, s_y signifies the standard deviation for the second sample, $\tilde{x}$ denotes the sample mean, and x_i stands for the raw data point. Both the r value and the p (probability value) re provided in cases of reporting correlations, indicating that two variables are correlated or possess a relationship when $p < .05$

Moreover, multivariate regression analysis (MRA) was chosen to scrutinise the connection between predictor and response variables. In regression analysis, the predictor variable (x variable) elucidates the response variable (y variable). The researcher exercises control over the predictor variable, making it the independent variable that does not fluctuate freely. Conversely, the response variable fluctuates and serves as the dependent variable. Selecting a specific type of regression analysis hinges on the unique research context.

In this study, MRA was employed to provide insights into the influence of predictor variables on the response variable while considering the impacts of other independent variables. Its objective was to determine the dependent variable by considering several independent variables, thereby uncovering the predictive capacity of the connection between them. Variables employed in MRA must be measured at a higher level, interval, or ratio. For nominal data, it can be transformed into categorical data using dummy variables (Singleton et al., 1993). Acknowledging that MRA operates on the assumption of linear relationships between the variables is vital.

The MRA model enhances the elucidation of the predictor variables. As indicated by Shalabh (2013), the formulation of the MRA model is as follows:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + ...+ \beta_K x_k + \varepsilon_i$$

Where: y = dependent variable to be predicted; The parameters β_0, β_1, β_2, $\beta_3, \ldots \beta_k$ are the regression coefficients associated with x_1, $x_2, x_3 \ldots\ldots x_k$ = independent variables measured without errors; and ε is the random error component reflecting the difference between the observed and fitted linear relationship

The j^{th} regression coefficient β_j represents the expected change in y per unit change in j^{th} the independent variable x_j . Assuming E (ε) = 0

$$\beta_j = \frac{\partial \mathrm{E}(y)}{\partial x_j}.$$

Moreover, the employed MRA necessitates assessment. This assessment involves scrutinizing the goodness of fit and the estimated coefficients. The goodness of fit assesses the model's effectiveness in depicting the correlation between the two variables. The coefficient of multiple determination is used to measure the goodness of fit. R^2 evaluates the strength of the regression equation and is determined by:

$$R^2{}_{y.1,2...k} = \frac{\sum(\hat{y} - \tilde{y})^2}{\sum(yi - \tilde{y})^2}$$

A large R^2 signifies that a significant proportion of the dependent variable can be elucidated in the equation, implying that the regression expounds on the interconnection between the variables. In this scenario, preference is given to the regression equation. However, in a smaller case R^2, instead of rejecting the regression outright, it is subjected to a test of significance. This test evaluates the effectiveness of the regression equation in forecasting and approximating the response variable. The F ratio serves as the test statistic employed in MRA and is formulated as follows:

$$F = \frac{(N - k - 1)R^2}{k(1 - R^2)}$$

Where: N = the number of cases and K = number of predictors in the model

The information regarding the statistical analysis, including the Analysis of Variance (ANOVA), was provided by the statistical packages used, such as SPSS version 23 software

(Agresti and Finlay, 1997). In this study, SPSS version 23 was utilized to perform Multivariate Regression Analysis (MRA) and conduct all the necessary tests simultaneously.

Utilizing MRA, the study aimed to ascertain the impacts of radical terraces' adoption on both food production and security. The regression model was designed with independent variables, including household attributes, affiliation with self-help groups, access to agricultural information, external assistance, and involvement. These independent variables were examined in relation to the dependent variables, namely, the adoption measures and food security.

3.8 Ethical Considerations

Throughout the research endeavour, ethical considerations held the utmost significance. Ethical aspects encompassed factors like trustworthiness, responsibility, mutual regard, equity, and confidentiality during data gathering and analysis (Recker, 2013). Adhering to ethical principles ensures that the rights of research subjects in the study are upheld, and their involvement remains voluntary, with the freedom to withdraw from the study if they feel uncomfortable or threatened, as emphasized by Remeyi, Money, and Swartz (2005). All necessary ethical requirements were duly observed and followed throughout this research, ensuring the protection of participants' rights and compliance with relevant research regulations and laws.

3.9 Clearance

In conducting this study, research permits were essential. Initially, research and ethical clearance were obtained from the University of Nairobi in May 2019 (see Appendix 13). Subsequently, this clearance facilitated the acquisition of a research permit from the Nyamagabe district office (see Appendix 13). This permit introduced me and my research assistants to the executive secretaries of sectors and cells, as well as the chiefs of villages where interactions with the study participants took place.

3.9.1 Consent Forms

Farmers were invited to participate in the study voluntarily, and their formal consent to join the research was sought. To ensure transparency, they were provided consent forms, which were included in the research questionnaires (see appendices 1-3). These consent forms clearly explained the purpose of the study and the expected level of engagement from the participants. Additionally, they were informed of their rights to continue participating or to

withdraw from the study at any time. While participants were encouraged to stay involved throughout the study, they were under no obligation to do so.

3.9.2 Anonymity

To encourage participation and uphold research ethics, participants were informed about the confidentiality of their identities. They were guaranteed that their details would be handled with the utmost confidentiality during the analysis and presentation of research results. However, participants were informed that their data could be employed for follow-up and data pairing during data collection. Consequently, in adherence to ethical research standards, no identifying information about the 192 participants was disclosed publicly.

3.9.3 Confidentiality

The information provided by participants was treated with strict confidentiality and anonymity. Despite gathering identity details during the study, respondents were given assurance that the information extracted from the interview guides would exclusively serve the objectives of this research. As a result, the results were presented in a manner that prevented specific participants from being linked to the data after analysis, ensuring their privacy and confidentiality.

3.10 Problems Encountered

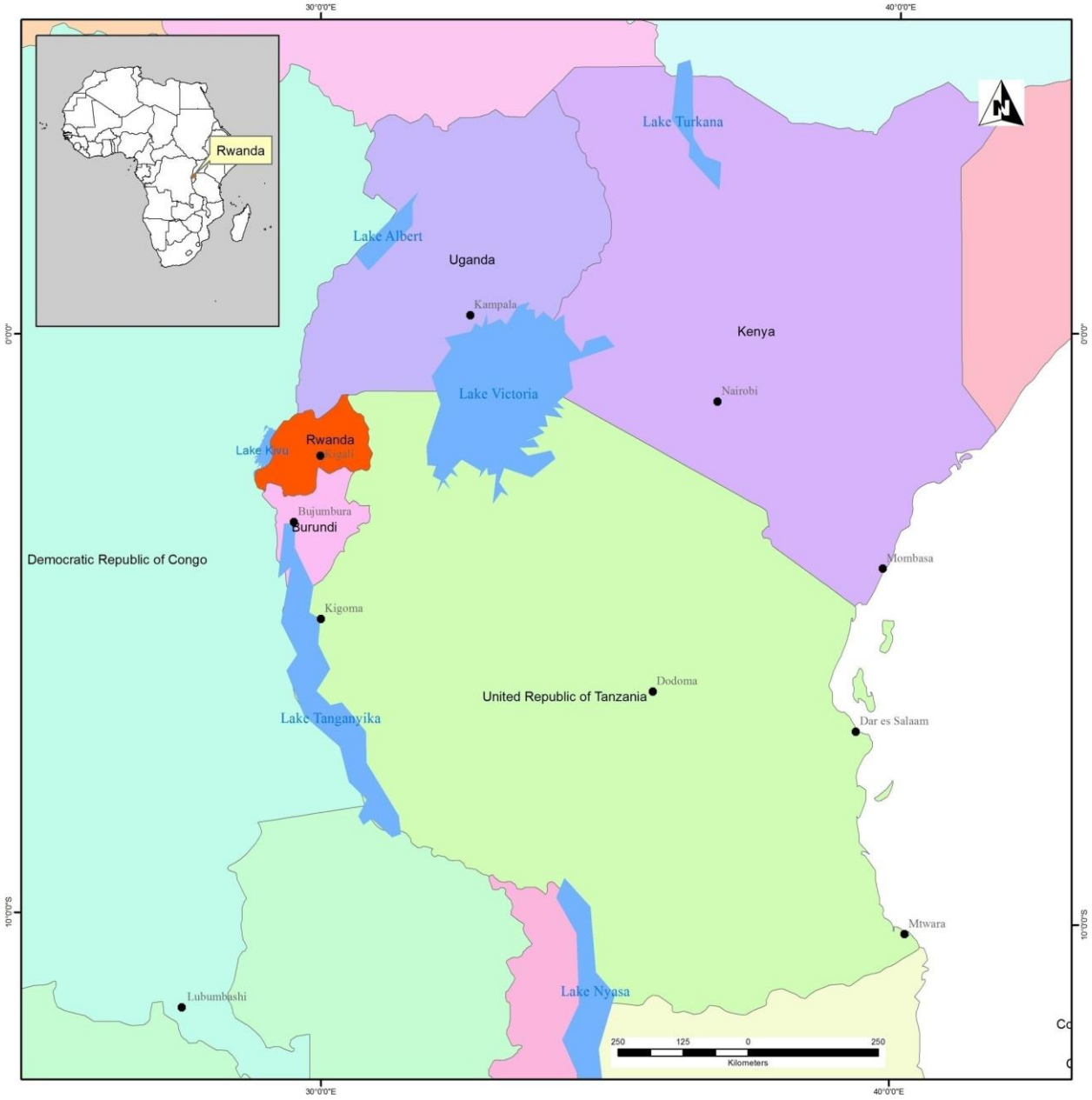
During the data collection process in the field, the research team encountered several challenges. First, some key informants did not respect their scheduled appointments, which required us to adjust our interview timetable accordingly. Secondly, locating and reaching some farmers and key respondents proved difficult as they were engaged in farming activities in different areas from where their farms were situated. Thirdly, communication was hindered by the lack of electricity, particularly in the Nkomane sector, where the researcher spent several weeks, including weekends. Fourthly, heavy rains posed a problem as they made local communication in the villages difficult due to impassable roads, making it challenging to travel between villages using vehicles and motorcycles. Lastly, some respondents were unwilling to answer questions related to their seasonal income. They expressed concerns that the study might be used to profile and categorize people of Ubudehe[2] in Rwandan society based on their level of education, income, and occupation.

[2]In the year 2001, the Ubudehe initiative was launched as a collaborative effort between MINECOFIN and MINALOC. The term ‘Ubudehe’ was deliberately selected to highlight the significance of

3.11 Maps

The following maps offer visual representations of the geographic positioning of Rwanda, Nyamagabe district, and the selected sectors within this district. Map 4 exhibits Rwanda's location on the African continent and accentuates its situation in the Central Eastern region of Africa. Furthermore, the map delineates the adjacent nations of Rwanda, specifically Uganda to the North, Tanzania to the East, Burundi to the South, and the Democratic Republic of the Congo to the West.

collective involvement and participatory advancement deeply rooted in the ancestral culture of Rwanda. The recent formulation of the Ubudehe approach in Rwanda strives to build upon the favorable attributes of this historical strategy while incorporating modern participatory methods that have demonstrated effectiveness in community progress (Niringiye and Ayebale, 2012: 141-142). Presently, the Ubudehe concept has transformed into a domestically cultivated development program, categorizing citizens based on diverse criteria. These groupings play a pivotal role in determining the extent of support extended to families through governmental social protection initiatives. In 2014, the Local Administrative Entities Development Agency introduced new Ubudehe classifications. Households are grouped according to their socio-economic condition, ownership of assets (including land and other possessions), and the livelihood activities of their primary earners. The defined categories are as follows: Category 1: Families lacking residential property and facing challenges in fulfilling basic necessities. Category 2: Those possessing their own residence or capable of renting one, yet encountering difficulty in securing consistent employment. Category 3: Individuals with stable jobs and farmers involved in producing surplus beyond subsistence farming, encompassing those managing small and medium-sized businesses that offer employment prospects. Category 4: Individuals engaged in large-scale enterprises, employees affiliated with international organizations and industries, as well as government employees (Republic of Rwanda, 2015).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Lake Kivu
Kigali
Bujumbura
Burundi
Democratic Republic of Congo
Mombasa
Kigoma
Dodoma
United Republic of Tanzania
Lake Tanganyika
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Figure 4: The geographical location of Nyamagabe District

The administrative map of Rwanda illustrates the precise positioning of the Nyamagabe district, which is the primary focus of the current study within the array of districts in Rwanda. Nyamagabe district is among the 30 administrative districts within the nation.

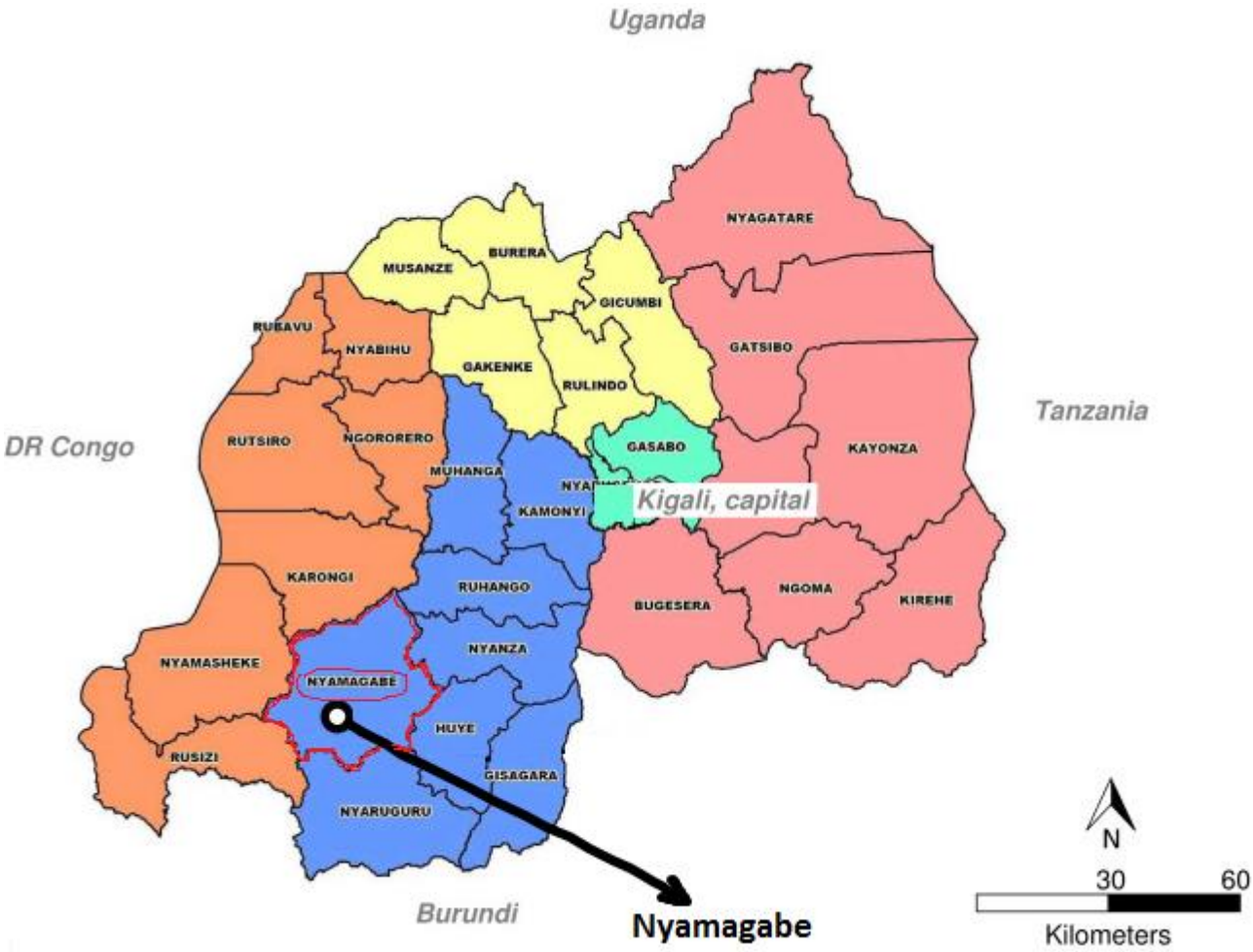

Figure 5: Administrative map of Rwanda

Figure 6 portrays the administrative map of the Nyamagabe district, showcasing the distinct sectors chosen as focal points for the research. Nyamagabe district is partitioned into 17 administrative sectors in total. From these, four sectors, namely Buruhukiro, Gatare, Kibilizi, and Nkomane, have been designated as research sites due to their noteworthy achievements in implementing and utilizing radical terraces within the district.

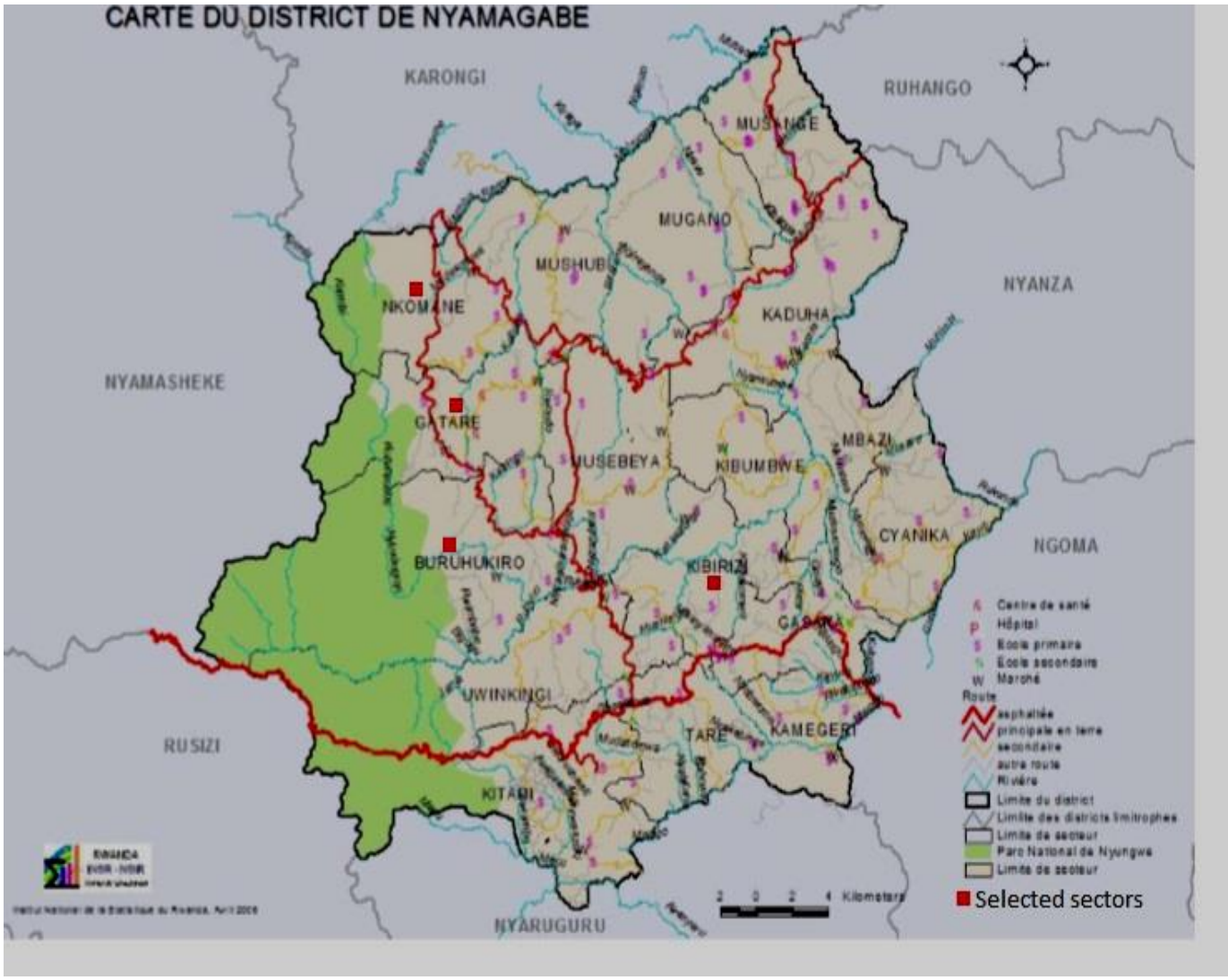

Figure 6: Nyamagabe District Map

CHAPTER FOUR: DATA ANALYSIS, PRESENTATION AND INTERPRETATION

4.0 Introduction

This chapter presents the empirical data gathered from a sample of 192 smallholder farmers. Descriptive statistics are utilized to present the data on the study variables, including farmers' adoption of radical terraces, food security, household characteristics, access to agricultural information, membership in Self-Help Groups, outside support, and farmers' participation in radical terraces. The chapter offers a detailed account of the empirical results of the data analysis using descriptive statistics. The findings obtained from inferential statistics will be presented in the subsequent chapter.

4.1 Farmers' Adoption of Radical Terraces

The initial aim of this study was to assess the degree to which farmers have embraced the concept of radical terraces and its repercussions on their food security. In this segment, we analyze the data related to farmers' adoption of radical terraces, their agricultural yield, livestock rearing, and their current food security situation.

4.1.1 Adoption of Radical Terraces

The metrics utilized for assessing the acceptance of radical terraces encompassed the duration of adopting radical terraces, the overall acreage dedicated to the construction of these terraces, the extent of maintenance carried out on them, and the varieties of fodder cultivated within the terraces.

4.1.1.1 Year of experience in adopting radical terraces

Table 3 presents the years of experience farmers had in using radical terraces, and the data is reported based on the year in which each farmer started constructing them. The results indicate that 10.4% of the farmers had experiences of less than 5 years, 43.8% had experiences ranging from 5 to 14 years, 26.6% had experiences ranging from 15 to 25 years, and 19.3% had experiences of 25 years and above. The findings reveal a diverse range of experiences, with some farmers becoming aware of radical terraces as early as the 1980s, while others did so in the 2000s. Additionally, it was observed that farmers in the NNP belt adopted radical terraces more recently. Moreover, only a few farmers started using radical terraces when the project was initiated to support terracing efforts, and gradually they learned

how to construct their terraces. Almost all the farmers constructed radical terraces with the help of different organizations, but a minority of them made the terraces using their efforts.

A sector-level key informant (Gatare FFS) revealed that the implementation of radical terraces had been underway within the district for an extended period: “The project of CZN constructed radical terraces since 1985, and people did not exploit them, but nowadays, after realizing their usefulness, farmers construct them by themselves…people understand the importance of radical terraces because every citizen who owns a field that is destroyed by soil erosion is constructing them to preserve the land.”

4.1.1.2 Ares of Radical Terraces Constructed

Table 3 illustrates that 58.3% of the respondents constructed terraces ranging from 1 to 99 ares, 29.7% constructed terraces covering 100 to 299 ares, and 12.0% constructed terraces spanning 300 ares and above. When asked why they constructed the radical terraces, several farmers highlighted their importance in farming. They mentioned that the terraces improved the production of both fodder and food, served as anti-erosion tools, and aided in retaining fertilizers and water in the terraced area, leading to better growth of food crops. A key informant from the Nkomane sector further emphasized the significance of radical terraces in enhancing farming practices: “Citizens know that radical terracing is land organized to facilitate growing plants and increase production. Radical terraces are constructed using known techniques given that people do it by themselves.”

This was supported by another key informant at the district level (FDE):

> The importance of radical terraces includes preventing soil erosion in the period of heavy rain, keeping good arable land for the next generation, and keeping good relationships among farmers. It is better to spread radical terraces in order to fight against hunger and poverty by increasing food production and income from the sold surplus. Radical terraces keep rainwater that feeds the crops, which permits farmers to cultivate during the dry season (June, July, and August) because the land is fresh.

4.1.1.3 Level of Maintenance of Radical Terraces

Respondents used different methods for maintaining their radical terraces, including planting fodder and agroforestry trees; making anti-erosion ditches; rotation of food crops in radical terraces; proper land use and management; rebuilding damaged radical terraces; planting improved seeds; and keeping animals away from the terraces. Table 3 shows that the level of maintenance was very good at 80.7%, good at 16.7%, and poor at 2.6%. The farmers gave

different views on the status of radical terraces, which included terraces were very good/good because they improved food production, retained soil fertility, and water, gave fodder to livestock, were anti-erosion tools, helped to get enough produce, helped to use land properly, helped in improved livestock production, helped to improve a farmer's social status, helped improve production than traditional ways and protected land from overexploitation. However, as stated by the respondents, radical terraces required a lot of inputs (chemical and organic fertilizers) and resources (workforce, financial and technical resources). They provided low production when farmers did not use enough fertilizers or constructed them poorly.

Table 3: Farmers' Adoption and Use of Radical Terraces

		Number	**Per cent**
Years of experience in constructing radical terraces (Binned)	< 5	20	10.4
	5 – 14	84	43.8
	15 – 24	51	26.6
	25 – 38	37	19.3
	Total	**192**	**100.0**
Square meters of radical terraces constructed	1-99 Ares	112	58.3
	100-299 Ares	57	29.7
	>=300 Ares	23	12.0
	Total	**192**	**100.0**
Levels of maintenance of radical terraces	Low	5	2.6
	Medium	32	16.7
	High	155	80.7
	Total	**192**	**100.0**

Regarding the upkeep of radical terraces, a key informant at the sector level (Nkomane) provided the following information: "In Nyarwungo cell, farmers claimed not to plant Napier grass because it does not grow well in the wet weather. Seeds like Setaria, calliandra, and Pennisetum can help farmers maintain radical terraces as they last longer. Other kinds of natural fodder can feed animals and increase the quantity of milk, but RAB claimed not to have mountain ones for planting on radical terraces."

Photo A Photo B

Photo 4 1: Radical terraces

Source (Photo A): WOCAT (2014) database reference: T_RWA003en Radical Terraces Rwanda (Radical terraces under construction)

Source (Photo B): Radical terraces in Gatare sector, Nyamagabe district (Researcher on field work, taken on 27th June 2019).

4.1.2 Types of Fodder Planted in the Radical Terraces

The acreage of fodder planted in radical terraces varied among farmers. Table 4 reveals that 62.0% of the respondents planted Setaria, 37.0% opted for Napier grass, and 1.0% chose Caliandra. Regarding the acreage of fodder planted on radical terraces for feeding livestock, both tables 5 and 6 indicate different ranges of grass planted in radical terraces. Specifically, 60.4% of the respondents planted fodder for livestock covering 1 to 99 Ares, 29.2% between 100 and 299 Ares, and 10.4% planted 300 Ares and above.

Table 4: Type of Fodder and Acreage Planted in Radical Terraces

		Number	Per cent
Type of fodder planted in radical terraces	Napier grass	71	37.0
	Caliandra	2	1.0
	Setaria	119	62.0
	Total	**192**	**100**
Acreage of fodder planted in radical terraces	1-99Ares	116	60.4
	100-299Ares	56	29.2
	>=300Ares	20	10.4
	Total	**192**	**100**

By adopting radical terraces, farmers expanded their access to fodder for livestock. They cultivated various types of fodder to ensure sufficient feed for their animals, providing valuable manure for the radical terraces. Additionally, the farmers introduced new forage species such as calliandra, Pennisetum, and Setaria. Table 5 presents the types of fodder planted and their corresponding acreages. The introduction of fodder on the radical terraces not only maintained their quality but also played a significant role in reducing soil erosion. Furthermore, the fodder planted on the terraces helped retain rainwater in the highlands of the study area, contributing to better water management in the region.

Table 5: Types and Acreage of Fodder Planted in Radical Terraces

Types of fodder and acreage		**Number**	**Per cent**
Acreage of Napier grass	1-99 Ares	56	78.9
	100-299Ares	13	18.3
	>=300 Ares	2	2.8
	Total	**71**	**100.0**
Acreage of Calliandra	1-99 Ares	2	100.0
	100-299Ares	0	0.0
	>=300 Ares	0	0.0
	Total	**2**	**100.0**
Acreage of Setaria	1-99 Ares	58	48.7
	100-299Ares	43	36.1
	>=300 Ares	18	15.1
	Total	**119**	**100.0**

Photo 2: Image of Napier *grass* and *setaria planted* in Gatare Sector taken on 27th June 2019

4.1.3 Level of Adoption of Radical Terraces

To classify the adoption of the radical terraces variable, we assigned scores between 0 and 3 for each indicator, considering each indicator's significance within this study. The cumulative scores for all adoption indicators ranged from 0 to 40.5. Using this range, we established three distinct categories for this variable: Low adoption (0-20), Medium adoption (21-27), and High adoption (28-41) scores (see the scoring table in Annex 4).

As illustrated in Table 6 below, the findings reveal that the degree of adoption and utilization of radical terraces was predominantly high (81.8%), with a smaller segment falling within the medium adoption category (17.7%) and a very minimal fraction representing low adoption (0.5%).

Table 6: Distribution of Respondents According to their Level of Adoption of Radical Terraces

Level of adoption of radical terraces	Number	Per cent
Low adoption	1	.5
Medium adoption	34	17.7
High adoption	157	81.8
Total	**192**	**100.0**

In conclusion, the study revealed that the years of experience adopting radical terraces varied widely, ranging from 1 to 38 years. Most respondents (43.8%) had 5 to 14 years of experience, while 26.6% had 15 to 25 years of experience. Regarding the acreage of radical terraces, 58.3% of farmers reported constructing between 1 to 99 acres. Notably, 80.7% of farmers maintained their radical terraces very well.

Regarding fodder cultivation, farmers planted various species, including Napier grass (37%) and Setaria (62%), while the acreage allocated for fodder planting spanned from 1 to 300 acres. Overall, the evaluation of adopting and utilizing radical terraces revealed a high level among most farmers, reaching 81.8%.

4.2 Farmer Food Security Situation

Food security served as the dependent variable in this study, formulated as part of the fifth objective, which aimed to investigate the impact of smallholder farmers' food production and the adoption of radical terraces. The indicators used to measure food security included households' production in terms of crops and livestock, their yield, food availability, utilization of surplus produce, and the frequency of meals consumed.

4.2.1 Crop Production

The indicators related to food crop farming were categorized as follows: crop types, farm inputs and practices utilized, acreage planted, and the yield obtained.

Types of food crops planted in the last long rainy season: The respondents identified the primary crops they planted during the last long rainy season. Table 7 illustrates that Irish potatoes were planted by 58.3% of the respondents, followed by beans (20.8%), maize (13.0%), and wheat (7.8%). Although the assortment of food crops exhibited variation among diverse regions, certain crops were consistently grown in the study area. Many farmers employed terraces to cultivate Irish potatoes, maize, wheat, and climbing beans.

Acreage planted to the food crops: Table 7 also shows different ranges of acreage in Ares[3] planted by farmers to food crops in the study area. About 70.8% of the respondents cultivated less than 100 Ares, 28.2% cultivated from 100.01 to 1,414.33 Ares, 0.5% cultivated from 1,414.34 to 2,726.67 Ares, and 0.5% cultivated 2,726.68 Ares and above.

Yield harvested: Table 7 presents the yield obtained from the farmers' primary food crops in kilograms (kgs). Approximately 76.6% of the farmers achieved a yield of 401 kgs and above, 15.6% obtained a yield between 201-400 kgs, and 7.8% obtained a yield between 80-200 kgs. The obtained yield was sufficient to meet the food needs of the farmers' households during

[3] Are (a) is a square piece of land shown alongside; 1are=100 square metters and 100ares=1hectare (ha)

the period between two harvests. Table 7 displays the specific yield of each food crop that was planted.

Table 7: Types, acreage, and yield of planted food crops in the radical terraces

		Number	Per cent
a. Type of food crops	Beans	40	20.8
	Irish potatoes	112	58.3
	Maize	25	13.0
	Wheat	15	7.8
	Total	**192**	**100**
Acreage of crops (Binned)	<=100.00	136	70.8
	100.01 - 1413.33	54	28.1
	1413.34 - 2726.67	1	0.5
	2726.68+	1	0.5
	Total	**192**	**100**
Yield of crop production (in Kgs) (Binned)	80-200	15	7.8
	201 – 400	30	15.6
	401+	147	76.6
	Total	**192**	**100**

Concerning the primary crops grown by farmers, a sector-level key informant (from Nkomane) conveyed: "This area is among very cold places, which results in having few crops, especially food crops. The main crops cultivated in this sector include Irish potatoes, wheat, maize, beans, and peas, but some people grow vegetables and some fruits which help to fight against malnutrition."

Photo 3: Image of Irish *potatoes (Nkomane Sector taken on 15th June 2019)* and *Wheat* (Gatare Sector) taken on 27th June 2019.

4.2.2 Use of Farm Inputs and Practices

Food security was closely related to the inputs and practices used in food crop farming. Table 8 reveals that 79.2% of the farmers practised improved seedbed preparation, whereas 20.8% used traditional seedbed practices. Regarding the planted type, 71.9% opted for hybrid seeds, while 28.1% chose local seeds. Almost all farmers (97.9%) reported using chemical fertilizers, and a similarly high percentage (99.5%) utilized farmyard manure during the last long rainy season. Additionally, 99.5% of the farmers reported effectively weeding their fields.

Table 8: Food Crop Farming Inputs and Practices Reported by the Respondents

		Number	**Per cent**
Seedbed preparation	Traditional	40	20.8
	Modern	152	79.2
	Total	**192**	**100.0**
Type of seeds planted	Hybrid	138	71.9
	Local	54	28.1
	Total	**192**	**100.0**
Chemical fertilizers used	No	4	2.1
	Yes	188	97.9
	Total	**192**	**100.0**
Farmyard manure used	No	1	0.5
	Yes	191	99.5
	Total	**192**	**100.0**
Clean weeding	Not clean	1	0.5
	Clean	191	99.5
	Total	**192**	**100.0**

A key informant at the sector level (Buruhukiro Agronomist) talked about seeds as follows: “Concerning the improved seeds, we requested MINAGRI, and they accepted to give us a stock of Irish potato seeds, and to increase the number of seed multipliers but there were no maize seeds.”

For maize seeds, a key informant at the sector level (Gatare Agronomist) reported that:

> Concerning maize, we cultivate white hybrid seeds, which are expensive at the market, and other local seeds that resemble palm oil and which we plant in the cold areas, and which are very cheap at the market and sometimes sold at home by farmers. We need good hangars to keep them dry.

A key informant at the sector level (FFS from Nkomane) confirmed the use of manure by the farmers: “Adopting radical terraces by smallholder farmers is very important because when one cultivates a single crop, he/she produces the quantity which is enough to feed the family due to use of manure.”

4.2.2.1 Acreage Planted to the Food Crops and Yield Realized

Table 9 details the acreage planted for food crops and the corresponding kilogram yields (kgs) obtained from beans, Irish potatoes, maize, and wheat. Most respondents (97.5%) reported planting beans in less than 100 ares, while only 2.5% planted them in 100.01 - 1413.33 ares. Regarding bean production, 47.5% of respondents harvested more than 401 kgs, 30.0% obtained between 201 – 400 kgs, and 22.5% obtained 80-200 kgs.

For Irish potatoes, 58.9% of respondents planted less than 100 ares, and 39.3% used 100.01 - 1413.33 ares. Among those who used the more significant acreage, 92% reported harvesting more than 401 kgs, while 6.3% harvested between 201–400 kgs. As for maize, 76% of respondents planted on less than 100 ares, and 24% on 100.01-1413.33 ares. About 60% of the respondents reported harvesting more than 401 kgs, 32% obtained between 201–400 kgs, and 8% harvested 80-200 kgs.

Regarding wheat, 66.7% of respondents reported planting less than 100 acres, while 20% planted it on 100.01 - 1413.33 ares. Approximately 60% harvested more than 401 kgs, 26.7% obtained 201 – 400 kgs, and 13.3% harvested 80-200 kgs.

Table 9: Acreage of Planted to Food Crops and Yield Obtained

Acreage Planted and Yield		Number	Per cent
Beans	**Yes**	**40**	**20.8**
Acreage category of Beans	<=100.00	39	97.5
	100.01 - 1413.33	1	2.5
	1413.34 - 2726.67	0	0.0
	2726.68+	0	0.0
The yield of beans production (in KG) (Binned)	80-200	9	22.5
	201 – 400	12	30.0
	401+	19	47.5
Irish potatoes	**Yes**	**112**	**58.3**
Acreage category of Irish potatoes	<=100.00	66	58.9
	100.01 - 1413.33	44	39.3
	1413.34 - 2726.67	1	0.9
	2726.68+	1	0.9
The yield of Irish potatoes production (in KG) (Binned)	80-200	2	1.8
	201 – 400	7	6.3
	401+	103	92.0
Maize	**Yes**	**25**	**13.0**
Acreage category of Maize	<=100.00	19	76.0
	100.01 - 1413.33	6	24.0
	1413.34 - 2726.67	0	0.0
	2726.68+	0	0.0
The yield of maize production (in KG) (Binned)	80-200	2	8.0
	201 - 400	8	32.0
	401+	15	60.0
Wheat	**Yes**	**15**	**7.8**
Acreage category of Wheat	<=100.00	10	66.7
	100.01 - 1413.33	3	20.0
	1413.34 - 2726.67	2	13.3
	2726.68+	0	0.0
The yield of wheat production (in KG) (Binned)	80-200	2	13.3
	201 – 400	4	26.7
	401+	9	60.0

Photo 4: Image of farmer's Irish potatoes and maize storage (Nkurikiyimana JMV) visited by the researcher in Buruhukiro Sector, Kizimyamuriro Cell, taken on 03rd July 2019.

4.2.2.2 Level of Farmer's Food Crop Production

To classify this variable, a score was assigned within the range of 0 to a maximum of three (3) for each indicator, considering their significance in the context of this study. The cumulative score for food production amounted to 51 scores (refer to Appendix Table 9). Based on this scoring range, we established three distinct categories for food production: low production (0-20), medium production (21-30), and high production (above 31). The outcomes revealed that the level of food production was high for 19.3% of participants, medium for 76.6%, and low for 4.2%, as depicted in Table 10.

Table 10: Respondents' Level of Food Crop Production

Level of Adoption of Crop Farming	Number	Per cent
Low food production	8	4.2
Medium food production	147	76.6
High food production	37	19.3
Total	**192**	**100.0**

The study revealed that Irish potatoes were the most commonly cultivated food crop (58.3%) among beans, maize, and wheat in the last long rainy season in the study area. Additionally, it was evident that 70.8% of respondents cultivated less than 100 Ares. About 76.6% of farmers obtained a yield of 401 kgs and above. However, respondents reported facing significant challenges in their food crop farming, such as the lack of sufficient lime, manure, and chemical fertilizers, difficulties obtaining improved seeds, and limited technical assistance and financial capacity.

4.2.2.3 Farmers' Keeping of Livestock

The farmers' livestock-keeping indicators were measured in terms of the number of livestock kept, their production, and sales.

Types of livestock kept by the sampled households

Table 11 presents data on the various kinds of livestock kept by households, including cattle (72.9%), pigs (10.9%), and goats (6.8%). In Rwandan traditional culture, cattle hold significant importance, and cows symbolise household wealth and prosperity. This cultural belief contributes to the prevalence of cow possession, as they are viewed as prestigious livestock. Another factor is that the Girinka Program of "One cow for one poor family[4]" in Rwanda increased the number of farmer households that own and keep cattle as major livestock in the study area.

The two types of livestock were categorized as local breed and improved modern breed. Regarding local livestock, 33.9% of farmers kept 1-5 animals, 9.4% kept 6-9, 1.0% had more than 11, and 55.7% did not keep any local animals. On the other hand, the number of improved livestock varied between 1 and 13, with 51.0% of farmers keeping 1-5 improved livestock, 10.9% kept 6-10, 7.8% kept more than 11, and 30.2% did not have any improved livestock. It was evident that more farmers kept improved types of livestock compared to local traditional cattle. Livestock keeping contributed to production that supplemented household food crop production, thereby increasing food security for farmers' households.

Livestock Products

The products obtained from livestock included milk, eggs, meat, and butter. For this study, the researcher focused on milk production as the primary livestock product in the Rwandan

[4]To realize the goals outlined in the 2020 vision, the Rwandan government introduced the "one cow per poor family program" or the Girinka program in August 2006. The primary aim of this initiative is to provide support to the neediest households in the nation, enabling them to raise milk for domestic consumption. This program was established and commenced its implementation in November 2006, with the objectives of reducing poverty levels in rural households and addressing malnutrition rates among children under five years of age. The underlying strategy involves granting a cow to a disadvantaged family, and subsequently, the calf is gifted to a neighbouring family. This neighbour, in turn, takes care of the calf and passes the second calf to another neighbouring family, forming a chain (Mutarutwa, N. C., 2014: 3-5).

community. Specifically, the study looked at the litres of milk produced by farmers' households per day. About 12.5% of farmers obtained milk ranging between 1-10 litres, 4.7% obtained 11-20 litres, and 2.1% obtained more than 21 litres. Most farmers obtained adequate milk daily for household consumption, and any surplus had to be sold.

However, selling the surplus milk posed challenges because there was no milk-processing plant to add value to the milk. As a result, farmers had to sell their milk at lower prices due to lower demand for milk consumption compared to its high supply. The lack of value chain processing for transforming milk into different products remained a significant challenge faced by the farmers.

Sales of Farmer's Livestock

The farmers engaged in selling some of their livestock. Table 11 presents the different ranges of sales the farmers make per year. Approximately 40.1% of farmers made medium sales, with a value estimated at 100,000 to 549,999 Rwf. Additionally, 13.5% made sales of less than 100,000 Rwf, 6.8% made sales between 549,999 and 1,000,000 Rwf, and 2.1% made sales exceeding 1,000,000 Rwf. However, about 37.5% of farmers did not sell any of their livestock.

During interviews with the farmers, many indicated that they used the income from livestock sales to invest in agricultural technology, aiming to improve crop production. The revenue generated from these sales allowed farmers to purchase improved seeds and fertilisers and adopt and maintain radical terraces, contributing to their overall agricultural productivity.

Table 11: Farmers' Livestock Keeping

		Number	Per cent
Types of livestock kept by Households	None	18	9.4
	Cows	140	72.9
	Goats	13	6.8
	Pigs	21	10.9
	Total	**192**	**100.0**
Number of farmers keeping local livestock	0	107	55.7
	1-5	65	33.9
	6 – 10	18	9.4
	11+	2	1.0
	Total	**192**	**100.0**
Number of farmers keeping improved livestock	0	58	30.2
	1-5	98	51.0
	6 - 10	21	10.9
	11+	15	7.8
	Total	**192**	**100.0**
Milk Yield obtained	None	155	80.7
	1-10L	24	12.5
	11-20L	9	4.7
	>=21L	4	2.1
	Total	**192**	**100.0**
Sales of farmer's livestock per year	< 100000	26	21.7
	100000 - 549999	77	64.2
	550000 - 999999	13	10.8
	1000000+	4	3.3
	None	72	37.5
	Total	**192**	**100.0**

Table 12: Number of Local and Improved Livestock Kept By Household

Types of livestock kept by households		Number	Per cent
Cows	**Yes**	**140**	**72.9**
Number of local cows	1-5	45	73.8
	6 - 10	14	23.0
	11+	2	3.3
	Total	**61**	**100.0**
Number of improved cows	1-5	81	69.8
	6 - 10	20	17.2
	11+	15	12.9
	Total	**116**	**100.0**
Goats	**Yes**	**13**	**6.8**
Number of local goats	1-5	8	80.0
	6 - 10	2	20.0
	11+	0	0.0
	Total	**10**	**100.0**
Number of improved goats	1-5	8	100.0
	6 - 10	0	0.0
	11+	0	0.0
	Total	**8**	**100.0**
Pigs	**Yes**	**21**	**10.9**
Number of local pigs	1-5	12	85.7
	6 - 10	2	14.3
	11+	0	0.0
	Total	**14**	**100.0**
Number of improved pigs	1-5	9	90.0
	6 - 10	1	10.0
	11+	0	0.0
	Total	**10**	**100.0**

Photo 5: Image of feeding livestock

Level of farmer's livestock keeping: To classify this variable, we allocated scores ranging from 0 to a maximum of three (3) to each indicator, considering their respective significance. The scoring process for livestock management encompassed a range of scores from 0 to a cumulative total of 38 (refer to Appendix Table 10). These scores were then used to establish categories for livestock keeping: low (0-20), medium (21-27), and high (28-38) levels of livestock production (see Appendix Table 10). The results indicated that the level of livestock keeping among the farmers was low for the majority (84.4%), medium for a smaller proportion (13.0%), and high for only a few (2.6%), as presented in Table 13.

Table 13: Respondents' Level of Livestock Keeping

Level of livestock husbandry	Number	Per cent
Low livestock keeping	162	84.4
Medium livestock keeping	25	13.0
High livestock keeping	5	2.6
Total	**192**	**100.0**

In conclusion, it was evident that the number of local livestock kept by farmers' households was lower than that of improved ones. Cattle was the significant type of livestock kept by farmers, accounting for 72.9% of the livestock. This indicated that milk was the most important product of livestock, and most farmers obtained enough milk for household consumption while also selling the surplus.

The study further revealed that 62.5% of the farmers who reported keeping livestock had sold it, while the remaining 37.5% did not engage in livestock sales. The level of livestock husbandry was assessed as low among the majority of the farmers (84.4%) since it supplemented the adoption of radical terraces and food crop farming activities.

4.2.3 Food Availability

This metric refers to the duration of the crop harvest, indicating the number of months it lasted. When asked if they had harvested enough yield to sustain their households until the next harvest, 54.7% of the farmers confirmed that they had, while the remaining had not. Table 14 presents the duration of the food crop harvest, regardless of whether it was sufficient to carry them through to the next harvest. Food security depended on the availability of food in the farmers' households, which relied on their crop production.

One sector-level key informant (FFS Buruhukiro) noted: “If there were no radical terraces in this sector, everybody would have died of hunger caused by soil erosion. Food is available abundantly, and people are satisfied with their Irish potato production.”

Table 14 displays the availability of food in relation to the duration of the harvested food crop. About 17.7% of farmers reported that their yield lasted less than 3 months, 24.5% obtained a yield between 4-9 months, and 3.1% claimed to have had food production for over 10 months.

It was evident that food security was contingent upon the duration of food availability between two harvests. Households whose harvest did not last for three months after harvesting were classified as “food insecure,” while those whose yield lasted between four and six months were considered “somewhat food secure.” Farmers’ households were considered food secure when the harvested yield lasted for a period of seven (7) to nine (9) months and “very secure” when it provided food for more than ten months. Although some households experienced insecurity, they sold food in local markets to meet their immediate needs.

4.2.4 Utilization of Surplus Production

To evaluate the influence of adopting radical terraces on food security, the investigator analysed how farmers utilized food crop production from their households. The utilization of the harvested food was employed as one of the metrics or markers for assessing food security. Table 14 presents the findings, indicating that 55.2% of the farmers confirmed that most of their crop produce was consumed by household members. Approximately 30.7% reported that food crop production was used for household consumption and economic transactions, as they sold the surplus. Additionally, 8.3% used the produce for household consumption and stock, while 5.7% engaged in consumption and exchange with others. The same table also reveals that 15.5% of the respondents sold surplus milk.

In this context, a sector-level key informant (Gatare agronomist) stated:

> As we practice market-oriented agriculture, people aim at taking the surplus to the market. We have already formed a cooperative that collects Irish potatoes with a vehicle to distribute them in other districts of the country. This activity was previously

done by bicycles, and people carried them on their heads. Beans cultivated are sold at the local market, while green peas are sold in Kigali city.

These findings underscore the positive impact of adopting radical terraces on food security, as it ensures sufficient food availability for households and creates opportunities for farmers to generate income by selling surplus produce and livestock products.

4.2.5 Number of Meals Taken Per Day

The frequency of daily meals consumed by household members serves as a crucial gauge of food security, encompassing food availability, accessibility, and utilization. It reflects a farmer's production level and the abundance or scarcity of food resources. Table 14 furnishes insights into the daily meal count before and after adopting radical terraces.

Figure 7 graphically depicts the shifts in food security patterns before and after implementing radical terraces within the study locale. It contrasts two variables, delineating trends in daily meal frequencies. The visual representation discloses that before adopting radical terraces, 31.8% of participants had only one meal daily, which diminished to 14.1% post-adoption. Conversely, the proportion of respondents consuming two meals per day increased from 59.9% pre-adoption to 64.6% post-adoption. Furthermore, adopting radical terraces yielded a substantial upswing in respondents reporting the consumption of three daily meals, surging from 8.3% before adoption to 21.4% after.

This graphical representation underscores the affirmative influence of adopting radical terraces on food security, correlating with improving daily meal intake among farmers. The augmentation in the percentage of farmers partaking in three meals a day denotes an enhancement in food availability and accessibility following the implementation of radical terraces.

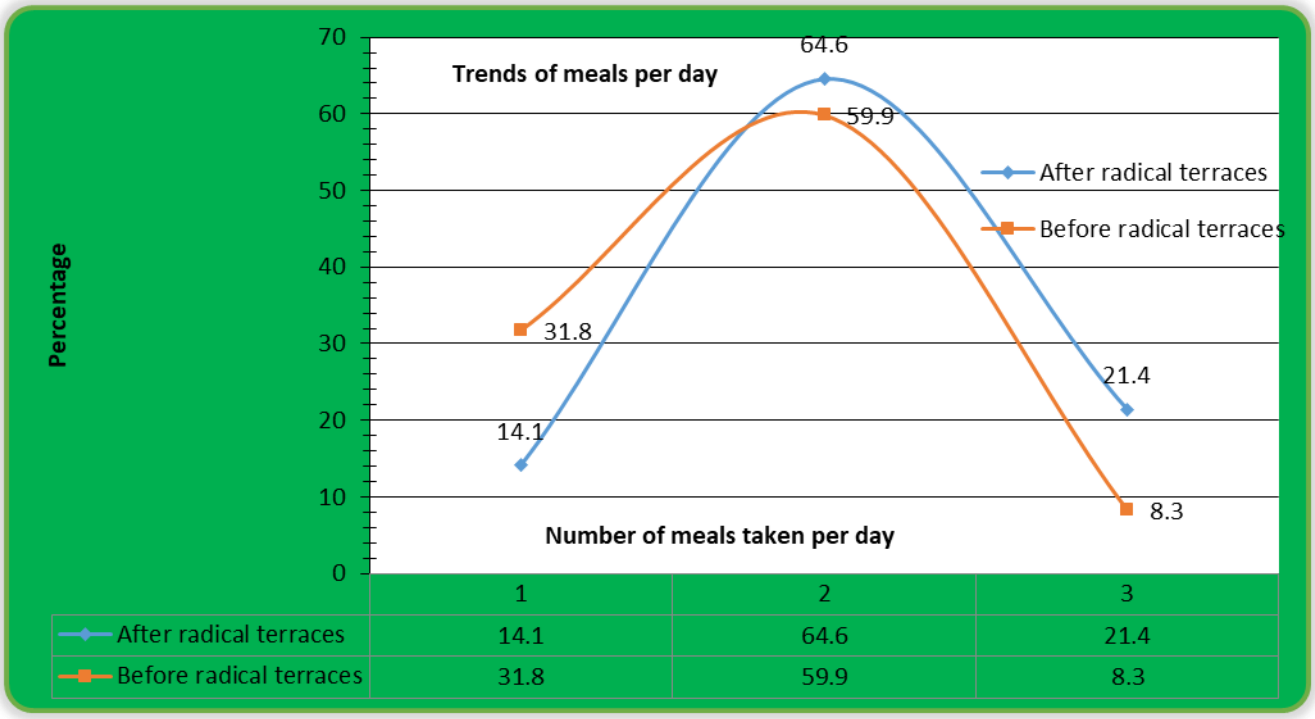

Figure 7: Number of Meal-Taking Vs Radical Terraces

Source: Primary data, May - July 2019

In his study, Murwanashyaka (2013) discovered that during the 1980s and 1990s, people suffered from severe hunger, leading to fatalities. As a result, some individuals had to relocate to Bugesera and Kibungo areas in search of food and fertile land. The famine in Nyamagabe district caused significant displacement during that period. However, such migration patterns were no longer observed during this current study. People were no longer forced to leave the Nyamagabe district in search of food, indicating that the district had made notable strides in improving food security.

Table 14: Farmers' Food Security Situation

		Number	Per cent
Household's yield obtained for the next harvest	Yes	105	54.7
	No	87	45.3
	Total	**192**	**100.0**
Number of months of harvest lasting	None	105	54.7
	Less than 3 months	34	17.7
	4-9 months	47	24.5
	>=10 months	6	3.1
	Total	**192**	**100.0**
Use of crop production	Household consumption	106	55.2
	Consumption and exchange	11	5.7
	Consumption and selling	59	30.7
	Consumption and stock	16	8.3
	Total	**192**	**100**
Selling the Surplus of milk	Yes	30	15.6
	No	162	84.4
	Total	**192**	**100.0**
Meal taken per day after the adoption of radical terraces	Once	27	14.1
	Twice	124	64.6
	3 times	41	21.4
	Total	**192**	**100.0**

Level of Farmer's Food Security: A scoring mechanism was developed to classify the food security variable. Each indicator was assigned a score from 0 to a maximum of three (3) based on its relevance within this research. The cumulative scores spanned the range of 0 to 18.0, which then facilitated the establishment of three distinct categories: low food security (0-5), medium food security (6-9), and high food security (10-18) (refer to the scoring table in Appendix Table 11). As depicted in Table 15, the analysis indicates that the farmers' food security level was stratified as high food security (1.0%), medium food security (73.4%), and low food security (25.5%).

Table 15: Distribution of The Respondents According to their Level of Food Security

Level of food security	Number	Per cent
Low food secure	49	25.5
Medium food secure	141	73.4
High food secure	2	1.0
Total	**192**	**100.0**

In conclusion, the study found that 54.7% of the respondents reported that the yield obtained from their crops was sufficient to sustain their households until the next harvest. This indicated that food security was closely related to food availability in the farmers' households. It was also observed that most respondents ensured food availability between four and nine months after their harvest, demonstrating the importance of food security in the period between the two harvests.

Moreover, the adoption of radical terraces exerted a notable influence on the daily meals consumed by the farmers. Following the implementation of radical terraces, the proportion of individuals consuming only one meal per day decreased significantly (from 31.8% to 14.1%). Conversely, there was a rise in the percentage of individuals consuming two meals (from 59.9% to 64.6%) and three meals (from 8.3% to 21.4%) per day after adopting radical terraces. These findings underscore the positive impact of radical terrace adoption on farmers' food security, with an average food security level of 73.4%.

4.3 Factors Influencing Farmers' Adoption of Radical Terraces

The factors considered in the study were related to various aspects of the farmers' circumstances, including the characteristics of their households, their access to sources of information, support from outside agencies, membership in self-help groups, and participation in decision-making processes concerning radical terraces.

4.3.1 Characteristics of the Sampled Household Heads

The information provided in this segment pertains to the study's second objective, which aimed to evaluate how farmer attributes impact the adoption of radical terraces. The investigated attributes of household heads encompassed age, gender, educational attainment, marital status, the number of children and other dependents, occupation, primary source of income, estimated seasonal amount, land size, and ownership.

4.3.1.1 Age of the Respondents

Studies on farm adoption conducted by Rogers (1981) have demonstrated that younger farmers tend to embrace novel techniques more than their older counterparts. Table 4.14 showcases the distribution of respondents' ages, indicating that 7.3% fell within the young category (below 29 years), 49.0% were categorized as middle-aged (30-49 years), and 43.8% were considered elderly (50 years and above). As a result, most respondents (70.4%) were above 40, signifying their likely extensive experience in utilizing radical terraces to address their households' food needs. Age holds significance in adoption decisions due to the

extended time frame within which adoption benefits materialize while initial costs are incurred. Consequently, the age of the farmer can significantly influence technology adoption outcomes (Kinyangi, 2014). Other investigations, like Wairiuko's study (2018), have found that younger individuals are more inclined towards technology adoption than their older counterparts.

Corresponding to the aspect of age, a key informant at the sector level (Nkomane) affirmed that the ownership of radical terraces predominantly rested with mature individuals, implying their heightened likelihood of engaging in the adoption and management of these terraces: "A farmer who owns radical terraces is not among youth since people in this category have no land. They are physically mature and financially active to manage terraces since, in this sector, a citizen can sell his /her cow to find financial means to construct radical terraces."

4.3.1.2 Gender of the Respondents

Gender-related aspects in adopting agricultural technology have been extensively explored, with various studies offering mixed findings about the distinct roles assumed by men and women in technology adoption (Bonabana-Wabbi, 2002; Mwangi, 2015). In the research locales, farming activities demanded substantial input and labour, prompting active involvement from both men and women to enhance agricultural output. Given that agriculture forms the primary livelihood in these regions, most men embraced radical terraces, as they typically functioned as the primary earners. In Rwanda's patriarchal society, a traditional ethos of shared responsibilities between genders exists.

Gender assumes a moderating function in the assimilation of novel technology (Wairiuko, 2018), and a correlation exists between the gender of the household head and the adoption of innovative farming practices. Consequently, a reasonable assumption might be that both genders, men and women, play akin roles in both 'effort' and 'adoption,' implying that they equally embrace these practices (Kinyangi, 2014). In this study, 74% of respondents were males, while 26% were females (Table 4.14). Acknowledging that agriculture represents a collaborative endeavour involving all family members is crucial.

Concerning characteristics of smallholder farmers, a key informant at the sector level (Gatare) highlighted that agricultural production activities engaged the participation of all family members, regardless of their gender:

> In this sector, radical terraces are practised on a household basis as normally in Rwandan culture, ownership is considered for the head of the family, who is a man but roles of production concern all family members. Both parents and children work

together. All people in this sector, employees or not, young or old, work on farms without gender considerations.

4.3.1.3 Level of Education of the Respondents

Najafi (2003), cited by Sigei (2014), highlighted that education constitutes an additional determinant significantly impacting household food security. When the head of the household possesses elevated educational attainment, it fosters heightened awareness regarding the potential merits of modernizing agriculture via technological interventions. Moreover, educated individuals are more inclined to comprehend instructions on fertilizer packaging and explore avenues for diversifying household incomes, thereby contributing to an enriched food provision within the household. Gathaara et al. (2011) also reported that the level of education wielded a noteworthy influence over the assimilation of agricultural technologies and innovations.

Table 16 delineates respondents' educational attainment as none, primary, TVET/CERAI, secondary, and above. The data depicts that 16.1% of respondents lacked formal schooling, 57.8% completed primary education, 13.5% concluded vocational training and only 12.5% attained a secondary education level or beyond. The information mirrors the diversified educational backgrounds of respondents, which might wield substantial influence over their viewpoints and decisions pertaining to agricultural practices and food security.

4.3.1.4 Marital Status of the Respondents

Marital status has been identified as a significant factor that influences the adoption of new agricultural technologies (Muya, B. I., et al., 2016). In smallholder farming, most individuals have families, and many of these families are monogamous (Sigei, 2014). The family unit is the foundation of human society, providing subsistence and essential resources for farming activities. Hence, starting a family is fundamental to ensuring agricultural engagements. Marital status can also impact participation in farming projects to fulfil the family's needs (Kariuki, 2016).

In Table 16, the different marital statuses of respondents are categorized as single, married, and widowed. The data shows that 92.2% of the farmers were married, 4.2% were single, and 3.6% were widowed. The high percentage of married farmers highlights the significance of family-based farming practices, where the household often shares responsibilities and decisions regarding agricultural activities. Understanding the influence of marital status can

provide valuable insights into the adoption and utilization of farming technologies for improving household food security.

4.3.1.5 Size of the Family

Research on food security has consistently demonstrated that the food requirements of a household increase in proportion to the number of its members (Sigei, 2014). As a result, farmers with larger families are more likely to adopt new agricultural technologies at a faster pace than those with smaller families. This inclination stems from the understanding that adopting such technologies may lead to increased farm production, enabling them to meet the food needs of their households better (Muya, B.I. et al., 2016).

In traditional Rwandan society, having many children was considered a sign of prosperity. Consequently, household size was considered a measure of labour availability, as Mwangi (2015) stated. The household size significantly influences the adoption process, as larger households possess the capacity to overcome labour constraints associated with introducing new technologies.

Table 16 reveals that 90.6% of farmers had between 4 to 9 family members, 6.3% had 1 to 3, and 3.1% had 10 or more family members. The significant proportion of farmers with five or more children suggests that children are likely to be utilized as a valuable source of labour to exploit radical terraces. This further highlights the influence of household size on farmers' decisions and actions in adopting innovative agricultural practices.

Table 16: Distribution of the Farmers According to their Characteristics

		Number	Per cent
a. Farmer's age	Young (<29)	14	7.3
	Middle-aged (30-49)	94	49.0
	Old (50+)	84	43.8
	Total	**192**	**100.0**
b. Gender	Male	142	74.0
	Female	50	26.0
	Total	**192**	**100.0**
c. Level of education	None	31	16.1
	Primary	111	57.8
	Secondary and above	24	12.5
	TVET/CERAI	26	13.5
	Total	**192**	**100.0**
d. Marital status	Single	8	4.2
	Married	177	92.2
	Widowed	7	3.6

	Total	**192**	**100.0**
e. Size of the family	1-3	12	6.3
	4-9	174	90.6
	10+	6	3.1
	Total	**192**	**100.0**

4.3.1.6 Occupation of the Respondents

The occupation of household heads was identified as another variable that could influence the adoption of small-scale farming. Having household members engaged in off-farm employment increased the likelihood of adoption due to its supportive role. Off-farm employment activities could enhance the farmer's income, which could be utilized to support agricultural activities (Mango et al., 2018).

Regarding the occupation of the respondents, it was observed that while all respondents were farmers, some of them combined agriculture with other income-generating activities, such as wage employment, self-employment, or seasonal and casual employment. For analytical purposes, we considered those with other occupations as part-time farmers. As shown in Table 17, most respondents (98.4%) were full-time farmers, whereas only a small proportion (1.6%) were classified as part-time farmers. Off-farm employment opportunities could have significant implications for adopting radical terraces and other agricultural innovations, as they may offer additional financial resources to support farming activities.

4.3.1.7 Main Source of Income of the respondents

The research by Aynalem, Nand, and Seema (2018) underscored the affirmative and notable influence of agricultural technology adoption on farm income, resulting in adopters enjoying a more favourable financial position than non-adopters. Our investigation revealed that farming and livestock activities constituted respondents' primary source of income, contributing to a substantial 97.9% of their overall earnings. Moreover, an inclination towards commercial orientation was observed among farmers who engaged in significant harvest sales, rendering them more receptive to adopting specific agricultural technologies (CIMMYT, 1993). Nonetheless, it is crucial to acknowledge that income derived from farming and livestock was contingent upon the agricultural season's dynamics.

4.3.1.8 Amount of Income per Season

The role of farmers' income in influencing their technology adoption could have been substantial. While measuring income within surveys can present challenges, it retains significance in elucidating the embrace of novel agricultural technology (CIMMYT, 1993). Indeed, farmers with higher earnings might exhibit a greater propensity to explore new agricultural technology, mainly if it entails input acquisition. This inclination could be attributed to their risk-taking capacity, access to extension information or credit, and capacity to employ personal financial resources for experimentation with innovative techniques.

Within this study, an agricultural season was demarcated as a four-month interval, and seasonal income was quantified in Rwandan francs (Rwf). During the data collection period, the exchange rate was 1 US$ to 920 FRw. As depicted in Table 17, 68.2% of respondents recorded a moderate income (ranging from 100,000 to 1 million Rwf), and 17.7% registered a lower income (below 100,000 Rwf). In comparison, 14.1% garnered a higher income per season (above 1 million Rwf). Income likely played a pivotal part in adopting and utilising radical terraces, facilitating the acquisition of agricultural inputs like improved seeds and labour hiring. Furthermore, income generated from farming endeavours was possibly directed toward radical terraces and meeting the needs of family members.

4.3.1.9 Size of Land Owned by the Respondents

The farm size is often recognized as a pivotal determinant in the literature on adoption, and it is plausible that it ranks among the most influential factors shaping the uptake of novel agricultural methods (Kinyangi, 2014). In various adoption inquiries, the dimensions of the farm are a frequently scrutinized parameter and often function as a surrogate for wealth. The premise is that farmers overseeing larger parcels are more inclined toward adopting innovative technologies (CIMMYT, 1993).

Regarding land size possessed by the farmers in this study, as shown in Table 4.15, 54.7% of the farmers held plots exceeding 1.0 ha, while 45.3% managed less than 0.9 ha of land. Over time, numerous farmers expanded their landholdings as they persisted in farming and livestock undertakings, particularly those proximate to the Nyungwe National Park region. It has been documented by CYMMT (1993) that farmers with greater land resources were more apt at leveraging new agricultural technologies. It is plausible that farmers with more extensive land holdings achieved elevated agricultural production and seasonal income.

Regarding land ownership, various informants elucidated farmer attributes. A primary informant at the sector level (FFS Nkomane) conveyed, "A farmer who owns a big land

constructed with radical terraces is characterized by a good quantity of production, fodder for feeding animals, and well-managed fields."

Table 17: Occupation, Income and its Source, and Land Size of Respondents

		Number	Per cent
f. Occupation of farmer	Full-time farmer	189	98.4
	Part-time farmer	3	1.6
	Total	**192**	**100.0**
g. Main source of income	Farmer	4	2.1
	Farmer and livestock	188	97.9
	Total	**192**	**100.0**
h. Reported seasonal income	Low income (<100k)	34	17.7
	Medium income (100k-1M)	131	68.2
	High income (>1M)	27	14.1
	Total	**192**	**100.0**
i. Land-sized ownership	Less than 0.9 ha	87	45.3
	Above 1 ha	105	54.7
	Total	**192**	**100.0**

In conclusion, this section revealed several essential characteristics of the farmers in the study. Most farmers (70.4%) were above 40 years old, which suggests they were likely to have significant experience utilizing radical terraces to meet their household food needs. About 74% of the respondents were male, indicating a higher representation of men adopting radical terraces. Regarding education, 57.8% of the farmers had attended primary school, while 16.1% had no formal education. Most farmers (92.2%) had families, and a significant proportion (90.6%) had five or more children, considered a crucial source of labour for the exploitation of radical terraces.

Nearly all respondents (98.4%) were full-time farmers, with agriculture and livestock as their main source of income, reported by 97.9% of the participants. The income for the majority (68.2%) fell within the medium range, ranging from 100,000 to 1 million Rwf. This income was likely to be invested in radical terraces and other agricultural activities. Although the sizes varied, all the farmers owned land, with 54.7% owning land above 1.0 ha.

These characteristics of the farmers are significant as they may influence their access to farming information sources, which, in turn, can impact the adoption of radical terraces and food security outcomes. Understanding these characteristics can provide valuable insights into the dynamics of technology adoption and food security in the study area.

4.3.2 Farmers' Access to Information on Radical Terraces

The third objective of this study aimed to assess the level of farmers' access to agricultural information for adopting radical terraces. Access to farming information was crucial in encouraging farmers' participation in adopting radical terraces. This section presents the various sources from which smallholder farmers obtained information about farming and radical terraces, the levels of access to farming information, and the benefits gained from these sources.

The farmers accessed multiple sources of information, but we specifically asked them to mention the most common source for overall farming and another one for radical terraces. The reported sources of agricultural information are presented in Table 18.

The most frequently mentioned sources of agricultural information were the radio (16.1%), followed by neighbours (15.1%), visits to agricultural extension offices (11.5%), interactions with farm inputs dealers (11.5%), and farm visits by agricultural extension agents (10.4%). On the other hand, respondents mentioned some sources of farming information less frequently, such as TV and farm workshops (3.6%) and visitors (5.7%). Furthermore, as indicated in Table 4.16, smallholder farmers adopting radical terraces used different sources of agricultural information. Fifteen per cent (15%) of farmers reported being visited by agricultural extension agents, while 14.6% reported attending farm shows. Other sources they used were farm inputs dealers (13.0%), neighbours (12.0%), radio (10.9%), farm demonstrations (9.4%), field trips (8.3%), visitors (5.7%), farm visits to extension offices (5.2%), farm workshops and seminars (4.2%), and finally, TV (1.6%). The lower use of TV and farm workshops was attributed to the lack of electricity and limited use by extension workers. Additionally, there were other channels for transmitting farming information to farmers, such as Umuganda (community work), Inteko z'abaturage (community gatherings), and Umugoroba w'ababyeyi (evening meetings for parents).

Regarding the sources of agricultural information for farmers, a key informant at the district level (FED) confirmed that farmers were informed about agricultural activities through various channels as follows:

> All farmers, owners of radical terraces, or those who do not access agricultural information through our meetings. At the sector level, well-trained committees of self-resilient farmers can educate them through field trips. They also get information from Agronomists and the personnel in charge of social and development affairs and

> farmers' committees at each cell (CAC), Sector (SAC), and district levels (DAC). They aim to spread agricultural information to the farmers at the lowest level.

Another key informant at the sector level (FFS from Nkomane) reported that agricultural information was important in livestock-keeping activities: "It is very helpful in animal husbandry because we can manage our animals well by storing fodder for the dry season, planting Napier grass for that period or saving money to spend on them.''

Apart from sources of farming information related to overall farming practices, there were also sources of agricultural information related to radical terraces for ensuring food security.

Table 18: Access to Agricultural Information

	a. Sources of agricultural information about overall farming		**b. Sources of agricultural information about radical terraces**	
Sources	Frequency	Per cent	Frequency	Per cent
Farm visits by agricultural extension agents	20	10.4	29	15.1
Farmer visits extension offices	22	11.5	10	5.2
Farm demonstrations	16	8.3	18	9.4
Field trips	15	7.8	16	8.3
Radio	31	16.1	21	10.9
T. V	7	3.6	3	1.6
Neighbours	29	15.1	23	12.0
Farm shows	12	6.3	28	14.6
Farm workshops	7	3.6	8	4.2
Visitors	11	5.7	11	5.7
Farm inputs dealers	22	11.5	25	13.0
Total	**192**	**100.0**	**192**	**100.0**

One Key Informant at the district level (agronomist) indicated that: "Farmers access information about radical terraces through meetings, community work at the end of each month and leaflets related to how radical terraces are used and maintained and advertisements through Radio and television."

In addition, a key informant at the sector level (FFS Nkomane) stated that:

> Farmers are organized in self-reliant groups, and their committees are from the village to the sector level. Agricultural advisers and facilitators spread the information needed. We plan to launch the agricultural seasons and meetings and ensure they are held regularly. The personnel in charge of development at the cell level are also responsible for visiting farmers at home individually or in their groups.

4.3.2.1 Level of Access to the Information Sources

The level of usage of these sources of agricultural information depended on the specific information needed by the farmers, as well as their accessibility, availability, and perceived benefits. The sources used for accessing agricultural information for overall farming were the same as those used for obtaining information related to radical terraces. However, the levels of accessing and using information varied between the two.

Table 19 presents the levels of access to these information sources. It indicates that 42.2% of farmers accessed the information at a medium level, 43.2% at a high level, and 14.6% at a low level for overall farming. Regarding the levels of access to information on terracing, a scoring system was used to assess the use of different sources of farming information, ranging from one to eleven, corresponding to the levels of access. Table 19 categorizes the levels of access to agricultural information on radical terraces. Approximately 50.5% of the farmers obtained information at a high level, 28.6% at a medium level, and 20.8% at a low level.

These findings indicate that farmers had relatively better access to information on radical terraces than overall farming. The higher level of access to information on terracing suggests that farmers recognized the importance and benefits of adopting radical terraces, which could have motivated them to seek and utilize relevant information from various sources.

A key informant at the sector level (Buruhukiro agronomist) stated that: “Agricultural information is accessed through regular meetings of local leaders and the farmers, community workers, agricultural advisers, and agricultural facilitators from the village. There are also visits, listening to the news at radio stations, and training.”

Another key informant (Cooperative chairperson, Kibilizi) indicated that farmers got agricultural information through peer learning these words: “Model farmers help other farmers to perform well in their activities.”

In addition, a key informant from NGO (Hinga Weze) confirmed that farmers were informed to increase food production: “We inform farmers about agricultural inputs use, improved seeds and marketing of their products.”

Table 19: Level of Access to Information Sources

	Levels of getting agricultural information about overall farming		**Levels of getting agricultural information about radical terraces**	
Level of access	Number	Per cent	Number	Per cent
Low access	28	14.6	40	20.8
Medium access	81	42.2	55	28.6
High access	83	43.2	97	50.5
Total	**192**	**100.0**	**192**	**100.0**

4.3.3 Benefits of Agricultural Information on Radical Terraces Adoption

The information received played a significant role in the adoption of radical terraces. Table 20 presents the benefits of this information, which include sharing experiences with other farmers (27.1%), learning from others (22.9%), ensuring solidarity among farmers (15.6%), becoming a self-reliant farmer, and using modern farming techniques (both at 12.5%), and making better use of modern agricultural inputs.

Table 20: Benefits of Access to Agricultural Information on Radical Terraces

Benefits gained		Number	Per cent
Benefits gained from various sources of information	Being self-reliant farmer	24	12.5
	Modern farming techniques	42	21.9
	Sharing experiences with others	96	50.0
	Solidarity of farmers	30	15.6
	Total	**192**	**100.0**

Concerning the benefits of agricultural information, a key informant at the district level (Key informant FED) reported that:

> The farmers benefited from farming information related to the agricultural season, climate change, and the period of the rainy season. We teach them to fight against soil erosion and sunny seasons in the meetings held at district, sector, and cell levels. Farmers are aware of the agricultural season and the period of the distribution of fertilizers and improved seeds. We hold demonstration meetings in the form of agricultural community work.

Another key informant at the sector level (FFS Nkomane) confirmed that farmers got agricultural information: "The agronomist sensitizes farmers about climate change. For instance, he requested that we plant wheat before 20th March. When you plant crops late, the harvest reduces due to insufficient rain."

The findings of this study indicate that farmers accessed various sources of information in different ways. They expressed the need for information on the agricultural season, availability, and cost of inputs. Such information was acquired through diverse channels, including radio (16.1%), visits to agricultural extension agents (15%), interactions with neighbours (15.1%), agro-input dealers (13%), farm demonstrations, and visits by experts (14.6%). Other sources mentioned were television, local leaders, meteorology officers, and TUBURA.

Farmers emphasized that timely access to agricultural information was crucial in enhancing food production by adopting radical terraces. Overall, most farmers had high access to information sources for farming and radical terraces. This access proved beneficial, as respondents reported sharing experiences with others (50%) and applying modern farming techniques (21.9%), among other advantages.

However, the study also revealed some challenges farmers face in accessing information. They expressed difficulties in obtaining adequate information on new, improved seeds, fertilizers, and proper pesticide usage. Additionally, there were concerns about insufficient meteorological information relating to climate change, communication issues, electricity shortages, and the high prices of lime and chemical fertilizers. These challenges may hinder the optimal adoption of radical terraces and food production efforts.

4.3.4 Membership in Self-Help Groups

The fourth objective of this study was to examine the role of farmers' membership in Self-Help Groups (SHGs) in adopting radical terraces. SHG membership serves as a means of organizing and mobilizing community members to collectively address their social, economic, environmental, and institutional challenges. This section presents information on farmers' years of experience as members of SHGs, the leadership positions they held within these groups, and the various benefits they received from being part of SHGs.

When asked about their membership in SHGs, 82.3% of the respondents confirmed they were indeed members, while the remaining participants were not affiliated with any SHGs. These self-help groups aimed to foster farmers' collaboration in social and economic functions. By being socially integrated into SHGs, smallholder farmers had the opportunity to share farming experiences and receive assistance from community development partners. Consequently, farmers were part of various self-help groups. A few of these groups were

identified by specific names, including Abadahigwa, Abahujumugambi, Abafatanije, Jyamberemuhinzi, Dukorane umwete, Dukunde isuku, Dusasirane, Kotebu, Koabu, Turengereumusaruro, Turaheza, Dushyigikirane, Duterane inkunga, Duterimbere, Huguka, Icyerekezocyiza, Duterane inkunga, Saccos, Tubura, Tuganeheza, Igicumbi cy'ubumwe n'ubwiyunge, Ikimina, among others.

Farmers in the study area actively joined these Self-Help Groups, as affirmed by a key informant at the district level (FED): “In the west of the district, farmers were aware of the importance of joining self-help groups whereas in the East terraces were not well exploited which had an impact on the farming and so, joining others could increase production which could also generate an income.”

4.3.4.1 Farmers’ Years of Experience in their Self-Help Groups

Years of membership: Table 21 portrays farmers' dispersion based on their membership duration within their respective Self-Help Groups (SHGs). The respondents (51.6%) indicated a membership span of 1 to 5 years, while 14.6% had maintained their affiliations for 6 to 10 years, and 8.9% had been part of SHGs for 11 years and more. This suggests that farmers have been actively engaged in these self-help groups since approximately 2000. Significantly, this timeline coincides with the formulation of cooperative movement policies in Rwanda and the implementation of the agricultural policy of 2004, which sought to revolutionize the nation's agricultural landscape (Republic of Rwanda, 2004).

At present, strategies such as the TUBURA and TWIGIRE MUHINZI initiatives are in place, aiming to organize smallholder farmers into more compact units to amplify their capacities in food production. These endeavours galvanize farmers to embrace modern and enhanced agricultural practices, with the overarching objective of attaining self-sufficiency in food production within their localities. As corroborated by a pivotal informant at the sector level (FFS Nkomane), these endeavours have assumed a significant role in fostering collaboration among farmers and ushering in the adoption of innovative agricultural techniques:

> TUBURA helps farmers join groups, provides them with fertilizers on credit, and requests them to pay the amount due for the season. When they pay half of the credit, TUBURA distributes fertilizers for the next season so that they finish reimbursing at the end of June. Farmers are glad about it because the payment is made during harvest.

Another key informant (an NGO representative (Hinga Weze), expressed the following views: “In our intervention area, the SHGs carried out different activities including sharing agricultural related news and ideas; building-up savings, providing credit; helping members to find agricultural inputs like lime, chemical fertilizers and manure on time; and assisting them through advocacy.”

Since different groups are founded with different objectives, a key informant at the sector level (Cooperative president Kibilizi) noted that “the SHGs were cooperatives which were founded to unite farmers whose radical terraces were constructed, to facilitate the use of land for one selected crop and distribution of fertilizers.”

4.3.4.2 Farmer’s Leadership Positions in the SHGs

We inquired whether the respondents had ever held leadership positions within their SHGs, to which 41.3% responded positively. Subsequently, we asked them about their specific positions, and their responses are summarized in Table 4.19. The leadership roles reported were as follows: chairpersons (21.4%), vice-chairpersons (3.1%), secretaries (5.2%), accountants (4.7%), and committee members (65.6%).

Within the SHGs, the responsibilities of leaders varied depending on their positions. These responsibilities included overseeing financial matters, facilitating group members in obtaining timely health insurance, managing day-to-day affairs and activities, and monitoring and implementing all group initiatives. Additionally, some leaders were entrusted with coordinating planned activities across all SHGs or cooperatives, actively mobilizing members to participate, finding ways to support the group's duties and development, teaching modern agricultural practices, and ensuring group members' compliance with relevant laws and regulations for the smooth functioning of the group. Furthermore, they were responsible for maintaining proper records and harmonizing reporting systems.

As for those farmers who had not held leadership positions within their SHGs, they provided reasons for their decision, including lack of interest in such roles, limited education, advanced age, lack of time to invest in SHG functions, financial constraints, ignorance, or indifference towards the process of electing leaders, and unfamiliarity with the procedures involved.

4.3.4.3 Benefits Smallholder Farmers Gained from their SHGs

Upon inquiring whether respondents had benefited from their SHGs, most (97.6%) affirmed that they had, while the remaining had not. As illustrated in Table 20, the key benefits

highlighted by the SHGs were: shared consciousness (47.4%), mutual help and aid (20.3%), and group support (17.5%).

The farmers experienced various advantages through their SHGs, such as being encouraged to accumulate savings and receiving support through small loans. Additionally, the SHGs provided mutual assistance, encompassing emotional and social support, fostering a sense of camaraderie and unity among the members. Another notable benefit was guidance on novel farming practices, including adopting radical terraces. Moreover, the SHGs facilitated access to financial and technical support for agricultural endeavours, including constructing radical terraces. They further supplied essential agricultural inputs like lime, chemical fertilizers, pesticides, and manure. Equally valuable was the provision of agricultural information to the farmers. Lastly, the SHGs assisted farmers in obtaining health insurance cards and funding school fees for their children.

Table 21: Membership in Self-Help Groups (SHGs)

		Number	Per cent
a. Farmers' years of experience in SHGs	None	43	22.4
	< 1 year	5	2.6
	1-5 years	99	51.6
	6-10 years	28	14.6
	>=11 years	17	8.9
	Total	**192**	**100.0**
c. Farmer's leadership position in SHGs	None	126	65.6
	Chairperson	41	21.4
	Vice-Chairperson	6	3.1
	Secretary	10	5.2
	Accountant	9	4.7
	Total	**192**	**100.0**
d. Types of benefits received by farmers from SHGs	None	28	14.6
	Mutual help and aid	39	20.3
	Group support	34	17.7
	Shared consciousness	91	47.4
	Total	**192**	**100.0**

One key informant at the district level (Planner) said that "when people join SHGs, they are more advantaged than others because those SHGs struggle to be legally known. They can get credit from banks and agricultural inputs that facilitate increased production from radical terraces."

A key informant from NGO, Hinga Weze, also highlighted the advantages of joining SHGs saying that "places where Hinga Weze constructs radical terraces for farmers, we organize

them in SHGs and provide the support in the form of training, organic and inorganic manure, fodder and improved seeds."

A key informant at the sector level (Nkomane Agronomist) reported this:

> The government of Rwanda put in place agricultural advertisement methods from the national to village level and all other best methods which could improve the agricultural system practised in groups of self- reliant farmers. There is an agricultural adviser in charge of those groups in the village. He /she is trained and is aware of fighting against soil erosion, trains farmers, sensitizes fellow neighbours to join those groups and, makes a follow-up of those groups, reports at the cell level to the personnel in charge of development who are also agronomists. They report at the sector level, but in some cases, farmers can contact the sector agronomist directly by asking for a visit or any other advice.

Furthermore, some SHG members encountered challenges, as pointed out by a few farmers, which comprised issues such as inadequate leadership, lack of proper supervision and accountability; delays and high costs associated with lime, fertilizers, seeds, and manure; a dearth of shared consciousness and agreement in preserving radical terraces; inability to repay loans; instances of misappropriation and mismanagement of group resources; favouritism and nepotism; and a shortage of pertinent agricultural information.

A key informant at the sector level, the cooperative president of Kibilizi (KOAKUKI), added the following insights: "Farmers in our SHGs face the challenge of lack of purchasing power for improved seeds and fertilizers."

This section focuses on farmers' membership in self-help groups, with 82.3% of the respondents being affiliated. The membership duration varied among farmers, with 51.6% having experience ranging from one to five years. Joining self-help groups was deemed crucial for farmers, allowing them to address various socio-economic challenges collectively. Organizing smallholder farmers into self-help groups was part of the strategy implemented in the TUBURA and TWIGIRE MUHINZI programs to boost food production. SHGs provided opportunities for active participation in various roles, such as being a committee member (65.6%) or a chairperson (21.4%).

Being part of SHGs offered social integration for smallholder farmers, resulting in numerous benefits (97.6%), including shared consciousness (47.4%) through the exchange of farming experiences. They also provided mutual aid and assistance to each other (20.3%). However, SHGs also faced challenges, such as issues with leadership, the ability to repay loans, mismanagement of group resources, favouritism, and nepotism.

In conclusion, the affiliation of farmers with self-help groups played a significant role in their social and economic development, fostering collective efforts and supporting each other in adopting radical terraces and other farming practices.

4.3.5 Farmers' Support by Development Agencies

The fifth aim of this research was to evaluate the influence of support provided by development organizations to farmers on their uptake of radical terraces. This process demanded considerable resource allocation. Given financial limitations, farmers frequently encountered difficulties fulfilling all the prerequisites for embracing radical terraces. External development agencies stepped in to offer aid, intending to facilitate the adoption of these terraces. Such assistance usually encompassed credit, equipment, and educational provisions. Within this segment, we will delineate the institutions that extended credit, detail the extent of credit extended, and elucidate its utilization by the farmers.

4.3.5.1 Type of Agencies that Provided Support to the Farmers

Participants were prompted to specify the development organizations that provided them with assistance. The outcomes are showcased in Table 22, demonstrating that support was extended by three distinct entities: the Government (50.0%), non-governmental organizations (44.3%), and the Private Sector Federation (PSF) (5.7%). However, during interviews, certain farmers accentuated difficulties associated with agency support. These included challenges related to climate change, elevated interest rates, delays in providing improved seeds, lime, manure, and fertilizers, a lack of adequate follow-up on supported projects, instances of crop diseases, and non-functional biogas facilities.

4.3.5.2 Benefits Reported by the Farmers from the Agencies

Upon inquiry regarding their receipt of credit assistance from development agencies, 69.3% of the participants affirmed that they had indeed secured loans. At the same time, the remaining respondents had not availed of such support. Consequently, approximately one-third of the farmers relied on their resources to meet the expenses associated with terrace adoption and broader farming endeavours. In terms of the organizations extending aid to farmers, Agronomist Nkomane, a pivotal informant at the sector level, conveyed the ensuing

information: “NKUNGANIRE[5] is a national program whereby the price of agricultural inputs is subsidized for some crops and farmers pay a certain percentage of the total price, and the government pays the remainder.”

Another sector-level key informant (Agronomist Kibilizi) emphasized the organizations that delivered assistance: “Those agencies include LWH, MINAGRI and WORLD VISION. Owners of terraces constructed by LWH had an organized cooperative that was assisted to construct post-harvest facilities.”

Additional non-governmental organizations offered support, as verified by the district-level informant (agronomist): “Farmers get the support of constructing radical terraces from the government. They are provided start-up kits of organic manure, lime, and improved seeds. Non-Governmental Organizations like Hinga Weze, ENERGIE VERTE et ELEVAGE and UNICOOPAGI supported the actions.”

Upon inquiring about the nature of assistance provided by these organizations, respondents indicated that 30.2% had received credit-based support, whereas 39.1% did not benefit from credit assistance. This indicates a notable proportion of farmers who did not receive credit support from these agencies. The distribution of credit recipients is detailed in Table 22, showcasing diverse financial institutions involved: Umurenge SACCO (15.6%), VUP (5.2%), TUBURA (4.7%), BPR (3.1%), Vision Finance (1.0%), and RAB (0.5%). Remarkably, Umurenge SACCO exhibited a higher level of collaboration with farmers than other institutions, likely due to its geographical proximity across all sectors.

In relation to external assistance rendered to farmers, a sector-level key informant (FFS Nkomane) communicated the following: “TUBURA provided agricultural credit in the form of fertilizers, improved seeds, and lime. Financial institutions like SACCO (Savings and Credit Cooperatives) can give a farmer credit of 100,000 or 200,000 to reimburse other credits or solve farm needs.”

[5]The *"Nkunganire"* initiative is directed at assisting farmers in shifting from conventional agricultural practices to contemporary methods that guarantee optimal land utilization (Anitha Kirezi, The New Times, June 17, 2016, article titled "Farmers urged to embrace modern agriculture practices"). Subsequently, the “Smart NKUNGANIRE System” was formulated through collaboration between Bank of Kigali TecHouse and the Rwanda Agriculture and Animal Resources Development Board (RAB), with the aim of digitizing the entirety of the agro-inputs subsidy program value chain (RAB.gov.rw).

Table 22 displays the monetary assistance provided to farmers through credit by financial institutions. Roughly 16.1% of the farming respondents received less than 400,000 Rwf, 9.4% received 1,000,001 Rwf and beyond, while 4.9% were recipients of credit ranging between 400,001 and 1,000,000 Rwf.

4.3.5.3 Farmers' Use of the Credit

As depicted in Table 22, financial credit sourced from institutions was utilized by farmers not solely for investing in radical terraces but also to tackle assorted issues they faced in their routine activities. To be precise, among the respondents, 8.3% directed credit towards radical terraces, 6.3% for matters linked to crops, 4.7% for activities concerning livestock, and 3.1% for miscellaneous uses.

Furthermore, respondents who directed credit towards improving radical terraces reported additional advantages beyond enhancing them. These benefits encompassed the establishment of community postharvest infrastructure facilities, procurement of lime, fertilizers, seeds. They upgraded production techniques, enrolment in cooperatives, participation in terrace utilization sensitization programs, and the utilization of previously unproductive or untapped land.

Conversely, farmers who opted not to utilize loans to advance radical terraces cited diverse reasons. Some mentioned their inability to meet loan repayment requirements. In contrast, others indicated that certain projects, such as UBUDEHE, Crete Zaire Nile, VUP, PAM, World Vision, and LWH, were unresponsive to their financing requests. Some farmers said they did not require credit due to their reliance on self-help groups and cooperatives for funding. Additionally, limited access to credit facilities and a lack of awareness about available credit opportunities were also cited as barriers.

Table 22: Farmers' External Support by Development Agencies

		Number	Per cent
Amount of financial support /credit	None	134	69.8
	<=400,000	31	16.1
	400,001 - 1,000,000	9	4.7
	1,000,001+	18	9.4
	Total	**192**	**100.0**
Types of agencies which provided support	None	134	69.8
	B.P. R	6	3.1
	RAB	1	0.5
	SACCO	30	15.6
	TUBURA	9	4.7
	V.U. P	10	5.2
	Vision finance	2	1.0
	Total	**192**	**100.0**
Farmers use the support/credit in	None	149	77.6
	Terraces	16	8.3
	Crops	12	6.3
	Livestock	9	4.7
	Others	6	3.1
	Total	**192**	**100.0**
Development agencies provided other support	Government	96	50.0
	NGO	85	44.3
	PSF	11	5.7
	Total	**192**	**100.0**

The informant in charge at the district level (FED) highlighted the assistance extended to farmers by the government:

> For new radical terraces constructed by the district, farmers are provided with all the necessities like inorganic fertilizers, pesticides, and improved seeds to motivate and encourage them for exploitation. However, in general, His Excellency the President of the Republic of Rwanda, has provided support of 50% of the cost of lime distributed to farmers.

In this section, it became evident that adopting radical terraces required significant resources. The urgency to support farmers in their farming activities was highlighted as well. The external support was provided by various entities, with the Government contributing to 50% of farmers through programs like VUP (Vision Umurenge Program) and RAB (Rwanda Agriculture Board). NGOs and humanitarian agencies covered 44.3% of farmers, including organizations like LWH (Living Water International), World Vision, PAM (Partners in Food Solutions), and TUBURA. Financial institutions and PSF (Private Sector Federation) supported 5.7% of farmers through institutions like BPR (Banque Populaire du Rwanda), Umurenge SACCO, and Vision Finance.

While some farmers received support through credit (30.2%), a significant portion did not receive any (39.1%). Among the respondents who received credit, the majority used it for various purposes, with only 8.3% using it specifically for radical terraces. The findings also revealed that the farmers devised strategies, such as joining saving groups and keeping livestock, to address the challenges they encountered.

However, there were challenges related to external support for adopting radical terraces, including the impact of climate change, high-interest rates on credit obtained from banks, difficulties in accessing, and delays in receiving improved seeds, lime, manure, and fertilizers. Additionally, there were issues with the lack of follow-up on supported projects and the presence of crop diseases.

4.3.6 Farmer Participation in Decision-Making on the Radical Terraces

The sixth objective of this study aimed to assess farmers' participation in decision-making processes related to the radical terraces project and its impact on adoption. This also involved evaluating farmers' attendance at meetings and their contributions to implementing radical terraces. Their involvement encompassed decision-making in initiating, planning, implementing, monitoring, and evaluating the radical terraces project. The extent of farmers' involvement in the decision-making process is presented in Table 23, where 77.6% were classified as having a medium level of involvement, 21.9% had rare involvement, and only 0.5% demonstrated a high level of involvement.

In this context, a key informant at the sector level (Gatare agronomist) provided the following insights:

> Before the Tutsi genocide, a project called Crete Congo Nil (CZN) aimed at developing agriculture by constructing radical terraces for farmers and providing what they needed, like lime, organic manure, and improved seeds. Since then, the population became aware that terraces increased production and continued constructing terraces for themselves.

Participating in the execution of radical terraces projects played a significant role in increasing smallholder farmers' awareness about terraces. It also facilitated their understanding of the entire process of monitoring and evaluating the terracing project. This involvement in adopting radical terraces projects was closely connected to the development of social capital, as farmers actively took part in planned meetings to discuss project-related matters.

The farmers contributed to the project, including providing information, engaging in consultations, making joint decisions, taking collective action, and supporting each other's interests. The contribution levels were as follows: 40.1% of farmers demonstrated a high level of involvement, 44.8% showed medium involvement, and 15.1% had low involvement, as indicated in Table 23. Consultations were recognized as crucial in raising farmers' awareness and commitment to the project. After consulting with experts, they collectively decided on the actions to be taken. Adopting new farming practices required community ownership and engagement, and participatory decision-making was essential.

The sense of community interest was rooted in shared social values of social solidarity and cohesion, fostering interdependence between farmers and agricultural extension agents in adopting radical terraces. This social relationship promoted collective action and mutual support among social actors in producing food through radical terraces. Lastly, respondents emphasized that supporting each other involved respecting individual interests while working towards a common understanding. This interaction helped reduce social inequality and promoted value-sharing among farmers and agricultural extension agents.

4.3.6.1 Farmers' Attendance of Meetings on Radical Terraces

When we inquired about the respondents' attendance at preparatory meetings for the radical terraces project, 80.6% confirmed their participation. However, as shown in Table 23, the number of farmers who reported attending the project's preparatory meetings was distributed as follows: 50.0% reported low attendance (1-4 meetings), 13.0% reported medium attendance (5-9 meetings), and 37.0% reported high attendance (10 meetings and above). The researcher aimed to understand why some farmers (17.2%) had not participated in the project's preparatory meetings. Some respondents cited that they obtained information about the project through radio broadcasts and learned from others (peer learning), which served as reasons for not attending the meetings. Others did not attend the meetings due to non-selection, lack of awareness regarding the scheduled meetings, unavailability during meeting times, or simply lack of interest in attending.

4.3.6.2 Farmers' Material Contributions to the Radical Terraces

Farmers willingly contributed their labour, materials, land, and funds towards implementing the radical terracing project. Table 23 illustrates that a significant portion of farmers participated voluntarily (high), with a percentage of 78.6%. In contrast, a smaller portion negotiated their contributions (low), with a percentage of 16.1%, and a few were required to

provide labour and payment (medium), with a percentage of 5.2%. This voluntary involvement by farmers in adopting radical terraces showcases their determination to enhance the value of their land. Their collective investment of labour, materials, land, and finances highlights the commitment and dedication they exhibited towards the project's success.

4.3.6.3 Levels of Farmers' Contributions to the Adoption of Radical Terraces

The levels of contribution by smallholder farmers were as follows: high at 40.1%, medium at 44.8%, and low at 15.1%, as indicated in Table 23. These percentages demonstrate farmers' varying degrees of interest and dedication towards adopting radical terraces to ensure food production and security in the study area.

Table 23: Farmers' Participation in the Decision-Making Process of Radical Terraces Projects

		Frequency	Per cent
Farmer's involvement in decision making	Low (Rare involved)	42	21.9
	Medium (Involved)	149	77.6
	High (Fully involved)	1	0.5
	Total	**192**	**100.0**
Farmer's attendance at meetings	Low (1-4)	96	50.0
	Medium (5-9)	25	13.0
	High (>10)	71	37.0
	Total	**192**	**100.0**
Farmers' material contribution	Low (Negotiated)	31	16.1
	Medium (Required)	10	5.2
	High (Voluntary)	151	78.6
	Total	**192**	**100.0**
Levels of farmer's contribution	Low	29	15.1
	Medium	86	44.8
	High	77	40.1
	Total	**192**	**100.0**

A key informant at the sector level (FFS Buruhukiro) listed materials used in constructing radical terraces. "Materials used in constructing radical terraces, including hoes, decameter, spade, pickaxe, etc., were purchased by the farmers. And farmers released their land for terracing without any compensation."

A key informant from the NGO (UNICOOPAGI agronomist) explained the methods and approaches used for the exploitation of radical terraces: "There are some individual farmers

who invested their money and constructed their terraces, but others faced financial shortage that prevented them from fulfilling this responsibility."

According to a key informant at the sector level (Gatare agronomist), farmers actively invested their own money in adopting radical terraces:

> Constructing radical terraces is expensive because it can cost around 800,000-1,000,000Rwf. So, they exploit them to make much return from cultivating Irish potatoes, wheat, and peas traditionally done with hoes. Both inorganic and organic manure are needed, which shows the necessity of having some livestock like cows, goats, pigs, hens, and sheep.

In summary, the research findings indicate that farmers' involvement in the decision-making phase of radical terraces initiatives was of moderate magnitude, comprising 77.6%. The farmers reported attending preparatory meetings for the radical terraces project, with 37% participating in 10 or more meetings and 50% attending between 1 and 4 meetings. Additionally, the levels of contribution by farmers in adopting radical terraces were distributed as follows: high contribution at 40.1%, medium contribution at 44.8%, and low contribution at 15.1%. Their contributions included providing land, materials, and money, attending active meetings, and sharing valuable ideas. Moreover, model farmers played a crucial role by sharing their experiences and insights, motivating reluctant individuals to adopt new farming practices such as radical terraces, thereby contributing to food security efforts.

CHAPTER FIVE: ANALYSIS OF RELATIONSHIPS BETWEEN THE VARIABLES OF THE STUDY

5.0 Introduction

The study focused on three main factors: farmers' adoption of radical terraces as the intervening variable, food security as the response variable, and several predictor variables. These predictor variables included farmer household characteristics, membership in self-help groups, access to agricultural information, outside support, and participation in radical terraces activities. This chapter presents the relationships between these variables.

To examine the relationships, Chi-square analysis was conducted for the intervening and predictor variables and the intervening and response variables. This analysis aimed to demonstrate the associations among them. Additionally, the chapter includes a section on regression analysis, which explores the influence of predictor variables on both the intervening and response variables.

5.1 Relationships Between Farmers' Adoption of Radical Terraces and Predictor Variables

5.1.1 Relationship Between Farmers' Adoption and their Characteristics

The respondents were divided into two groups based on whether they adopted radical terraces. In order to investigate the factors influencing the adoption process, we conducted a chi-square analysis focusing on adoption in relation to household characteristics.

To facilitate the cross-tabulation of adoption and the predictor factors, we devised a scoring system for adoption, which allowed us to categorize it as either low (0-20 scores), medium (21-27 scores), or high (28-41 scores) adoption (please refer to the scoring Appendix Table 8 for details). We aimed to validate or disprove the following hypotheses:

H1: A positive association exists between household characteristics and adopting radical terraces.

HO: No correlation exists between household attributes and the adoption of radical terraces.

We conducted a cross-tabulation between adoption and diverse socioeconomic attributes, including age, gender, marital status, family size, educational background, primary income source, seasonal earnings, profession, and land ownership extent. The outcomes of this analysis are outlined in Tables 24 and 25.

Age of the Farmers: Age was significantly related to farmers' adoption of radical terraces (χ^2=14.504, df=4, p=0.011). This suggests that older farmers exhibited higher adoption levels than their younger counterparts. Older farmers' increased adoption could be attributed to their experience and familiarity with radical terraces, enabling them to meet their household food needs better.

Gender of the Farmers: Gender did not significantly affect adoption (χ^2=4.096, df=2, p=0.109). This indicates that the level of adoption was reasonably equal among men and women farmers, suggesting that both genders equally embraced the adoption of radical terraces.

Formal Level of Education: Education was found to significantly influence farmers' adoption (χ^2=13.126, df=6, p=0.043). Adoption rates were higher among respondents with a better education than those with less education. This implies that more educated farmers were more likely to adopt radical terraces.

Marital Status: There was a significant relationship between marital status and adoption (χ^2=36.104, df=4, p=0.001). Adopting radical terraces varied among single, married, and widowed respondents. Adoption rates were higher among married farmers than in other marital categories.

Size of Family: Family size was found to be significantly associated with adoption (χ^2=19.446, df=4, p=0.006). Farmers with larger families were likelier to adopt more terraces than smaller ones.

Farmers' Occupation: Farmers' occupation did not significantly influence adoption (χ^2=0.633, df=2, p=0.729). Full-time and part-time farmers showed similar levels of adoption, suggesting that occupation did not play a significant role in adopting radical terraces.

Table 24: Characteristics of the sampled households by Adoption of radical terraces

	Adoption of radical terraces			
	Low adoption	Medium adoption	High adoption	Total
	N	n	n	N
Farmer's age				
Young (<29)	3	10	1	14
Middle-aged (30-49)	2	85	7	94
Old (50+)	5	64	15	84
Total	10	159	23	192
$\chi 2$=14.504, df=4, p=0.011				
Gender				
Male	7	114	21	142
Female	3	45	2	50
Total	10	159	23	192
$\chi 2$=4.096, df=2, p=0.109				
Level of education				
None	5	24	2	31
Primary	2	95	14	111
Secondary and above	1	18	5	24
TVET/CERAI	2	22	2	26
Total	10	159	23	192
$\chi 2$=13.126, df=6, p=0.043				
Marital status				
Single	4	4	0	8
Married	5	150	22	177
Widowed	1	5	1	7
Total	10	159	23	192
$\chi 2$=36.104, df=4, p=0.001				
Size of the family				
1-3	3	9	0	12
4-9	7	147	20	174
10+	0	3	3	6
Total	10	159	23	192
$\chi 2$=19.446, df=4, p=0.006				

Farmers' Sources of Income: The Pearson Chi-Square test (χ^2=0.821, df=2, p=0.533) indicated no significant relationship between the main sources of income and adoption. This suggests that farmers' sources of income did not have a significant influence on their adoption behaviour.

Farmers' Seasonal Income: The Chi-square test (χ^2=28.793, df=4, p<0.001) revealed that seasonal income significantly influenced adoption. Farmers with higher incomes were likelier

to adopt terraces than those with lower incomes. This implies that higher income gave farmers more resources to invest in adopting radical terraces.

Farm Size: The size of land the farmers owned was significant in influencing their adoption (χ^2=15.905, df=2, p<0.001). This indicates that farmers who owned larger farms were likelier to adopt more terraces than those with smaller land holdings. A larger land size may give farmers the opportunity and capacity to implement radical terraces effectively.

Table 25: Characteristics of the sampled households by Adoption of radical terraces (cont.)

	Adoption of radical terraces			
	Low adoption	Medium adoption	High adoption	Total
	N	n	n	N
Occupation of farmer				
Full-time farmer	10	156	23	189
Part-time farmer	0	3	0	3
Total	10	159	23	192
χ2=0.633, df=2, p=0.729				
The primary source of income				
Farmer	0	3	1	4
Farmer and livestock	10	156	22	188
Total	10	159	23	192
χ2=0.821, df=2, p=0.533				
Seasonal income				
Low income (<100k)	4	29	1	34
Medium income (100k-1M)	6	114	11	131
High income (>1M)	0	16	11	27
Total	10	159	23	192
χ2=28.793, df=4, p<0.001				
Farm size ownership				
<=0.9 ha	3	82	2	87
>=1 ha	7	77	21	105
Total	10	154	23	192
χ2=15.905, df=2, p<0.001				

The H1 hypothesis is accepted regarding farmers' age, level of education, marital status, size of the family, reported seasonal income, and land size. It implies that older farmers with higher educational levels, married individuals, and those with larger farms and higher seasonal incomes were more likely to adopt radical terraces than their counterparts in the opposite situations.

5.1.2 Relationship Between Farmers' Adoption and their Membership in SHGs

H1: Membership in self-help groups positively influenced the adoption of radical terraces.

HO: No association exists between membership in self-help groups and adopting radical terraces.

The indicators of self-help groups (SHGs) were Membership, years of experience in the groups, leadership position, and benefits from the SHGs. Table 26 presents the relationships between adoption and membership indicators in SHGs.

Years of farmers' membership in SHGs: With a p-value greater than 0.05, there was no significant relationship between years of farmers' membership and the adoption of radical terraces ($\chi2=9.647$, df=8, p=0.291). This suggests that farmers who had been members of SGHs for a more extended period adopted radical terraces to a similar extent as newer members.

Leadership in SHGs: Having a leadership position in SHGs did not show a significant relationship with adoption ($\chi2=3.104$, df=2, p=0.212). This indicates that the leaders of the SHGs did not adopt terraces better than non-leaders.

Types of Benefits: A Chi-square test ($\chi2=5.942$, df=6, p=0.430) indicated that the types of benefits derived by the farmers from their SHGs did not significantly influence their adoption. This implies that adoption was more-or-less the same among members who had benefitted differently from their SHGs.

Table 26: Membership in Self-Help Groups (SHGs) by Adoption of radical terraces

	Adoption of radical terraces			
	Low adoption	Medium adoption	High adoption	Total
	n	n	n	N
Years of experience in SHGs				
None	4	35	4	43
< 1 year	0	5	0	5
1-5 years	5	84	10	99
6-10 years	0	24	4	28
>=11 years	1	11	5	17
Total	10	159	23	192
$\chi 2$=9.647, df=8, p=0.291				
Leadership position in SHGs				
None	9	101	16	126
President	1	35	5	41
Vice-president	0	5	1	6
Secretary	0	10	0	10
Accountant	0	8	1	9
Total	10	159	23	192
$\chi 2$= 4.717, df=8, p=0.920				
d. Types of benefits of farmers from SHGs				
None	4	21	3	28
Mutual help and aid	1	33	5	39
Group support	2	28	4	34
Shared consciousness	3	77	11	91
Total	10	159	23	192
$\chi 2$=5.942, df=6, p=0.430				

The H1 hypothesis is rejected, and the Null hypothesis is accepted. Therefore, the duration of membership, leadership positions held, and types of benefits derived from self-help groups did not significantly influence the adoption of radical terraces.

5.1.3 Relationship Between Farmers' Adoption and their Access to Agricultural Information

H1: There is a positive association between farmers' access to sources of agricultural information and their adoption of radical terraces.

HO: There is no association between farmers' access to sources of agricultural information and their adoption of radical terraces.

The indicators of access to agricultural information were the types of sources of information about farming and radical terraces, levels of accessing the information about farming and

radical terraces, and the benefits of accessing these sources. Table 27 presents the relationship between adoption and access to agricultural information.

Types of Sources of Information about Farming: Different sources of obtaining information about overall farming did not have a significant influence on farmers' adoption ($\chi2$=9.736, df=6, p=0.136). This suggests that farmers' access to various sources of agricultural information did not significantly impact their adoption of radical terraces.

Levels of Farmers' Access to Information: The levels of access to farming information about overall farming ($\chi2$=13.419, df=4, p=0.009) and on radical terraces ($\chi2$=15.082, df=4, p=0.005) were significantly associated with adoption. This suggests that farmers endowed with greater access to sources of information were more prone to embracing radical terraces compared to those with restricted access.

The Benefits of Access: The advantages accrued by farmers from agricultural information sources did not exert a statistically significant impact on their adoption of radical terraces within the study region ($\chi2$=4.537, df=6, p=0.604). This indicates that farmers who reported greater benefits did not inherently exhibit a superior adoption of radical terraces compared to those who reported fewer benefits.

Table 27: Access to agricultural information by Adoption of radical terraces

	Adoption of radical terraces			
	Low adoption	Medium adoption	High adoption	Total
	n	n	n	N
Types of information sources for farming				
Visits	3	66	13	82
Social media and seminar	4	33	8	45
Farm demonstration	2	39	2	43
Farm inputs dealers	1	21	0	22
Total	10	159	23	192
$\chi 2$=9.736, df=6, p=0.136				
Levels of getting agricultural information about overall farming				
Low access	1	26	1	28
Medium access		72	4	81
High access	4	61	18	83
Total	10	159	23	192
$\chi 2$=13.419, df=4, p=0.009				
Levels of getting agricultural information about radical terraces				
Low access	4	36	0	40
Medium access	4	47	4	55
High access	2	76	19	97
Total	10	159	23	192
$\chi 2$=15.082, df=4, p=0.005				
Benefits gained from various sources of information				
Being self-reliant farmer	0	21	3	24
Modern farming techniques	3	32	7	42
Sharing experiences with others	4	82	10	96
Solidarity of farmers	3	24	3	30
Total	10	159	23	192
$\chi 2$=4.537, df=6, p=0.604				

The H1 hypothesis is partially accepted, as the level of access to agricultural information positively influenced the adoption of radical terraces. In other words, farmers with greater exposure to various sources of information were more likely to adopt terraces than those with limited access.

5.1.4 Relationship Between Adoption and External Support

H1: Farmers' adoption of radical terraces is positively influenced by the external assistance provided to them by agencies.

HO: There is no significant association between farmers' adoption of radical terraces and the support they received from external agencies.

Evaluation of support from development agencies was conducted by analysing multiple factors, encompassing the year of support provision, the financial assistance amount, the variety of agencies extending the support, and the utilization of the support by farmers. The connections between adopting radical terraces and the external support provided by development agencies are illustrated in Table 28.

Year Support was Provided: The examination of the association between the timing of support and the adoption of radical terraces through cross-tabulation, utilizing the Pearson Chi-square test ($\chi2=13.232$, df=8, p=0.104), demonstrated that the temporal aspect of support did not exert a substantial impact on the adoption of terraces by farmers. Both individuals who received support earlier and those who received it later exhibited similar levels of terrace adoption.

Types of Agencies: By utilising the Chi-square test ($\chi2=9.028$, df=12, p=0.701), it was ascertained that no substantial correlation existed between the categories of agencies extending support and the adoption of terraces. In simpler terms, adopting radical terraces demonstrated consistency among farmers, regardless of the diverse agencies that supported them.

Amount of Financial Support: By employing a cross-tabulation analysis, specifically focusing on the financial support or credit received by farmers in relation to their adoption of radical terraces and utilizing a significance threshold of P>0.023, it became evident that the extent of financial support played a notable role in influencing the adoption of terraces by farmers ($\chi2=23.591$, df=12, p=0.023). This outcome implies that farmers with higher credit amounts were inclined to adopt terraces more than those who received comparatively lower sums of credit.

Farmers' Use of Support/Credit: Conducting a cross-tabulation analysis to examine the correlation between farmers' utilization of credit and their adoption of radical terraces,

employing the Chi-square test ($\chi 2=8.811$, df=8, p=0.358), yielded results indicating the absence of a noteworthy connection between these two variables. This suggests that the extent of adopting radical terraces among farmers did not significantly differ based on how they chose to employ the support or credit provided.

Table 28: Outside Support by Adoption of radical terraces

	Adoption of radical terraces			
	Low adoption	Medium adoption	High adoption	Total
	n	n	n	N
Year of receiving support				
None	8	114	12	134
Before 2005	0	3	1	4
2006-2010	1	1	2	4
2011-2015	0	5	1	6
2016-2019	1	36	7	44
Total	10	159	23	192
$\chi 2=13.232$, df=8, p= 0.104				
Amount of financial support /credit				
None	8	114	12	134
<=400,000	0	26	5	31
400,001 - 1,000, 000	0	8	1	9
1,000,001+	2	11	5	18
Total	10	159	23	192
($\chi 2=23.591$, df=12, p=.023)				
Types of agencies providing support				
None	8	114	12	134
B.P. R	1	4	1	6
RAB	0	1	0	1
SACCO	1	22	7	30
TUBURA	0	8	1	9
V.U. P	0	8	2	10
Vision finance	0	2	0	2
Total	10	159	23	192
$\chi 2=9.028$, df=12, p=0.701				
Farmers use the support/credit in				
None	8	125	16	149
Terraces	1	11	4	16
Crops	0	12	0	12
Livestock	1	7	1	9
Others	0	4	2	6
Total	10	159	23	192
$\chi 2=8.811$, df=8, p=0.358				

The H1 hypothesis was conditionally confirmed concerning the extent of financial support or credit obtained by farmers. To elaborate, it was observed that farmers who received more substantial amounts of assistance exhibited higher adoption of terraces compared to their counterparts who received comparatively smaller levels of support.

5.1.5 Relationship Between Farmers' Adoption and their Participation in Radical Terraces

The H1 hypothesis states that farmers' participation in decision-making on radical terraces adoption is significantly related to their level of adoption of radical terraces.

The H0 hypothesis, on the other hand, posits that farmers' participation in decision-making on radical terraces adoption does not influence their level of adoption of radical terraces.

The predictor variable of 'participation' was cross-tabulated with the intervening variable of 'adoption of radical terraces.' The relationships between these variables are presented in table 29. Farmers' participation showed a significant association with adoption ($\chi 2=12.342$, df=4, $p<0.015$). This suggests that the level of farmers' involvement meaningfully impacted their adoption of radical terraces. In other words, farmers who actively participated in decision-making on radical terraces were better adopters than those with low participation levels.

Table 29: Farmers' participation in the Adoption of radical terraces

	Radical Terrace Adoption			
	Low	Medium	High	Total
	n	n	n	N
Farmer's Participation				
Low participation	3	22	2	27
Medium participation	5	86	6	97
High participation	2	51	15	68
Total	10	159	23	192
$\chi 2=12.342$, df=4, $p<0.015$				

The H1 hypothesis has been validated, signifying a significant correlation between farmers' level of participation and their adoption of radical terraces. In simpler terms, farmers who actively engaged in decision-making concerning radical terraces were more inclined to adopt these farming practices in comparison to those with lower levels of participation.

5.2 Relationship between Radical Terraces Adoption and Food Security

The H1 hypothesis suggests that farmers' adoption of radical terraces positively influences food security. On the contrary, the null hypothesis (HO) posits a lack of connection between farmers' embrace of radical terraces and their food security status.

Food security indicators were measured through various factors, including the level of food crop production, level of livestock keeping, food availability, food utilization selling surplus milk, number of months the harvest lasted, and number of meals taken.

Table 30 presents the relationships between radical terraces adoption and the indicators of food security. The results revealed significant associations for some indicators.

Level of Food Crop Production: The Pearson Chi-square test ($\chi2=86.201$, df=4, p=0.000) indicated a significant influence of the level of food crop production on radical terraces adoption by farmers.

Level of Livestock Keeping: The Chi-square test ($\chi2=144.363$, df=4, p=0.000) showed a relationship between the level of livestock keeping and radical terraces adoption.

Food Availability: The Pearson Chi-square test ($\chi2=7.839$, df=2, p=0.020) indicated that food availability significantly influenced radical terraces adoption by farmers.

Number of Months of Harvest Lasting: According to the Pearson Chi-square test ($\chi2=9.510$, df=6, p=0.147), it was determined that the duration of harvest availability did not exert a statistically significant impact on radical terraces adoption by farmers.

Selling the Surplus of Milk: The Chi-square test ($\chi2=67.816$, df=2, p=0.000) showed a relationship between selling the surplus of milk and radical terraces adoption.

Food Utilization: The Pearson Chi-square test ($\chi2=4.207$, df=6, p=0.649) indicated that the level of food utilization did not significantly influence radical terraces adoption by farmers.

Number of Meals: The Pearson Chi-square test ($\chi2=41.919$, df=4, p=0.000) revealed a statistically significant association between the daily meal consumption frequency after adopting radical terraces and farmers' adoption of these farming practices.

Level of Food Security: The results from the Pearson Chi-square test ($\chi 2$=19.950, df=4, p=0.001) indicated that radical terraces adoption by farmers significantly influenced food security.

Table 30: Relationship between Farmers 'food security and Radical Terraces Adoption

	Radical Terraces Adoption			
	Low adoption	Medium adoption	High adoption	Total
	n	n	n	N
Level of food crop production				
Insufficient Food Production	6	2	0	8
Moderate Food Production	3	129	15	147
Abundant Food Production	1	28	8	37
Total	10	159	23	192
$\chi 2$=86.201, df=4, p=0.000				
Level of livestock keeping				
Low adoption	10	152	0	162
Medium adoption	0	7	18	25
High adoption	0	0	5	5
Total	10	159	23	192
$\chi 2$=144.363, df=4, p=0.000				
Food availability				
Yes	3	84	18	105
No	7	75	5	87
Total	10	159	23	192
$\chi 2$=7.839, df=2, p=0.020				
Number of months of harvest lasting				
None	3	84	18	105
Less than 3 months	3	30	1	34
4-9 months	4	40	3	47
>=10 months	0	5	1	6
Total	10	159	23	192
$\chi 2$=9.510, df=6, p=0.147				
Selling the Surplus of milk				
Yes	0	13	17	30
No	10	146	6	162
Total	10	159	23	192
$\chi 2$=67.816, df=2, p=0.000				
Food utilization				
Household consumption	5	86	15	106
Consumption and exchange	0	9	2	11
Consumption and selling	3	51	5	59
Consumption and stock	2	13	1	16
Total	10	159	23	192

χ2=4.207, df=6, p=0.649				
Number of meals				
Once	4	23	0	27
Twice	5	112	7	124
3 times	1	24	16	41
Total	10	159	23	192
χ2=41.919, df=4, p=0.000				
Level of food security				
Inadequately Food Secure	3	45	1	49
Moderately Food Secure	7	114	20	141
Well Food Secure	0	0	2	2
Total	10	159	23	192
χ2=19.950, df=4, p=0.001				

The assessment of food security involved various criteria, including the projected yield for the upcoming harvest, the duration for which the harvest provided sustenance to the household, the utilization of household food crop production, surplus milk sales, and the number of daily meals consumed subsequent to the adoption of radical terraces. To categorize food security, a scoring system was devised, delineating three categories: Low (0–5 scores), medium (6–9 scores), and high (10–18 scores) levels of food security (refer to Appendix Table 11).

To investigate the factors influencing the adoption of radical terraces, a chi-square analysis was conducted, using the adoption of radical terraces as the dependent variable and household characteristics, membership in self-help groups, access to agricultural information, outside support, and participation as independent variables. The results of this analysis are presented below.

5.3 Regression Analysis of Predictor on Response Variables

A comprehensive multivariate analysis encompassing both predictor and outcome variables was conducted, with a significance threshold set at $p<0.1$. Pearson's correlation coefficient was employed to evaluate the degree of associations among these variables. Furthermore, a regression analysis was executed to quantify the robustness of the relationships between the predictor (independent) variables and the response (dependent) variables, maintaining a confidence level of 95%.

For predicting or explaining the effect of the predictor on the response variables, multivariate regression analysis (MRA) was employed. The response variables consisted of indicators of

adoption of radical terraces, which were regressed on predictor variables, including farmer household characteristics, membership in Self-Help Groups, access to agricultural information, outside support, and participation. Below are the outcomes derived from the regression analysis.

5.3.1 Regression of Indicators of Food Security and Farmers' Adoption Indicators

The study's primary objective was to investigate whether radical terraces adoption would influence food security. To examine this hypothesis, a multivariate regression analysis was conducted, examining the relationship between adoption and the dependent variable of food security. The results of the analysis revealed positive and significant correlations between all indicators of food security and the indicators of radical terrace adoption.

More specifically, all food security indicators displayed positive correlations with radical terrace adoption by farmers. These correlations were as follows: Years of terracing experience ($r = 0.485$, $p < 0.01$), square meters of terraced land ($r = 0.708$, $p < 0.01$), the level of maintenance for radical terraces ($r = 0.439$, $p < 0.01$), acreage dedicated to fodder cultivation ($r = 0.697$, $p < 0.01$), level of food security ($r = 0.618$, $p < 0.01$), number of meals ($r = 0.455$, $p < 0.01$), surplus milk sales ($r = 0.471$, $p < 0.01$), duration of harvest availability ($r = 0.401$, $p < 0.01$), adoption of livestock ($r = 0.828$, $p < 0.01$), food availability ($r = 0.508$, $p < 0.01$), and food crop production level ($r = 0.592$, $p < 0.01$) were all significantly linked with the adoption of food security.

However, the type of fodder planted ($r = 0.11$, $p > 0.05$) and food utilization ($r = 0.005$, $p > 0.05$) did not exhibit significant associations with radical terrace adoption concerning food security, as indicated in Table 31.

Table 31: Relationships between Indicators of Food Security and those of Adoption of Radical Terraces.

Correlations	Adoption of radical terraces	Years of experiences in terracing	Square meters terraced	Levels of maintenance of radical terraces	Type of fodder planted	Acreages of fodder planted	Level of food security	Number of meals	Selling the Surplus of milk	Number of months of harvest lasting	Adoption of livestock	Food Availability	Level of food crop production	Food Utilization
Adoption of radical terraces	1													
Years of experiences in terracing	.485**	1												
Square meters terraced	.708**	.349**	1											
Levels of maintenance of radical terraces	.439**	0.098	.198**	1										
Type of fodder planted	0.11	-0.074	0.079	.278**	1									
Acreages of fodder planted	.697**	.316**	.842**	.196**	0.076	1								
Level of food security	.618**	.283**	.441**	.219**	-0.03	.405**	1							
Number of meals	.455**	.166*	.322**	.151*	0.013	.313**	.764**	1						
Selling the Surplus of milk	.471**	.197**	.347**	0.047	-0.097	.318**	.840**	.505**	1					
Number of months of harvest lasting	-.401**	-.293**	-.308**	-.310**	0.029	-.282**	-.433**	-.253**	-.229**	1				
Adoption of livestock	.828**	.274**	.462**	.219**	0.018	.442**	.626**	.476**	.545**	-.291**	1			
Food Availability	.508**	.331**	.369**	.376**	0.01	.332**	.620**	.360**	.276**	-.901**	.387**	1		
Level of food crop production	.592**	.246**	.234**	.376**	-0.039	.265**	.252**	.189**	.152*	-.265**	.306**	.298**	1	
Food Utilization	-0.005	-0.083	-0.089	0.078	0.087	-0.053	-0.02	-0.007	-0.061	0.049	0.024	-0.008	0.018	1

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

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

The regression model revealed a robust association between radical terrace adoption and all food security indicators, explaining a substantial 96.8% of the variance, which was highly statistically significant ($R^2=0.968$; $F(12,179)=446.775$, $p<0.001$). The food security indicators displayed positive and significant correlations with radical terrace adoption by farmers and the model effectively forecasted the relationship between these indicators.

Specifically, the variables including years of experience in terracing ($\beta=0.934$, $t=10.096$, $p<0.001$), square meters terraced ($\beta=1.093$, $t=6.95$, $p<0.001$), levels of maintenance of radical terraces ($\beta=1.085$, $t=7.491$, $p<0.001$), type of fodder planted ($\beta=0.825$, $t=4.111$, $p<0.001$), acreages of fodder planted ($\beta=1.043$, $t=6.607$, $p<0.001$), level of food security ($\beta=1.382$, $t=3.055$, $p=0.003$), level of adoption of livestock ($\beta=1.257$, $t=16.281$, $p<0.001$), level of food crop production ($\beta=1.308$, $t=10.834$, $p<0.001$), number of months harvest endured ($\beta=0.304$, $t=2.087$, $p=0.038$), and food availability ($\beta=0.208$, $t=2.129$, $p=0.035$) all exhibited a positive and statistically significant impact on both adoption and food security. This suggests that an increase in these indicators would significantly enhance radical terrace adoption, subsequently leading to an improvement in food security, as illustrated in Table 32.

However, the variables of number of meals ($\beta=0.03$, $t=0.246$, $p=0.806$), selling surplus milk ($\beta=0.011$, $t=0.168$, $p=0.867$), and food utilization ($\beta=0.006$, $t=0.118$, $p=0.906$) did not significantly influence the strength of association between adoption and food security (as shown in Table 32).

Table 32: Regression of Indicators of Food Security and Adoption of Radical Terraces

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
	B	Std. Error	Beta			Lower Bound	Upper Bound
(Constant)	5.524	1.486		3.716	0.000	2.59	8.457
Years of experience in terracing	0.934	0.093	0.152	10.096	0.000	0.751	1.116
Square meters terraced	1.093	0.157	0.181	6.95	0.000	0.782	1.403
Levels of maintenance of radical terraces	1.085	0.145	0.121	7.491	0.000	0.799	1.371
Type of fodder planted	0.825	0.201	0.059	4.111	0.000	0.429	1.221
Acreages of fodder planted	1.043	0.158	0.167	6.607	0.000	0.732	1.355
Level of food security	1.382	0.128	0.618	10.834	0.000	1.130	1.633
Number of meals	0.03	0.12	0.004	0.246	0.806	-0.267	0.208
Selling surplus milk	0.011	0.067	0.003	0.168	0.867	-0.122	0.145
Number of months harvest lasted	0.304	0.146	0.067	2.087	0.038	0.017	0.592
Level of adoption of livestock	0.997	0.036	0.512	27.902	0.000	0.926	1.067
Food availability	0.208	0.097	0.073	2.129	0.035	0.015	0.4
Level of food crop production	0.999	0.059	0.264	17.052	0.000	0.884	1.115
Food utilization	0.006	0.053	0.002	0.118	0.906	-0.111	0.099

Note: Dependent Variable: Food security, R^2 =0.968; F (12, 179) =446.775; Number of observations(N) = 191, p<0.001

5.3.2 Relationship Between Adoption and Farmers' Demographic Characteristics

The study subjected the adoption of radical terraces by farmers to regression analysis based on their demographic attributes, with the results detailed in Table 33. The primary objective of this investigation was to ascertain whether the predictor variables representing farmers' characteristics could exert an influence on their adoption of radical terraces. To assess this hypothesis and explore the connections between adoption of radical terraces by farmers and their demographic traits, a multivariate regression analysis was performed.

The analysis outcomes revealed significant correlations between several factors related to the adoption of radical terraces and farmers' demographic characteristics. Specifically, years of terracing experience ($\beta=0.485$, $p<0.01$), the area in square meters that was terraced ($\beta=0.708$, $p<0.01$), the level of maintenance for radical terraces ($\beta=0.439$, $p<0.01$), the acreage dedicated to fodder cultivation ($\beta=0.697$, $p<0.01$), farmer's age ($r=0.193$, $p<0.01$), reported seasonal income ($r=0.546$, $p<0.01$), and land ownership size ($r=0.524$, $p<0.01$) were all found to have significant correlations with adoption of radical terraces by farmers. These findings indicate that these factors play a substantial role in influencing farmers' decisions to adopt radical terraces, as depicted in Table 33.

Conversely, the remaining predictor variables, such as gender, educational attainment, marital status, family size, farmer's occupation, and primary source of income, did not demonstrate statistically significant associations with farmers' adoption of radical terraces, as evidenced in Table 33.

Table 33: Relationships Between Farmers' Characteristics and Adoption of Radical Terraces

Correlations	Adoption of radical terraces	Years of experiences in terracing	Square meters terraced	Levels of maintenance of radical terraces	Type of fodder planted	Acreages of fodder planted	Farmer's age	Gender	Level of education	Marital status	Size of the family	Occupation of farmer	Main source of income	Reported seasonal income	Land sized ownership
Adoption of radical terraces	1														
Years of experiences in terracing	.485**	1													
Square meters terraced	.708**	.349**	1												
Levels of maintenance of radical terraces	.439**	0.098	.198**	1											
Type of fodder planted	0.11	-0.074	0.079	.278**	1										
Acreage of fodder planted	.697**	.316**	.842**	.196**	0.076	1									
Farmer's age	.193**	.294**	.187**	0.006	-0.023	.163*	1								
Gender	0.131	0.123	0.082	0.027	-0.061	0.105	0.12	1							
Level of education	0.099	0.042	-0.035	0.136	-0.089	-0.066	-0.1	-0.058	1						
Marital status	0.077	-0.025	-0.046	-0.001	-0.028	-0.009	0.027	-0.027	-0.09	1					
Size of the family	0.073	0.013	0.03	-0.011	-0.011	0.025	.256**	-0.022	-0.05	.483**	1				
Occupation of farmer	0.036	0.123	0.037	-0.058	-0.013	0.031	0.075	0.117	-0.062	-0.035	-0.013	1			
Main source of income	0.096	0.133	-0.045	0.087	-0.015	-0.054	0.027	-0.087	0.039	-0.04	-0.015	-0.018	1		
Reported seasonal income	.546**	.254**	.537**	.222**	0.081	.478**	0.032	.154*	.191**	-0.02	-0.034	-0.084	0.115	1	
Land sized ownership	.524**	.346**	.564**	.221**	0.113	.533**	.183*	0.08	-0.067	-0.131	-0.059	-0.03	0.087	.301**	1

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

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

The regression model explained 72.0% of the overall relationships between farmers' adoption of radical terraces and their demographic characteristics and was found to be statistically significant ($R2=0.720$, $F(14, 177) =32.469$, $p< 0.001$). Among the indicators of farmers' adoption of radical terraces, the following factors were found to significantly influence and have a positive effect on farmers' adoption of radical terraces: years of experience in terracing ($\beta=1.285$, $t=3.16$, $p<0.001$); square meters terraced ($\beta=1.433$, $t=2.926$, $p=0.004$); levels of maintenance of radical terraces ($\beta=2.26$, $t=5.784$, $p<0.001$); acreages of fodder planted ($\beta=1.715$, $t=3.649$, $p<0.001$); marital status ($\beta=1.09$, $t=2.409$, $p=0.017$); reported seasonal income ($\beta=1.09$, $t=2.532$, $p=0.012$); and land size ownership ($\beta=2.967$, $t=8.484$, $p<0.012$). These factors significantly influenced farmers' decisions to adopt radical terraces, as shown in Table 34.

Table 34: Regression of Farmers' Characteristics and Adoption of Radical Terraces

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
	B	Std. Error	Beta			Lower Bound	Upper Bound
(Constant)	17.853	5.65		3.16	0.002	6.703	29.004
Years of experience in terracing	1.285	0.283	0.209	4.535	0.000	0.726	1.845
Square meters terraced	1.433	0.49	0.237	2.926	0.004	0.466	2.399
Levels of maintenance of radical terraces	2.26	0.391	0.252	5.784	0.000	1.489	3.031
Type of fodder planted	0.124	0.589	0.009	0.21	0.834	-1.04	1.287
Acreages of fodder planted	1.715	0.47	0.275	3.649	0.000	0.788	2.642
Farmer's age	0.097	0.305	0.014	0.32	0.749	-0.504	0.699
Gender	0.615	0.803	0.032	0.766	0.445	-0.97	2.2
Level of education	0.375	0.205	0.078	1.829	0.069	-0.03	0.78
Marital status	1.09	0.452	0.112	2.409	0.017	0.197	1.982
Size of the family	0.241	0.661	0.017	0.365	0.716	-1.063	1.545
Occupation of farmer	0.596	0.933	0.026	0.639	0.524	-1.245	2.438
The primary source of income	1.582	1.233	0.053	1.283	0.201	-0.852	4.016
Reported seasonal income	1.09	0.431	0.13	2.532	0.012	0.24	1.94
Land sized ownership	2.967	0.3501	0.524	8.484	0.000	2.277	3.657

Note: Dependent Variable: Adoption of radical terraces, R^2 =0.720; F (14, 177) =32.469; Number of observations(N) = 191, p<0.001

5.3.3 Relationships Between Farmers' Adoption and Membership in SHGs

A regression analysis examined the impact of farmers' membership in Self-Help Groups (SHGs) on their adoption of radical terraces. The findings in Table 35 aimed to test the hypothesis that SHG membership would influence farmers' adoption of radical terraces. The study explored the relationship between farmers' adoption and their SHG membership through multiple regression analysis. The results of the analysis revealed noteworthy correlations between the adoption of radical terraces and several factors: years of terracing experience ($\beta=0.485$, $p<0.01$), area of terraced land ($\beta=0.708$, $p<0.01$), extent of radical terraces maintenance ($\beta=0.439$, $p<0.01$), acreage of cultivated fodder ($\beta=0.697$, $p<0.01$), duration of farmer's SHG membership ($r=0.157$, $p<0.05$), and farmers' roles in SHGs leadership ($r=0.189$, $p<0.01$). These factors displayed a significant association with farmers' adoption of radical terraces. However, the other membership indicators did not substantially connect with farmers' adoption of radical terraces (Refer to Table 35).

Table 35: Relationships between Indicators of Membership in SHGs and those of Adoption of Radical Terraces

Correlations	Adoption of radical terraces	Years of experiences in terracing	Square meters terraced	Levels of maintenance of radical terraces	Type of fodder planted	Acreages of fodder planted	Years of experience of farmer's membership in SHGs	Farmer's leadership position in SHGs	Types of benefits of farmers from SHGs
Adoption of radical terraces	1								
Years of experiences in terracing	.485**	1							
Square meters terraced	.708**	.349**	1						
Levels of maintenance of radical terraces	.439**	0.098	.198**	1					
Type of fodder planted	0.11	-0.074	0.079	.278**	1				
Acreages of fodder planted	.697**	.316**	.842**	.196**	0.076	1			
Years of experience of farmer's membership in SHGs	.157*	.174*	.243**	-0.046	-0.017	.192**	1		
Farmer's leadership position in SHGs	.189**	0.031	0.139	.210**	0.073	0.064	.332**	1	
Types of benefits of farmers from SHGs	-0.026	0.065	-0.06	-0.134	-0.134	-0.063	.438**	0.118	1
** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).									

The regression model accounted for 68.5% of the overall associations between farmers' adoption and their participation in SHGs as statistically noteworthy ($R2 = 0.685$; $F(8, 183) = 49.824$, $p < 0.001$). The variables encompassing years of engagement in terracing ($\beta = 1.285$, $t = 5.702$, $p < 0.001$), area of terraced land ($\beta = 1.842$, $t = 3.819$, $p < 0.001$), the extent of radical terraces maintenance ($\beta = 2.506$, $t = 6.145$, $p < 0.001$), and acreage of cultivated fodder ($\beta = 1.957$, $t = 4.038$, $p < 0.001$) had a noteworthy impact on farmers' adoption of radical terraces (Refer to Table 36). Conversely, variables related to the type of planted fodder, duration of farmers' SHG membership, their roles in SHGs leadership, and the types of benefits gained from SHGs did not demonstrate a substantial influence on adopting radical terraces.

Table 36: Regression of Farmers' Membership in SHGs and their Adoption of Radical Terraces

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
	B	Std. Error	Beta			Lower Bound	Upper Bound
(Constant)	31.242	2.001		15.612	0.000	27.294	35.191
Years of experience in terracing	1.578	0.277	0.257	5.702	0.000	1.032	2.124
Square meters terraced	1.842	0.482	0.305	3.819	0.000	0.891	2.794
Levels of maintenance of radical terraces	2.506	0.408	0.28	6.145	0.000	1.702	3.311
Type of fodder planted	0.051	0.607	0.004	0.084	0.933	-1.147	1.249
Acreages of fodder planted	1.957	0.485	0.313	4.038	0.000	1.001	2.913
Years of experience in farmer's membership in SHGs	-0.27	0.253	-0.054	-1.065	0.288	-0.769	0.23
Farmers' leadership positions in SHGs	0.232	0.148	0.071	1.565	0.119	-0.061	0.525
Types of benefits of farmers from SHGs	0.22	0.213	0.049	1.034	0.303	-0.2	0.639

Note: Dependent Variable: Adoption of radical terraces, R^2 =0.685; F (8, 183) =49.824; Number of observations(N) = 191, p<0.001

5.3.4 Relationships Between Farmers' Adoption and their Access to Information Sources

The study investigated farmers' adoption of radical terraces within the framework of their access to various information sources. The results of this research are presented in Table 37. The hypothesis driving this study postulated that particular indicators associated with access to information sources might impact the probability of farmers adopting radical terraces. To evaluate this hypothesis, a multiple regression analysis was conducted to explore the connection between adoption of radical terraces by farmers and their access to sources of information.

The outcomes of the analysis revealed that several factors exhibited significant correlations with the adoption of radical terraces. These factors encompassed years of experience in terracing ($\beta = 0.485$, $p < 0.01$), the area of terraced land ($\beta = 0.708$, $p < 0.01$), the degree of radical terraces maintenance ($\beta = 0.439$, $p < 0.01$), the extent of cultivated fodder ($\beta = 0.697$, $p < 0.01$), the levels of receiving general agricultural information ($r = 0.312$, $p < 0.001$), and information specifically concerning radical terraces ($r = 0.340$, $p < 0.001$).

However, other predictor indicators like the types of planted fodder, sources of information, and benefits derived from different information sources did not demonstrate a significant link to farmers' adoption of radical terraces (refer to Table 37).

Table 37: Relationships between Farmers' Access to Information Sources and their Adoption of Radical Terraces

Correlations	Adoption of radical terraces	Years of experiences in terracing	Square meters terraced	Levels of maintenance of radical terraces	Type of fooder planted	Acreages of fodder planted	Types of information sources farming	Levels of getting agricultural information about overall farming	Levels of getting agricultural information about radical terraces	Benefits gained from various sources of information
Adoption of radical terraces	1									
Years of experiences in terracing	.485**	1								
Square meters terraced	.708**	.349**	1							
Levels of maintenance of radical terraces	.439**	0.098	.198**	1						
Type of fodder planted	0.11	-0.074	0.079	.278**	1					
Acreages of fodder planted	.697**	.316**	.842**	.196**	0.076	1				
Types of information sources farming	-0.043	0.009	-0.002	0.015	-0.067	-0.039	1			
Levels of getting agricultural information about overall farming	.312**	.230**	.206**	0.079	-0.031	.213**	-0.025	1		
Levels of getting agricultural information about radical terraces	.340**	.209**	.277**	0.048	-0.026	.219**	-0.132	.408**	1	
Benefits gained from various sources of information	0.051	-0.015	0.027	0.021	-0.023	0.064	-0.013	0.116	0.003	1
** Correlation is significant at the 0.01 level (2-tailed).										

The regression model successfully explained 70.0% of the overall connection between farmers' adoption of radical terraces and their access to information sources, and this relationship was statistically significant ($R2 = 0.700$; $F(9, 182) = 47.283$, $p < 0.001$).

Among the predictor and adoption indicators, several factors positively and significantly influenced farmers' adoption of radical terraces. These factors include years of experience in terracing ($\beta = 1.409$, $t = 5.156$, $p < 0.001$), square meters terraced ($\beta = 1.687$, $t = 3.587$, $p < 0.001$), levels of maintenance of radical terraces ($\beta = 2.506$, $t = 6.145$, $p < 0.001$), acreages of fodder planted ($\beta = 1.826$, $t = 3.84$, $p < 0.001$), and levels of receiving agricultural information related explicitly to radical terraces ($\beta = 0.563$, $t = 2.276$, $p = 0.024$).

Nevertheless, the remaining indicators, including the variety of fodder crops cultivated, the extent of access to general agricultural information, and the advantages obtained from different information sources, did not exhibit notable correlations with farmers' adoption of radical terraces (refer to Table 38).

Table 38: Regression Analysis of Farmers' Access to Information Sources and their Adoption of Radical Terraces

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
	B	Std. Error	Beta			Lower Bound	Upper Bound
(Constant)	29.542	2.189		13.497	0.000	25.223	33.86
Years of experience in terracing	1.409	0.273	0.229	5.156	0.000	0.87	1.948
Square meters terraced	1.687	0.47	0.279	3.587	0.000	0.759	2.615
Levels of maintenance of radical terraces	2.611	0.387	0.292	6.752	0.000	1.848	3.374
Type of fodder planted	0.075	0.594	0.005	0.127	0.899	-1.096	1.247
Acreages of fodder planted	1.826	0.476	0.292	3.84	0.000	0.887	2.764
Types of information sources for farming	-0.113	0.223	-0.021	-0.508	0.612	-0.553	0.326
Degrees of access to agricultural information concerning general farming	0.427	0.274	0.071	1.558	0.121	-0.114	0.968
Degrees of access to agricultural information pertaining to radical terraces	0.563	0.247	0.105	2.276	0.024	0.075	1.051
Advantages derived from diverse sources of information	0.115	0.362	0.013	0.318	0.751	-0.599	0.829

Note: Dependent Variable: Adoption of radical terraces, R^2 =0.700; F (9, 182) =47.283; Number of observations(N) = 191, p<0.001

5.3.5 Relationships Between Farmers' Adoption and External Support

The examination of farmers' embrace of radical terraces was undertaken while taking into account the external assistance they obtained. The findings are presented in Table 39. The research hypothesized that distinct predictor factors might impact farmers' adoption of radical terraces. To examine this assertion, a multiple regression analysis was conducted to explore the relationship between farmers' adoption of radical terraces and the external support they received. The analysis results revealed several factors that exhibited significant correlations with the adoption of radical terraces. These factors included years of terracing experience ($\beta = 0.485$, $p < 0.01$), the extent of terraced land ($\beta = 0.708$, $p < 0.01$), the level of maintenance for radical terraces ($\beta = 0.439$, $p < 0.01$), and the acreage of cultivated fodder ($\beta = 0.697$, $p < 0.01$). Additionally, farmers' utilization of support or credit ($r = 0.126$, $p < 0.05$) was also found to be significantly associated with the adoption of radical terraces.

However, other indicators such as the year of receiving support ($r = 0.068$, $p > 0.05$), the amount of financial support or credit ($r = 0.089$, $p > 0.05$), and the types of agencies providing support ($r = 0.105$, $p > 0.05$) did not demonstrate a significant correlation with the adoption of radical terraces (refer to Table 39).

Table 39: Relationships between Farmers' External Support and their Adoption of Radical Terraces

Correlations	Adoption of radical terraces	Years of experiences in terracing	Square meters terraced	Levels of maintenance of radical	Type of fodder planted	Acreages of fodder planted	Year of receiving support	Amount of financial support /credit	Types of agencies providing support	Farmers use of the support/ credit in
Adoption of radical terraces	1									
Years of experiences in terracing	.485**	1								
Square meters terraced	.708**	.349**	1							
Levels of maintenance of radical terraces	.439**	0.098	.198**	1						
Type of fodder planted	0.11	-0.074	0.079	.278**	1					
Acreages of fodder planted	.697**	.316**	.842**	.196**	0.076	1				
Year of receiving support	0.068	0.052	0.107	-0.028	-0.121	0.111	1			
Amount of financial support /credit	0.089	0.032	0.136	-0.006	-0.084	0.111	.939**	1		
Types of agencies providing support	0.105	0.075	0.121	0.022	-.150*	0.122	.915**	.894**	1	
Farmers use of the support/credit in	0.126*	0.001	.223**	-0.056	0.055	.150*	.180*	.221**	.183*	1

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

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

The regression model effectively accounted for a substantial portion, 68.1%, of the comprehensive relationship between farmers' adoption of radical terraces and external support ($R2 = 0.681$; $F(9, 182) = 43.206$, $p < 0.001$).

Among the indicators influencing adoption and predictors, various factors showcased a noteworthy impact on farmers' adoption of radical terraces. These factors comprised years of experience in terracing ($\beta = 1.584$, $t = 5.677$, $p < 0.001$), extent of terraced land ($\beta = 1.756$, $t = 3.568$, $p < 0.001$), degree of maintenance for radical terraces ($\beta = 2.633$, $t = 6.499$, $p < 0.001$), and acreages of cultivated fodder ($\beta = 1.931$, $t = 3.928$, $p < 0.001$). Furthermore, farmers' utilization of support or credit ($\beta = 0.001$, $t = 2.105$, $p = 0.045$) also evidenced a noteworthy influence on adopting radical terraces.

Conversely, disparate metrics such as the variety of forage cultivated, year of assistance receipt, magnitude of financial support or credit, and the identity of supporting agencies did not exert a substantial impact on farmers' adoption of radical terraces (see Table 40).

Table 40: Regression of Farmers' External Support and Radical Terrace Adoption s

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
	B	Std. Error	Beta			Lower Bound	Upper Bound
(Constant)	31.476	1.951		16.137	0.000	27.627	35.324
Years of experience in terracing	1.584	0.279	0.258	5.677	0.000	1.033	2.134
Square meters terraced	1.756	0.492	0.29	3.568	0.000	0.785	2.727
Levels of maintenance of radical terraces	2.633	0.405	0.294	6.499	0.000	1.833	3.432
Type of fodder planted	-0.033	0.625	-0.002	-0.052	0.958	-1.265	1.2
Acreage of fodder planted	1.931	0.492	0.309	3.928	0.000	0.961	2.901
Year of receiving support	-0.569	0.722	-0.112	-0.789	0.431	-1.993	0.855
Magnitude of financial assistance or credit provisions	0.296	0.523	0.073	0.566	0.572	-0.736	1.329
Varieties of institutions offering support	0.193	0.552	0.038	0.349	0.728	-0.897	1.282
Farmers use the support/credit	0.001	0.000	0.376	2.105	0.045	0.000	0.001

Note: Dependent Variable: Adoption of radical terraces, R^2 =0.681; F (9, 182) =43.206; Number of observations(N) = 191, p<0.001

5.3.6 The Correlation Between Farmers' Adoption and Involvement in the Radical Terraces Initiative

The exploration of farmers' adoption of radical terraces encompassed an analysis of their extent of involvement in the terracing process. The outcomes are presented in Table 41. The underlying hypothesis of the study posited that specific predictor variables linked to participation would influence farmers' likelihood of adopting radical terraces. A thorough regression analysis was conducted to evaluate this hypothesis, examining the connection between farmers' adoption of radical terraces and the extent of their involvement.

The analysis outcomes indicated the existence of various factors significantly associated with the adoption of radical terraces. These factors encompassed years of terracing experience ($\beta = 0.485$, $p <$

0.01), area of land terraced ($\beta = 0.708$, $p < 0.01$), the level of radical terraces maintenance ($\beta = 0.439$, $p < 0.01$), and the extent of cultivated fodder acreages ($\beta = 0.697$, $p < 0.01$).

Furthermore, farmers' active engagement in decision-making ($r = 0.339$, $p < 0.001$), their frequency of meeting attendance ($r = 0.392$, $p < 0.001$), the magnitude of their contributions ($r = 0.612$, $p < 0.001$), the nature of their contributions ($r = 0.347$, $p < 0.001$), and their overall degree of participation ($r = 0.600$, $p < 0.001$) were all notably correlated with the adoption of radical terraces.

However, the sole indicator that did not manifest a significant association with farmers' adoption of terraces was the type of fodder planted ($r = 0.11$, $p > 0.05$) (see Table 41).

Table 41: Relationships Between Participation and Adoption of Radical Terraces

Correlations	Adoption of radical terraces	Years of experiences in terracing	Square meters terraced	Levels of maintenance of radical terraces	Type of fodder planted	Acreages of fodder planted	Farmer's involvement in decision making	Farmer's frequencies of meetings attended	Levels of farmer's contributions	Types of contribution	Participation
Adoption of radical terraces	1										
Years of experiences in terracing	.485**	1									
Square meters terraced	.708**	.349**	1								
Levels of maintenance of radical terraces	.439**	0.098	.198**	1							
Type of fodder planted	0.11	-0.074	0.079	.278**	1						
Acreages of fodder planted	.697**	.316**	.842**	.196**	0.076	1					
Farmer's involvement in decision making	.339**	.145*	.212**	.262**	0.07	.173*	1				
Farmer's frequencies of meetings attended	.392**	.316**	.326**	.209**	0.097	.279**	.276**	1			
Levels of farmer's contributions	.612**	.329**	.439**	.323**	0.11	.429**	.516**	.373**	1		
Types of contribution	.347**	.179*	.236**	.299**	0.086	.237**	.275**	.246**	.349**	1	
Participation	.600**	.361**	.439**	.379**	0.131	.406**	.625**	.746**	.765**	.671**	1
** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).											

The regression model provided a significant explanation of 72.2% for the overall relationship between farmers' adoption of radical terraces and their level of participation ($R2 = 0.722$; $F(9, 182) = 52.632$, $p < 0.001$).

Among the predictor and adoption indicators, several factors positively affected farmers' adoption of radical terraces. These factors include years of experience in terracing ($\beta = 1.232$, $t = 4.565$, $p < 0.001$), square meters terraced ($\beta = 1.544$, $t = 3.42$, $p < 0.001$), levels of maintenance of radical terraces ($\beta = 2.044$, $t = 5.196$, $p = 0.001$), and acreages of fodder planted ($\beta = 1.64$, $t = 3.58$, $p < 0.001$). Additionally, farmers' frequency of attending meetings ($\beta = 1.796$, $t = 5.881$, $p < 0.001$), their levels of contributions ($\beta = 1.149$, $t = 2.879$, $p < 0.001$), and their overall level of participation ($\beta = 1.274$, $t = 10.331$, $p < 0.001$) also had a positive effect on the adoption of radical terraces (see Table 42).

Table 42: Regression of Farmers' Participation and their Adoption of Radical Terraces

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
	B	Std. Error	Beta			Lower Bound	Upper Bound
(Constant)	30.874	1.86		16.6	0.000	27.204	34.544
Years of experience in terracing	1.232	0.27	0.2	4.565	0.000	0.699	1.764
Square meters terraced	1.544	0.451	0.255	3.42	0.001	0.653	2.434
Levels of maintenance of radical terraces	2.044	0.393	0.228	5.196	0.000	1.268	2.82
Type of fodder planted	-0.136	0.57	-0.01	-0.239	0.811	-1.262	0.989
Acreages of fodder planted	1.64	0.458	0.263	3.58	0.000	0.736	2.543
Farmer's involvement in decision making	0.084	0.526	0.008	0.16	0.873	-0.954	1.123
Farmer's frequency of attendance at meetings	1.796	0.305	0.392	5.881	0.000	1.194	2.399
Levels of farmer's contributions	1.149	0.399	0.19	2.879	0.004	0.361	1.937
Types of contributions	0.04	0.331	0.007	0.121	0.904	-0.613	0.693
Level of participation	1.274	0.123	0.600	10.331	0.000	1.031	1.518

Note: Dependent Variable: Adoption of radical terraces, R^2 =0.722; F (9, 182) =52.632; Number of observations(N) = 191, p<0.001

In summary, the findings indicate that several variables wielded a notable influence on the adoption of radical terraces and food security. Key adoption variables encompassed years of terracing experience, terraced area in square meters, the extent of radical terrace maintenance, the type and acreage of fodder planted. Moreover, most food security-related factors, including the level of food security, livestock adoption, food crop production, the duration of harvest availability, and food availability, exhibited a positive and statistically significant impact on the overall adoption of radical terraces and food security.

Regarding farmer characteristics, marital status, reported seasonal income, and land ownership size were identified as significant factors positively affecting farmers' propensity to adopt radical terraces. Among the sources of information, it was observed that only the receipt of agricultural information specifically related to radical terraces displayed a positive association with the adoption of these innovative farming practices.

Furthermore, among the various forms of outside support, only farmers' use of support or credit significantly influenced the adoption of radical terraces. Regarding participation, farmers' frequency of attending meetings, levels of contributions, and overall level of participation were the key factors that positively influenced the adoption of radical terraces.

All adoption-related variables demonstrated a statistically significant influence on the adoption of radical terraces, with the exception of membership in Self-Help Groups (SHGs). These findings offer valuable insights into the determinants motivating farmers to adopt radical terraces and their role in improving food security within the realm of agricultural practices.

CHAPTER SIX: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.0 Introduction

This section provides an overview of the results and deliberates on their theoretical implications in relation to the objectives of the research. Furthermore, it outlines the conclusions drawn from the findings and puts forth suggestions grounded in the results of the investigation.

6.1 Summary of the Findings and Discussion

6.1.1 Farmers' Adoption of Radical Terraces and Food Security

The primary aim of this research was to assess the influence of the implementation of transformative terraces by small-scale farmers on their food security within the Nyamagabe District.

H1: A significant relationship can be observed between farmers' embrace of radical terraces and the level of their food security.

H0: The adoption of radical terraces by farmers does not exert an impact on food security.

The findings revealed that adoption of radical terraces by farmers significantly positively affected their food security ($\beta = 19.950$, $df = 4$, $p = 0.003$). The regression model further demonstrated that 96.8% of food security variation was explained by the indicators of radical terraces adoption ($R2 = 0.968$; $F(12, 179) = 446.775$, $p < 0.001$). Food security indicators were strongly associated with farmers' adoption of radical terraces, and the model effectively predicted both food security indicators and farmers' adoption indicators. Consequently, many smallholder farmers managed to secure their food needs after adopting radical terraces.

These findings align with prior investigations carried out by Bashir et al. (2014), Karplus (2014), Mupenzi et al. (2014), the 2014 report from the Republic of Rwanda, and Posthumus (2005). These studies similarly documented beneficial effects of radical terraces on farmers' food production. The historical analysis by Murwanashyaka (2013) covering the 1980s and 1990s highlighted a stark contrast: people suffered from hunger, leading to migration in search of food and fertile land. Nonetheless, in the course of this investigation, the implementation of radical terraces within the Nyamagabe District exhibited successful alleviation of such circumstances, leading to a reduction in the occurrence of population migration to alternative regions prompted by insufficient food supply.

Furthermore, food crop production emerged as a critical indicator of food security, with Irish potatoes ranking highest at 58.3%, beans at 20.8%, maize at 13.1%, and wheat at 7.8%. Most farmers utilized the mountain highland and acidic soils to cultivate Irish potatoes, maize, and climbing beans. Bolarinwa et al. (2019) also observed that agricultural seasons are crucial in determining households' food security status in Rwanda.

These results emphasize the importance of implementing radical terraces as a means to augment food security among smallholder farmers in Nyamagabe District. The cultivation of essential food crops and improved agricultural practices can be attributed to the positive impact of radical terraces on food production and availability, thereby contributing to better food security outcomes for the farmers in the region.

As another measure of food security, the practice of livestock keeping demonstrated a noteworthy association with farmers' adoption of radical terraces ($\chi 2$= 21.654, df = 4, p = 0.001). This discovery corresponds with the findings of Masinde (2009), which suggested that livestock ownership positively influenced adoption by promoting fodder crop cultivation and correlating with increased wealth status. Similarly, Mutarutwa (2014) discovered that livestock contributed to augmenting household incomes among impoverished farmers. Mudingu (2018) also underscored the significance of livestock in enriching soil nutrients through the application of manure, thereby supporting small-scale crop cultivation and fulfilling household food requirements. As a result, the incorporation of livestock into the agricultural practices of smallholders emerged as a noteworthy contributor to food security within the study area, furnishing not only manure for the maintenance of radical terraces but also supplementary income and savings.

The significance of livestock products, including beef, milk, live animals, hides, and skins, as emerging export commodities generating notable revenue for Rwanda was additionally confirmed by the 2015 Annual Report of the National Agricultural Export Development Board (NAEB). Likewise, Mudingu (2018) observed that elements linked to the augmentation of household food security encompassed the variety of crops cultivated within radical terraces and vegetable gardens, alongside the possession of livestock. Additionally, the embrace of radical terraces was associated with an increase in the frequency of daily meals for households.

While most farmers had adopted radical terraces effectively, some were still indifferent and did not fully exploit the technology in the study area. This finding aligns with the Republic of Rwanda's (2012) report, which indicated limited adoption of radical terraces among rural communities in the

study area. The presence of unexploited radical terraces constructed by the Land Husbandry, Water Harvesting, and Hillside Irrigation (LWH/RSSP) program was also reported in the Nyamagabe district (Republic of Rwanda, 2015). Some farmers engaged in farming activities without terracing and relied on alternative means of subsistence, such as purchasing food products, engaging in business, and exploiting forests to sell sharks and timbers.

Adopting radical terraces in the hilly region of Nyamagabe reflects the influence of factors in Rogers' (1983) adoption and diffusion context. It was evident that adopting radical terraces brought significant advantages to smallholder farmers, including improved food crop production, water retention, soil and environmental conservation, and fodder for livestock. This shift from traditional to modern farming practices signifies changing rural and traditional mindsets towards modern agricultural techniques.

The mode of adoption observed in the study area aligns with Rogers' (2003) adoption and diffusion model. Some farmers initially embraced radical terraces but eventually rejected the innovation, while others discontinued its use after prior adoption. Such replacement discontinuance and disenchantment discontinuance were identified among farmers. They assessed the results of radical terraces and decided to reject them, turning some terraced areas into grazing grounds or planting forest trees. These negative practices further underscored the applicability of the farm adoption and diffusion model in the context of radical terraces adoption.

6.1.2 Household Attributes Radical Terraces Adoption

The second objective of this study encompassed the evaluation of how farmer attributes impact the adoption of radical terraces.

The hypotheses guiding the analysis were as follows:

H1: There is a positive association between household characteristics and adopting radical terraces.

HO: There is no association between household characteristics and adopting radical terraces.

The findings indicated that certain household characteristics significantly influenced the adoption of radical terraces, while others did not demonstrate such an effect. Specifically, farmers' adoption of radical terraces was significantly influenced by their age ($\chi2=14.504$, df=4, p=0.011), level of education ($\chi2=13.126$, df=6, p=0.043), marital status ($\chi2=36.104$, df=4, p=0.001), family size ($\chi2=19.446$, df=4, p=0.006), reported seasonal income ($\chi2=28.793$, df=4, $p<0.001$), and land size owned ($\chi2=15.905$, df=2, $p<0.001$).

Furthermore, the regression model revealed that 72% of the overall relationships between farmers' adoption of radical terraces and their characteristics were significant ($R2=0.720$, $F(14, 177) =32.469$, $p<0.001$). Significantly, the predictor variables of household size, reported seasonal earnings, and extent of land ownership exerted a substantial impact on the adoption of radical terraces by farmers.

Prominent factors that played a role in influencing the adoption of radical terraces by farmers included their age, family size, marital status, the expanse of land under their ownership, and reported seasonal earnings. Notably, age exhibited a considerable and statistically noteworthy association with farmers' inclination to embrace radical terraces. This observation indicated that older farmers, equipped with an enhanced experience, were better positioned to utilize radical terraces to fulfil household food requirements effectively. This finding resonated with Mwangi and Kariuki's (2015) research, revealing that older farmers had more knowledge and experience, allowing them to comprehend technical information than their younger counterparts better. Similarly, Chitere (1980) discovered that younger farmers were less adept at managing crops than their more seasoned counterparts. In contrast, Wairiuko (2018) noted that younger individuals were more receptive and effective in adopting technology. However, in this study, older farmers possessed the requisite land and experience for adopting radical terraces.

Furthermore, educational attainment emerged as a significant influencer of farmers' adoption of radical terraces, with higher adoption rates apparent among respondents with better education. The concurrence with the results reported by Gathaara et al. (2011) implies that the educational level assumed a central role in influencing the adoption of agricultural technologies and innovations. This notion was further substantiated by Wairiuko (2018), asserting that individuals with higher educational levels displayed a greater propensity to adopt novel technologies compared to those with less education. Similarly, Chitere (1980) found that farmers with more years of schooling exhibited better performance and more rapid innovation adoption.

Marital status emerged as another noteworthy factor significantly associated with adopting radical terraces, with married farmers displaying higher adoption rates than other marital status categories. This observation concurred with Sigei's (2014) research, highlighting that individuals with families predominantly undertook small-scale farming. Kariuki (2016) also emphasized the impact of marital status on adoption within CDF projects, indicating that married individuals had a broader range of needs linked to child-rearing. In the present investigation, it was observed that married farmers displayed a greater inclination toward adopting radical terraces. This propensity is likely attributed to

the stability associated with permanent residence, which fosters a cooperative approach within the farming household, distinguishing them from single and widowed farmers.

Furthermore, size of the family was found to exert a significant impact on the extent of the adoption of radical terraces, with larger family sizes exhibiting a positive correlation with the availability of additional labour resources for agricultural activities associated with the adoption of these terraces. This concurrence with the outcomes presented by Mwangi and Kariuki (2015) as well as Muya et al. (2016) demonstrated that farmers from larger households displayed a greater tendency to swiftly embrace novel technologies compared to those from smaller households. Sseguya's (2009) study further lent credence to this observation by highliting that farmers with bigger families exhibited a heightened inclination to adopt innovative technologies aimed at augmenting household food production.

Additionally, the study unveiled that seasonal income significantly impacted the adoption of radical terraces. Farmers possessing higher incomes displayed a heightened inclination to embrace these practices when compared to their lower-income counterparts. This alignment with the conclusions drawn by CIMMYT (1993) underscores the significant role of income in elucidating the adoption of innovative agricultural technology. Wealthier farmers often emerged as early adopters of agricultural innovations, particularly when using purchased farming inputs. In this study, income emerged as a critical determinant of radical terraces adoption, facilitating access to essential agricultural inputs like improved seeds and farm labour while catering to farmers' households' nutritional needs.

Furthermore, the size of land owned by farmers significantly influenced their adoption of radical terraces, with those possessing larger land holdings displaying a greater propensity to adopt novel farming practices. This finding corresponded with the research by Masinde (2009), Kinyangi (2014), and Mwangi and Kariuki (2015), all confirming that farmers with larger land holdings demonstrated an increased likelihood of adopting new farming technologies due to their capacity to allocate portions of land for experimental purposes, a luxury unavailable to those with smaller holdings.

On the contrary, gender, profession, and primary source of income exhibited no significant sway over the adoption of radical terraces, differing from the factors examined earlier. Masinde (2009) identified farmer characteristics like gender, occupation, and income as constraining factors in adoption decisions. Nevertheless, this study found no gender-based disparities in adopting radical terraces for food crop production. Both male and female farmers displayed equal opportunities to assume gender roles in adopting radical terraces for food security. This observation aligned with the findings of Morris and Doss (1999), cited by Mwangi and Kariuki (2015), who noted no significant

link between gender and the adoption of improved maize in Ghana. Similarly, Chitere (1998) documented in his study that gender had no discernible impact on new farming technology adoption.

Similarly, farmers' occupation did not emerge as a significant determinant of adopting radical terraces. Irrespective of their other occupations, all respondents identified as farmers, thus demonstrating equal rates of terrace adoption. Mango et al.'s (2018) research revealed that formal employment and small-scale businesses negatively impacted the adoption of small-scale irrigation farming. Conversely, the present study revealed that farmers' primary occupation, whether they engaged in it full-time or part-time, did not exert any discernible influence on their adoption behaviour.

Ultimately, it was ascertained that the primary source of income did not yield any substantial influence on farmers' adoption behaviour. This diverged from the findings reported in studies by CIMMYT (1993) and Aynalem et al. (2018), which suggested that farmers with a commercial orientation and a higher proportion of their harvest allocated for sale were more inclined to embrace innovative agricultural technologies. However, this study did not observe any significant effect of the primary income source on adoption. Respondents' predominant income source was agricultural activities such as farming and livestock. This concurred with Bolarinwa et al. (2019), whose research on household food security in Rwanda identified household socio-demographic characteristics, assets, income diversification, and household dwelling location as primary determinants of consistent changes in food security.

In regard to the H1 hypothesis, its validation was upheld concerning age, family size, monthly income, and land size. This implies that older farmers, married with larger families, possessed higher seasonal income, and held more extensive land holdings were more disposed to adopt radical terraces than those in different circumstances.

Furthermore, in alignment with Roger (2003), adopting radical terraces was explored within the framework of farmers' participation levels in the terracing process. The temporal dimension of the innovation-decision process impacted farmers' embrace of radical terraces, with certain individuals adopting the practice ahead of others, in accordance with the innovation adoption and diffusion model.

The relationship between farmers' adoption history and their knowledge regarding radical terraces was linked to their age, as a majority of participants had been aware of these terraces for more than 25 years. This aligns with the economic constraints or factors endowment model, which underscores the role of farmer characteristics in shaping the adoption and diffusion of farm innovations (Rogers,

1983). This contextually situates adopting radical terraces as a farming innovation linked to the agricultural landscape's new techniques.

6.1.3 The Disparity Between Farmers' Accessibility to Agricultural Knowledge and their Embrace of Radical Terraces

The third objective of this study was to investigate the impact of farmers' access to agricultural information on their adoption of radical terraces. The hypothesis tested was as follows:

H1: A direct positive correlation can be observed between the accessibility of agricultural information sources by farmers and their propensity to adopt radical terrace farming practices.

HO: No correlation exists between farmers' availability of agricultural information sources and their embrace of radical terraces.

Specific markers of accessibility to agricultural information held substantial sway over adoption, whereas others exhibited negligible impact. The level of farmers' access to agricultural information exhibited a significant association with their adoption of radical terraces ($\chi 2=15.082$, df=4, p=0.005). Furthermore, the regression analysis illuminated 70% of the comprehensive associations between farmers' adoption and their ability to access diverse categories of information sources, with statistical significance ($R2=0.7001$, $F(9, 182) =47.282$, $p<0.001$). Consequently, the predictor variables of access to sources of information demonstrated a positive and significant influence on farmers' adoption of radical terraces.

The smallholder farmers utilized various sources of agricultural information to gather insights about radical terraces, including farm visits by agricultural extension agents, interactions with farm input dealers, consultations with neighbours, and information obtained through the radio. This finding is consistent with the research conducted by Glendenning et al. (2010) and Yaseen et al. (2016) in India and Pakistan, where they identified multiple sources of agricultural information, such as other farmers (6.7%), agricultural input dealers (13.1%), and personal experience (24.0%).

This finding aligns with Odini's (2014) and Siyao (2012) conclusions, who highlighted that farmers sought information to enhance their participation in agricultural productivity. Moreover, previous research has pinpointed different avenues by which farmers access agricultural knowledge tailored to specific objectives. These include mass communication outlets, agricultural extension professionals, digital social networks, traditional narratives, and personal connections (Sokoya et al., 2014).

Similarly, Bachhay (2012) documented that farmers pursued information relating to seed accessibility (74.29%) and strategies for safeguarding crops (70.86%).

In this study, access to farming information played a pivotal role in adopting radical terraces, as it facilitated the transition from traditional, subsistence-based farming to modern, market-oriented agriculture, characterized by incorporating contemporary farming practices and technology.

In the adoption and diffusion model (Rogers, 1983), communication is the process through which participants create and share information to achieve mutual understanding. Communication channels are perceived as mechanisms for relaying messages, transferring information from agricultural extension officers and community leaders to farmers, and facilitating interpersonal exchanges among farmers. The dissemination of radical terraces hinges on the transmission of information through diverse sources, including on-site visits by extension agents, digital platforms, instructional sessions, practical field demonstrations, and agricultural input suppliers.

The study identified several valuable sources of farming information, commonly used for both radical terraces and overall farming in the study area. These sources included farm visits by agricultural extension agents, radio broadcasts, interactions with neighbours, farm shows, farm demonstrations, and consultations with farm input dealers. However, the use of television and farm workshops was comparatively limited due to issues with electricity access and a lack of organizing partners, respectively. Additionally, there were other channels for transmitting farming information to farmers, such as Umuganda (Community work), Inteko z'Abaturage (Citizen outreach program), and Umugoroba w'ababyeyi (Parents' evening forum).

These results are consistent with the principles of farm innovation adoption and diffusion, as well as the information-contagion model (Rogers, 1983). These frameworks are rooted in the premise that individuals are more inclined to embrace an innovation when they have been adequately exposed to informational content about it. Such exposure to relevant information from various sources facilitates farmers' adoption of innovations like radical terraces in the study area (Sonja, 2007).

6.1.4 Farmers' Membership in SHGs Versus Adoption of Radical Terraces

The fourth objective of this study was to assess the impact of farmers' membership in self-help groups on adopting radical terraces. The hypotheses tested were as follows:

H1: Membership in self-help groups positively influences the adoption of radical terraces.

HO: There is no association between membership in self-help groups and adopting radical terraces.

Most of the membership indicators in self-help groups did not significantly influence adoption, except for the years of experience of farmers' membership in self-help groups. The results indicated a significant relationship between membership in self-help groups and adopting radical terraces. Furthermore, the regression analysis accounted for 68.5% of the comprehensive associations between farmers' adoption and their affiliation with self-help groups, exhibiting statistical significance ($R2=0.685$, $F(8, 183) =49.824$, $p<0.001$). The other indicators, such as years of experience of farmers' membership in self-help groups, their leadership positions, and the types of benefits they had derived from SHGs, did not significantly influence their adoption behaviour.

The findings revealed that some membership indicators in self-help groups significantly influenced farmers' adoption of radical terraces. This finding aligns with the work of Sundaram (2012), who emphasized organizing community members and mobilizing resource-poor individuals to address their problems. Sundaram's approach was relevant to food production projects where individuals with limited land resources could contribute their labour force to exploit available land. In the present study, all farmers owned land for cultivating food crops, but there was inequality in the acreage of land among them. This finding contradicted the study by Reddy K. R. & Reddy, C. S. (2012), who argued that wealthy individuals typically owned large land resources and needed to be mobilized in self-help groups to enhance the adoption of farming resources for food security.

This finding is consistent with the work of Sundaram (2012), who emphasized the importance of marginalized individuals coming together in groups to address their problems collectively. Additionally, Reddy K. R. & Reddy, C. S. (2012) found that farmers organized in self-help groups were instrumental in utilizing their labour force to ensure food security through land exploitation.

Furthermore, the findings align with those of Jussi et al. (2009), which highlighted various challenges members of self-help groups face, such as limited government support, low education levels, poor leadership, lack of commitment, transparency, accountability, and limited resources. In this study, self-help groups encountered challenges like ineffective and inadequate leadership, mismanagement of group resources, lack of follow-up, and irresponsibility. Despite these problems, self-help groups were considered a means of savings mobilization in Cambodia, allowing impoverished individuals to pool their savings (ILO, 2006). However, the significance of self-help groups extended beyond economic and financial support, as they also facilitated various social, emotional, and technical benefits for smallholder farmers. These groups actively contributed to food inputs and outputs, which aligns with the findings of Chitere (2018), who observed that the groups engaged in soil conservation, crop production, livestock keeping, and trading activities. In this study,

the membership of self-help groups was inclusive, encompassing both rich and poor individuals, men and women, and individuals of various marital statuses and age groups. This indicated that there was no discrimination within the self-help groups. These findings contradict the findings of Jussi et al. (2009), who discovered gender discrimination towards men in the self-help groups studied in Kenya. In Rwanda, such discrimination could potentially affect the adoption of radical terraces, as equal participation of both genders is vital in the adoption of terraces.

Within self-help groups, farmers realized that adopting radical terraces could help overcome food insecurity and related problems, in addition to the various social, economic, and technical advantages gained from the groups. Although Rogers' adoption and diffusion model does not explicitly address the contribution of self-help groups to the adoption of agricultural innovations, this study found that these groups played a crucial role in farmers' adoption of radical terraces and achieving food security. The terraces served multiple purposes, including water retention, soil erosion control, environmental conservation, and provision of fodder for livestock. They facilitated the transition from traditional farming to modern practices, prompting a shift in rural and traditional mindsets towards improved farming methods.

6.1.5 Farmers' Assistance by Outside Agencies Versus their Adoption of Radical Terraces

The fifth objective of this study involved evaluating the effect of external assistance on farmers' adoption of radical terraces. The hypotheses examined were delineated as follows:

H1: External agency support has a favourable impact on farmers' adoption of radical terraces.

HO: No discernible correlation exists between the adoption of radical terraces by farmers and the external support extended to them by agencies.

None of the external support indicators significantly impacted farmers' adoption of radical terraces. However, the regression analysis proficiently explained 68.1% of the wider connections between the adoption of radical terraces among farmers and the assistance provided by external entities, yielding statistical significance ($R2=0.681$, $F(9, 182) = 43.232$, $p<0.001$). This emphasizes the substantial impact of external support on farmers' embrace of radical terraces. A considerable portion (69.3%) of the farmers had received external support from various agencies, yet only 30.2% had received credit within this external support framework. This observation resonates with Bandeth's (2010) findings in Cambodia, which highlighted similar support obtained by farmer water user communities from governmental and non-governmental entities and local authorities.

However, it is important to note that the external support extended to farmers by these agencies did not solely target the adoption of radical terraces. Consequently, several indicators of external support did not have a noteworthy impact on adoption. A case in point is evident in the report published by ActionAid (2015), which highlighted that even though governmental funds were directed towards the agricultural sector, a substantial proportion of the budget was apportioned to ongoing expenses such as salaries and administrative outlays. This distribution trend, observed in nations like Kenya, Zambia and Uganda, resulted in 23-27% of agricultural budgets being earmarked for remuneration and management, thereby constraining the availability of resources for farmer-focused support initiatives like credit and educational programs.

The constructive impact of external assistance on farmers' adoption of radical terraces corresponds with the findings of Garnevska et al. (2011), who noted that governmental involvement in the adoption of such terraces encompassed services such as cost-free registration, instructional programs, and financial support. This underscores the pivotal role of government-sponsored programs like radical terraces. Additionally, this finding is consistent with the insights drawn from Anandajayasekeram et al.'s (2008) investigation into the Training and Visit (T&V) program, a notable agricultural initiative implemented across East African nations to enhance state extension services for farmers. Beyond training and visits, this program also provided inputs and subsidies, expanding the government's involvement. Musabanganji et al. (2016) similarly unearthed a notable increase in smallholder farmers' input usage, bolstered by subsidies ranging from 15% to 35% for fertilizers and 50% to 80% for higher-quality seeds.

In this study, it was anticipated that external support would bolster local farmers' autonomy in adopting radical terraces. The drive for radical terrace adoption was further propelled by external financial agencies extending credit to 48.4% of respondents, with the remaining 51.6% not benefiting from such support. This trend echoed the findings of Musabanganji et al. (2015), who highlighted farmers' limited access to formal financial services as a hindrance to securing adequate resources for food production activities within the agricultural sector. This scenario mirrored Karplus's (2014) observation of Swaziland's food insecurity stemming from outdated agricultural practices and customs and a dearth of agricultural loans. The contextual background might elucidate the reasons why a substantial number of farmers in this research refrained from seeking financial credit from institutions to bolster their adoption of radical terraces. This lack of alignment among the diverse agencies providing support could contribute. These agencies encompassed governmental bodies (RAB, VUP), NGOs (UNICOOPAGI, HINGA WEZE, World Vision, LWH), PSF (Tubura), and financial institutions (SACCO, BPR). This finding echoes Muthoka's (2010) work, which

emphasized that food security's status is intertwined with the interactions among various individuals and institutions within a social community system.

These observations regarding external agency assistance correspond with Rogers' (2003) depiction of a social structure as an interlinked framework encompassing individuals, groups, and entities that collectively tackle challenges with the aim of attaining mutual goals. Within the radical terraces, diverse stakeholders participated in agricultural and broader development endeavours, including governmental institutions, financial entities, banks, NGOs, the Private Sector Federation (PSF), and farmer cooperatives.

6.1.6 Farmers' Participation Versus Their Adoption and Food Security

The sixth objective of this study was to evaluate the influence of farmers' participation in decision-making on adopting radical terraces.

The hypotheses tested were as follows:

H1: Active participation of farmers markedly impacts their embrace of radical terraces.

HO: Farmers' participation does not significantly influence their adoption of radical terraces.

The findings indicated that participation significantly influenced the adoption of radical terraces. Specifically, farmers' participation was significantly associated with adopting radical terraces ($\chi 2=12.342$, df=4, $p<0.015$). This suggests that farmers' participation in decision-making on radical terraces significantly impacted their adoption rates. In other words, farmers who participated more actively in decision-making regarding radical terraces were more likely to adopt the practice than those with lower participation levels. The regression model accounted for 72.2% of the total associations between farmers' adoption and their engagement, a statistically significant result ($R2=0.722$; $F(9, 182) =52.632$, $p<0.001$). Consequently, farmers' participation played a substantial role in significantly shaping the markers of radical terraces adoption.

It is worth noting that community projects may encounter challenges with sustainability as long as development and transformative organizations continue to implement actions for the community solely. Keen observers often point out that many community-level projects collapse shortly after the donor's handing-over ceremony due to several factors, with low or non-existent community participation in decision-making being considered critical (Mulwa, 2010). Regarding the years of experience in using radical terraces, evidence from the field revealed that some farmers had been

using radical terraces for over 25 years, while others had only 1 to 5 years of experience. This experience was additionally associated with the age demographic of farmers, given that the vast majority of survey participants (70.4%) were adults aged 40 years and above. This indicates that some farmers continued to use radical terraces even after the hand-over ceremonies by organizations like Gatare, Buruhukiro, and Nkomane. In contrast, others did not, as observed in the case of Kibirizi.

As defined by various authors, community participation involves actively engaging local communities in the decision-making process. Without ensuring people's participation, it becomes challenging to identify the problems and desires of the target community (Mamburi, 2014). The current study found that 80.7% of the respondents attended preparatory meetings organized to sensitize them about adopting the radical terraces project. Farmers also learned about adopting radical terraces through radio broadcasts and from fellow farmers. Furthermore, farmers took an active role in the decision-making phase of commencing the radical terraces initiative (77.6%), and this participation had a marked effect on their acceptance of these terraces. The commencement of a project encompasses activity planning, and the dynamic involvement of farmers played a crucial role in perpetuating the effects of the radical terraces initiative. Consequently, farmers played a substantial part in shaping the decision-making procedure surrounding the adoption of the terraces.

The findings indicated a positive and significant relationship between participation and adoption. Levels of involvement were greater among farmers who had progressed in the adoption of radical terraces compared to those who had not yet undertaken such measures. This finding aligned with Abatena's (1995) study in Ethiopia, which demonstrated the effectiveness of bottom-up development involving grassroots communities in the development process. In this study, both top-down and bottom-up approaches were used; the top-down approach initiated the construction of radical terraces as a pilot model, and subsequently, farmers adopted the bottom-up approach to construct their terraces after realizing the benefits and seeking support from the government and other development partners.

The participation indicators included farmers' involvement in decision-making, frequency of attendance at meetings, levels of contribution, and types of contributions. These results substantiated the notion of social participation (Rogers, 2003) as a driver in shaping the adoption and dissemination of farm innovation frameworks. Area farmers actively participated in decision-making, conducting needs assessments, devising action plans, executing programs, mobilizing resources, and overseeing the adoption of radical terraces. These practices were consistent with the

principles of the farm innovation adoption and diffusion model within the context defined by Rogers.

These results were consistent with the findings of Ouma (2016) and Ogunleye-Adetona & Oladeinde (2013), indicating that farmers' ownership of the project drove participation in the implementation of agricultural projects. In this study, farmers contributed to adopting radical terraces through labour, materials, land, cash, and ideas, aligning with Miseda (2014) and Jimu (2008), who found that farmers were willing to adopt modern farming techniques promoted by government extension agents.

The analysis of participation was theoretically based on the Ladder of community participation model, which categorizes eight levels of participation: Manipulation, therapy, informing, consultation, placation, partnership, delegated power, and citizen control (Arnstein, 1969). This study revealed that farmers' participation in adopting radical terraces ranged from low levels (1. Manipulation and 2. Therapy) to self-control of the Degree of Citizen Power (6. Partnership, 7. Delegated power, and 8. Citizen control), with some degree of Tokenism (3. Informing, 4. Consultation, and 5. Placation) as a medium level of participation. The participation of local farmers in adopting radical terraces aligned with this typology of eight rungs on the ladder of citizen participation.

However, some farmers discontinued using radical terraces, rejecting the farming practice after previously adopting it. They assessed the results of the terraces and turned them into grazing fields. Nevertheless, the suitability of the farm innovation adoption and diffusion model with regards to social engagement in the adoption of radical terraces was validated.

6.2 Conclusion

This study was focused on examining the adoption of radical terraces by small-scale farmers and its significant implications for food security within the Nyamagabe District of Rwanda. The study objectives were multifaceted, exploring the extent of radical terrace adoption and its associations with diverse farmer attributes, access to agricultural information, participation in self-help groups, external support, and active involvement in decision-making processes. The findings unveiled the intricate interconnections between these variables and farmers' adoption tendencies, deepening our comprehension of the intricate dynamics shaping embracing radical terraces and its subsequent implications for food security.

Notably, the study uncovered robust and statistically significant linkages between farmers' age, family size, marital status, educational attainment, land ownership extent and reported seasonal income with their adoption of radical terraces. These revelations underscore the pivotal significance of comprehending the nuanced interplay of these farmer-specific traits in moulding their adoption behaviour. By acknowledging the multifarious determinants influencing adoption, policymakers and development practitioners can formulate customized interventions and support mechanisms tailored to individual farmers' distinct needs and circumstances. This approach fosters an environment conducive to widespread adoption among smallholder farmers.

Furthermore, access to agricultural information emerged as a crucial determinant of radical terraces adoption, with sources like farm visits, radio, and peer learning proving pivotal in fostering adoption behaviours. The significant impact of information sources on adoption underscores the need for targeted and comprehensive educational programs that leverage these channels to disseminate knowledge effectively. By harnessing the power of these information sources and tailoring educational initiatives to address smallholder farmers' specific challenges and needs, policymakers and agricultural extension services can play a transformative role in promoting the broader adoption of innovative farming practices such as radical terraces. These initiatives have the potential to empower farmers with the necessary knowledge and skills to implement sustainable and productivity-enhancing practices, thereby strengthening food security and rural livelihoods in the study area and beyond.

The influence of self-help groups on adoption behaviour was evident, as farmers with more years of experience within these groups demonstrated heightened rates of embracing radical terraces. This discovery underscores the potential of social networks and collective endeavours in propelling agricultural innovations forward. It also underscores the imperative for all-encompassing and resilient support structures that empower farmers to coalesce into such groups. By cultivating an environment that nurtures collaboration and knowledge exchange among farmers, these self-help groups can function as potent platforms for disseminating information, furnishing reciprocal assistance, and expediting the adoption of novel technologies and methodologies.

In this context, policymakers and development organizations ought to acknowledge the importance of these community-rooted networks and allocate resources toward initiatives that fortify and broaden their influence. This strategic approach will further expedite the integration of sustainable farming practices, ultimately bolstering food security and rural advancement within the research locale and beyond.

External support from governmental and non-governmental agencies also played a pivotal role in influencing farmers' adoption decisions. However, the effectiveness of these interventions could be further enhanced through better coordination and alignment with farmers' specific needs and requirements. Strengthening collaboration between these agencies and local farming communities would allow for the design of targeted programs that address smallholder farmers' unique challenges in adopting radical terraces. Moreover, a participatory approach involving farmers in planning and implementing support initiatives can foster a sense of ownership and agency, leading to more successful adoption outcomes. By tailoring external support to match the context and capacities of the local farming communities, interventions can become more impactful and sustainable, ensuring that farmers are equipped with the necessary resources and knowledge to fully embrace innovative farming practices like radical terraces, thereby contributing to improved food security and livelihoods in the region.

Arguably the most notable finding of this study is the affirmative connection observed between the engaged involvement of farmers in decision-making procedures and the adoption of radical terraces. This points to the importance of fostering participatory approaches in agricultural development initiatives, wherein farmers' voices and perspectives are valued, empowering them to take ownership of innovative practices that directly impact their food security. Engaging farmers as co-creators and partners in the adoption process can lead to a deeper understanding of their unique needs, preferences, and challenges, thereby enabling the development of context-specific and farmer-cantered solutions. By actively involving farmers in the planning, implementing, and monitoring agricultural interventions, we can build a sense of agency and collective responsibility, creating a more conducive environment for the widespread adoption of radical terraces and other beneficial farming innovations. Moreover, the adoption and diffusion of farm innovation models, especially those emphasizing social participation, can serve as a guiding framework for promoting sustainable and inclusive agricultural development, where the success of transformative practices like radical terraces is intrinsically tied to the active engagement and commitment of the farming community.

The research highlighted the capacity for radical terraces to bring about transformation, amplifying the level of food security for small-scale farmers within the Nyamagabe District. The adoption and diffusion model, alongside the information-contagion and economic constraints models, provided a robust theoretical framework to understand and contextualize the dynamics of technology adoption in the agricultural landscape. These models validated the findings on factors influencing adoption behaviour and emphasized the importance of considering socio-economic and cultural dimensions

when designing interventions to promote sustainable agricultural practices. Moreover, the positive outcomes observed in this study underscore the need for policymakers, development agencies, and extension services to prioritize targeted support mechanisms that address farmers' specific challenges. By strategically aligning interventions with the diverse characteristics of farmers, such as age, education level, and access to information, we can create an enabling environment for the widespread and successful adoption of radical terraces, ultimately contributing to enhanced food security and rural livelihoods in the region.

Moving forward, policymakers, development practitioners, and local stakeholders must collaborate to design context-specific strategies that leverage the study's findings to promote sustainable adoption of radical terraces. By recognizing the interconnectedness of farmer characteristics, access to information, social networks, external support, and participation, transformative and inclusive interventions can be crafted to bolster food security and improve the livelihoods of smallholder farmers in Rwanda and beyond. This calls for a holistic approach that addresses the technical aspects of adopting radical terraces and the social and economic dimensions that influence farmers' decision-making processes. Stakeholders must actively engage with farmers to co-create solutions, tailoring support mechanisms to suit different farmer groups' specific needs and aspirations. A ripple effect can be generated by fostering farmer ownership and agency, coupled with targeted capacity-building initiatives, leading to the widespread and sustained adoption of innovative agricultural practices. As we look to the future, this study's insights provide a solid foundation for guiding evidence-based policies and development programs that foster agricultural sustainability and food security, contributing to the overall prosperity of rural communities in Rwanda and similar agrarian contexts worldwide.

6.3 Recommendations

6.3.1 Policy Recommendations

Farmers' Embrace of Terracing and Ensuring Food Security: Farmers' adoption of radical terraces yielded elevated agricultural yields and heightened output from livestock, thereby contributing to enhanced food security. Nevertheless, a subset of farmers had transformed their terraced lands into grazing grounds or afforestation areas, subsequently detrimentally impacting their food security situation. To tackle this concern, it is crucial for both the local and national governments of Rwanda, in conjunction with development collaborators, to persist in raising awareness among farmers about the significance of embracing and upholding radical terraces. Educational tours of well-maintained terraces could help farmers understand their significance and

construct them appropriately. Additionally, follow-up and encouragement for those using terraces for livestock grazing or tree planting to convert them back to food crop production are essential. Mobilising owners of unexploited terraces and promoting leasing to willing farmers or agricultural cooperatives can also optimize terrace utilization.

Farmers' Access to Agricultural Information: Farmers with better education and exposure to extension information demonstrated higher adoption rates of radical terraces. Strengthening information to farmers through workshops, farm demonstrations, and field visits by extension staff is crucial. Rwanda's local and national governments and development partners should invest in these information-sharing mechanisms to empower farmers and facilitate technology adoption.

Farmers' membership in SHGs: The study highlighted that farmers with longer membership tenure, especially those in leadership positions and benefiting more from SHGs, participated more in decision-making on radical terraces. Encouraging farmers to engage in SHGs can enhance their social and economic capacities, enabling better use of radical terraces. These groups possess the potential to foster partnerships with financial institutions, including banks and microfinance organizations, thereby enabling convenient access to agricultural credit. This collaboration, underpinned by effective leadership, can further enhance the efficient utilization of radical terraces.

External Support for Farmers: Numerous full-time agricultural practitioners encountered obstacles from insufficient seasonal income, impeding their capacity to invest in their agricultural endeavours. It is imperative that both local and national governmental bodies, along with developmental collaborators, including non-governmental organizations (NGOs), extend assistance in the form of low-interest credit. This measure will empower farmers to channel investments into their agricultural operations, augmenting production with economic viability. Providing timely access to novel strains of improved seeds, particularly tailored to crops such as Irish potatoes and wheat, is pivotal in elevating the agricultural output and the optimal utilization of radical terracing.

The Role of Participatory Decision-Making in Radical Terraces Adoption: This study emphasized a significant connection between farmers' involvement in decision-making procedures and their acceptance of radical terraces. Consequently, this wielded influence over their food security status. To foster the acceptance of radical terraces and bolster agricultural production and security, the local and national administrations of Rwanda and collaborative developmental entities must facilitate robust farmer involvement in decision-making procedures associated with radical terraces. A constructive effect on food security can be realised by bestowing farmers with the authority to influence the adoption of innovative methodologies.

6.4 Future Research

This study has primarily investigated the participation of smallholder farmers in adopting radical terraces for food production. However, there remains a need for a comparative study to examine the food security outcomes between adopters and non-adopters of radical terraces in the study area. Additionally, further research is warranted to explore the contribution of radical terraces to environmental conservation within the district and across other districts in Rwanda. In conclusion, an examination of the suitability of the technology characteristics-user's context model in the context of adopting radical terraces in Rwanda would yield valuable insights into the determinants that shape the adoption procedure. This, in turn, would offer informative guidance for future initiatives and policy implementations.

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Appendix 1: Interview Schedule for Farmers

Section A: Consent Form

Dear respondents,

I am Emmanuel Murwanashyaka, a doctoral student in the Faculty of Arts, Department of Sociology and Social Work at the University of Nairobi. I am conducting research for my final thesis titled: "Smallholder Farmers' Adoption of Radical Terraces and Their Effects on Food Production and Security in Nyamagabe District, Rwanda." The primary objective of this study is to explore people's participation in food production projects and their relevance in the context of community participation in Nyamagabe district.

First and foremost, I would like to express my gratitude to all participants who have agreed to take part in this study. Your voluntary participation is highly appreciated, and you are free to withdraw at any time without providing a reason. The estimated time for your participation will be approximately 30-35 minutes. Please rest assured that all personal data collected during the study will be kept confidential and will only be accessed by the study author and data collectors. However, a list of study participants will be made publicly available. Research questionnaires and records will be securely stored for as long as they remain valuable to the researcher and the wider research community, with a minimum retention period of 2 years after publication.

If you have any concerns or questions about any aspect of this research, please do not hesitate to contact me, Emmanuel Murwanashyaka, at (+250)788 416 349. Your input and participation are vital in advancing our understanding of smallholder farmers' adoption of radical terraces and its impact on food production and security in Nyamagabe District, Rwanda. Thank you for your valuable contribution to this study.

Name of farmer----------

Sector----------Mobile Phone----------

SECTION B: RESEARCH QUESTIONNAIRE

1. **Personal characteristics of the farmers**

1.1. Age of respondent …….

Below 29……..…1

30 - 39…….…….2

40 - 49…….…….3

50 – 59……4

Above 60……...…...5

1.2. Gender: Male ……..…. Female….…….

1.3. Level of education

None ……1

Primary…….……2

TVT/CERAI...…….……3

Secondary …….……4

Tertiary/University.…….……....5

1.4. Marital status

Single ….…… Married ……Widowed ……Divorced……. …..

1.5. Number of children: None……. 1 – 2 …... 3 – 4 …… above 5..…
Number of other dependents …….
1.6. Occupation: Farmer / Housewife ……...….
Formal employment ……....
Self-employed (e.g., Business) ……. …..
Casual / seasonal employment …….
Other (specify) …….
1.7. Main source of income: ……..……
1.8. Estimate income per month / season / year / ……
Other (specify) ……..…
1.9. Land ownership: Do you have arable land? Yes or **No**
Land size owned farmer's household is between:
Less than more than 0.4 ha ……...……1
0.5 – 0.9 ha ……...2
1.0 – 1.4 ha ……...3
1.5 – 1.9 ha ...……4
Above 2 ha …….……...5

2. Adoption and diffusion of radical terraces

A: Adoption of radical terraces

2.1 Which year did you become aware of radical terraces? **……..**
From which source: a) Agricultural agents b) Neighbours c) Others (specify) ……
2.2. Which year did you start constructing your radical terraces? ……..……
What are now many meters have you constructed? ……
What type of terraces have you constructed? ……..
Which agencies have been supported you to constructing the terraces? ……
2.3. Why are terraces important in your farming activities?.....…….……
……
……
2.4 Would you say your production has improved following your adoption of radical terraces?
Yes, somewhat **Yes**, much improvement.
If **no** improvement, why? ……
……
……..……
In which way have you maintained your terraces? ……
……
2.5. Would you say your terraces are: a) Very good b) Good c) Poor d) very poor?
If they are not very good / good, why? …….……
……
2.6 What were the challenges did you face in adopting radical terraces for producing food?
……...…
……...……
2.7 What are the main strategies would you propose to sustain the exploitation of radical terraces for food production and security in Nyamagabe district? …….……
……...……
……...……

2.8 Which are your three important food crops? (By using the table below, rank them)

a) …….. b) …… c) ……...

B. Farmer's important food crops planted during last long rains season.

2.9. From your three important food crops planted last long rains (annually) specify

Type of crop planted	Acreage	Seedbed clear		Type of seed		Chemical Fertilizers used		Farm Yield Manure used		Weeding		Yield obtained (bags)/kgs
		Traditional	Modern	Hybrid	Local	Yes	No	Yes	No	Clean	Not clean	
a)												
b)												
c)												

2.10. Was the yield you obtained enough to take your household to the next harvest? **Yes,** or **No**

If **No**, for how many months did it the harvest last?

a) Less than 3 months (food insecure)
b) 4 – 6 months (somewhat secure)
c) 7 – 9 months (secure)
d) Above 10 months (very secure)

2.11. If the harvest did not last to the next harvest, how did your household obtain the food?

a) Buying b) Gift from neighbours c) Food aid from agencies d) others (specify)……..…

Did you plant the food crop in terraced areas?

2.12. Would you say radical terraces improved your crop production? Yes, **or** No?

If **No**, why? ……..……..…

…….……

……..…

2.13. At which level of the adoption of radical terraces influence food access in your household? a) Highly access b) High access c) Middle access d) Low access e) Lower access

2.14. Which are your three important livestock you keep? (By using the table below, rank them)

a) …….. b) …… c) …….

C. Farmer's livestock keeping

	Number		Yield			Sales/year
	Local	Improved	Milk (L)	Eggs (N)	Meat (Kgs)	Rwfs
a)						
b)						
c)						

Have you planted fodder for your livestock? **Yes**------- **No**------

If **yes**, which type? ---------- What acreage ----------

2.15. Was the milk/eggs/meat you obtained from livestock enough to meet your household food production and security? **Yes,** or **No?**

If **yes**, was the milk/eggs/meat:

1. Very Adequate b) Adequate c) Somewhat adequate d) inadequate

2.16. If your milk/eggs/meat production was very adequate and adequate, did you have surplus? **Yes,** or **No?**

How did you dispose the surplus?

……...……

……..

If somewhat adequate or inadequate, how did you meet your household requirements?

a) Buying b) Gift from neighbours c) Food aid) Others (specify)…..…….

2.17. Would you say radical terraces improved your livestock production? **Yes, or no?**

If **yes**, in which ways? **……**……

……

If **No,** why? ……..……

……

2.18. In which way have your livestock affected your terraces?

…….……...……

……

2.19. Indicate how You utilize household crop production:

a) Household consumption b) Consumption and exchange c) Consumption and selling d) Consumption and stock

2.20. How many times do you take meals per day? 1 …… 2 …… 3 ……

How many times did you take the meals per day before you had constructed radical terraces? 1……..... 2…….……. 3……. …..…

3. Farmer participation (in decision making of radical terraces projects)

3.1. To what extent are you involved in community decision making process for participating in food production project of radical terraces?

Involvement in decisions	Fully involved	Involved	Rarely Involved	Not Involved
Initiating				
Planning				
Implementing				
Monitoring & Evaluation				

3.2. Did you attend the meeting in which radical terracing was discussed? **Yes,** or **No?**

- If **yes,** how many? ……..……
- If **no** organized the meeting, why? …….

3.3. As farmers, which level did you contribute to decision making process of the adoption of radical terraces?

Level of contribution / **Decision making process**	High	Medium	Low	Indifference
Information				
Consultation				
Deciding together				
Acting together				

Supporting each other's interest				
None				

If **None**, why? ……..……
……

3.4. Did you contribute to the exploitation of radical terraces? **Yes,** or **No?**

3.5. At which level did you contribute to the exploitation of radical terraces?

a) High level b) Middle level c) Low level

If **yes,** what is your contribution for adopting radical terraces? And how it comes?

	Voluntary	Required	Negotiated	Indifferent
Labor				
Material				
Land				
Cash				
Ideas				

3.6. As a farmer, what is the level of your participation in the adoption of radical terraces for producing food?

a) Highly adopted b) High adoption c) middle adoption d) low adoption

3.7. What are the factors affecting your willingness to participate in the adoption of radical terracing for producing food? ----------

---

3.8. What are the challenges being you faced in adopting radical terraces for food production and security? …….....……
……

3.9. What could you suggest as solutions that can be adopted to overcome those challenges?
……
……

4. Membership in self-help groups

4.1. Are you a member of a self-help group? Yes, or No?

4.2. If **yes,** what is the name of the group …….……..……

4.3. Which year did you join it? ……..…….……

4.4. What are its objectives?

…….....……...
……

4.5. What are its activities? .....……
……

4.6. In which ways does the group assist you in faring and in radical terraces?

.....

4.7. Have you held a leadership position in the group? **Yes,** or **No?**

4.8. If **yes**, which one? ……

4.9. What were your responsibilities as a leader?
……
……

4.10. If you have not been a leader in the group, why? ….……..…….

……
4.11. In which way has the group benefitted you in your radical terracing?
…..……..……
……
4.12. Have you benefitted from your group? **Yes,** or **No?**
4.13. If you have benefitted, in which of the following ways?

Benefits	**Yes**	**No**
a) Joint responsibility		
b) Group support		
c)Mutual help		
d) Shared consciousness		
e) Members professional control		

4.14. What challenges did you face in self-help groups in exploiting radical terraces for producing food and ensuring food security? ----------

5. Access to agricultural information

5.1. From which sources do you get information about farming and radical terraces?

Source of information/	**Radical terraces**		**Overall farming**	
	Yes	No	Yes	No
1. Farm visits by agricultural extension agents				
2. Farmer visit to extension offices				
3. Farm demonstrations				
4. Field trips				
5. Radio				
6. TV				
7. Neighbours				
8. Farm shows				
9. Education trips				
10. Farm workshops / seminars				
11. Visitors				
12. Farm inputs dealers				
13. Others (specify)…….				

5.2. A. What is the level of getting agricultural information about radical terraces?
a) Below 3 low b) 4-6 Average c) 7-9 High d) Above 10 Very High

B. What is the level of getting agricultural information about Overall farming?
a) Below 3 low b) 4-6 Average c) 7-9 High d) Above 10 Very High

5.3. Which of these sources has been beneficial to your radical terraces?
……
In which way?.....…….

5.4. What types of agricultural information do you get from these sources for exploiting radical terraces?.....
……..
5.5. What are the challenges being you faced in accessing agricultural information for adoption radical terraces in producing food? ……..……
……..…….…….
5.6. Suggest solutions that can be adopted to overcome those challenges for producing and ensuring food security. ……..……..……
……..……..……..…

6. Outside support

6.1. As a farmer, have you been supported by outside agencies? **Yes,** or **no?**
If **yes**, was the support in the form of credit? **Yes,** or **no?**
If **yes**, indicate type of support.

Year	Amount of credit	Agency	Purpose

6.2. Did you use some of the credit to improve radical terraces? **Yes,** or **no?**
Yes, used in radical terraces.
Not used in radical terraces
If **yes,** what improvement did you realize?
……..……..……
……..……
If **NO,** why? ……
……..
6.3. What other support have you received from development agencies?
a) Equipment b) Education c) Others (specify) ……

6.4 Which one among those development agencies have been supported you?
a) Government b) NGO c) Humanitarian agency d) PSF (Private Sector Federation)

6.5. What were the challenges related to external supports in adopting radical terraces for producing food and ensuring food security did you face? ……..……
……..
6.6. Suggest how you could overcome those challenges in order to ensure food security.
……
……
Thank you!

Appendix 2: Interview Guide for Leaders and Stakeholders in Food Production Projects

Section A: Consent form

Dear respondents,

I am Emmanuel MURWANASHYAKA, a Doctor of Philosophy Degree in Sociology student in the Faculty of Arts, Department of Sociology and Social Work at the University of Nairobi. Currently, I am conducting research for my final thesis entitled: "Smallholder Farmers' Adoption of Radical Terraces and Their Effects on Food Production and Security in Nyamagabe District, Rwanda." The primary objective of this study is to explore people's participation in food production projects and its relevance in the context of community participation in Nyamagabe district.

First and foremost, I extend my heartfelt gratitude to all participants who have graciously agreed to take part in this study. Your participation is entirely voluntary, and you are free to withdraw at any time without providing a reason. The anticipated time for participation will be approximately 30-35 minutes. Rest assured that all personal data collected during the study will be treated as confidential and will only be accessible to the study author and data collectors. However, a list of study participants will be made publicly available. Research questionnaires and records will be securely stored for as long as they remain valuable to the researcher and the broader research community, with a minimum retention period of 2 years after publication.

If you have any concerns or questions about any aspect of this research, please do not hesitate to contact me, Emmanuel Murwanashyaka, at (+250)788 416 349. Your participation in this study is crucial in advancing our understanding of smallholder farmers' adoption of radical terraces and its impact on food production and security in Nyamagabe District, Rwanda. Thank you for your valuable contribution to this research endeavour.

Section B: Identification of key informant

Date of Interview: ……..…

Key informant designation (Mayor of the district, District Vice Mayor in charge of economic development, district Agronomist, district planner; Representative of Rwanda Agricultural Board in Nyamagabe; NGOs representatives; Sector Agronomists; Farmer field school of cells; and Agricultural cooperative representatives**: ……..…….**

Organization / Department: ...……...…….

District level ……...……

Sector level: ……

Position / Category: ……..…….

Themes of interview: <u>As a leader comment on the following themes:</u>

Characteristics of farmers

……

……

……

……

Smallholder farmer's participation in adopting radical terraces.

……
……
……
……

Membership in self-help group and adoption of radical terraces

……
……
……
……

Access to agricultural information and adoption of radical terraces

……
……
……
……

Outside support and exploitation of radical terraces

……
……
……
……

Adoption and diffusion of radical terraces for producing food.

……
……
……
……

Recommendations

What do you recommend for better adoption and diffusion of radical terraces for?

a) **Producing food in Nyamagabe District?**

……
……
……
……

b) **Ensuring food security in Nyamagabe District?**

……
……
……
……

Thank you!!!!

Appendix 3: Observation on Terraces and Food Production Check List

Date of observation: ……...
Sector: …….
Cell: …….
Village: ……
Village's number of household: ……

No	Observed parameters	Indicators	YES, if present (Tick in the box)	NO if absent (Tick in the box)
2	**Types of construction material used for the majority of the cuts of radical terraces**	Trees		
		Stone walls		
		Cut land		
		Picks		
		Shovels		
3	**The exploitation of radical terraces**	Rationally exploited		
		Partially exploited		
		Abandoned		
		Planted trees		
		Turned into grazing		
4	**Types of crops planted in or harvested**	Maize		
		Beans		
		Wheat		
		Banana		
		Irish potatoes		
		Potatoes		
5	**Level of Maintenance**	Carefully maintained		
		Middle maintenance		
		Less maintained		
		Not maintained		
		Destroyed		
		Deplorable state		
6	**Level of water retention**	High		
		Medium		
		Low		
7	**Level of soil erosion control**	High		
		Medium		
		Low		
8	**Land use activities**	Crop farming		
		Livestock keeping		
		Mining		
		Quarrying		

		Vegetation		
		Others (specify)		
9	**Food storage**	Individual store		
		Household store		
		Community store		
		Market supply		

Appendix Table 4: Scoring Membership in Self-Help Groups (SHGs)

Variable	**Categories**	**Scoring**
Being a member of a SHGs	No	0.0
	Yes	3.0
a. Years of experience of farmer's membership in SHGs	None	0.0
	< 1 year	1.0
	1-5 years	1.5
	6-10 years	2.0
	>=11 years	3.0
b. Assistance of SHGs in farming	None	0.0
	Helping each other	1.5
	Find loans	2.0
	Improvement of farmer's capacity	3.0
Having a leadership position in SHGs	No	0.0
	Yes	3.0
c. Farmer's leadership position in SHGs	None	0.0
	President	3.0
	Vice-president	2.0
	Secretary	2.0
	Accountant	2.5
d. Types of benefits of farmers from SHGs	None	0.0
	Mutual help and aid	3.0
	Group support	2.5
	Shared consciousness	1.5
Total scores		**36.5**

Source: Developed by Author

Appendix Table 5: Scoring of Access to agricultural information.

Variable	Categories	Scoring
Sources of agriculture information about overall farming	Visits	1.0
	Social media and seminar	2.0
	Farm demonstration	3.0
	Farm inputs dealers	1.5
Sources of agriculture information about radical terraces	Visits	1.0
	Social media and seminar	2.0
	Farm demonstration	3.0
	Farm inputs dealers	1.5
c. Levels of getting agricultural information about overall farming	Low access	1.0
	Medium access	2.0
	High access	3.0
d. Levels of getting agricultural information about radical terraces	Low access	1.0
	Medium access	2.0
	High access	3.0
e. Benefits gained from various sources of information	Being self-reliant farmer	2.0
	Modern farming techniques	3.0
	Sharing experience with others	2.5
	Solidarity of farmers	1.5
Overall access to agricultural information	Low access	1.0
	Medium access	2.0
	High access	3.0
Total scores		**42.0**

Source: Developed by Author

Appendix Table 6: Scoring of outside support by food security.

Variable	Categories	Scoring
The support was in the form of credit	No	0.0
	Yes	3.0
Year of receiving support	None	0.0
	Before 2005	3.0
	2006-2010	2.5
	2011-2015	2.0
	2016-2019	1.5
c. Amount of financial support /credit	None	0.0
	<=400,000	1.5
	400,001 - 1,000, 000	2.5
	1,000,001+	3.0
a. Types of agencies providing support	None	0.0
	B.P. R	1.5
	RAB	3.0
	SACCO	1.5
	TUBURA	2.5
	V.U. P	2.0
	Vision finance	1.0
Farmers use some of the credit to improve radical terraces	No	0.0
	Yes	3.0
d. Farmers use of the support/credit in	None	0.0
	Terraces	3.0
	Crops	3.0
	Livestock	3.0
	Others	2.0
Famer were supported by outside agencies	No	0.0
	Yes	3.0
Development agencies provided other support	Government	3.0
	NGO	2.5
	PSF	2.0
Total scores		**55.0**

Source: Developed by Author

Appendix Table 7: Scoring for Farmer's participation in decision making process.

Variable	Categories	Scoring
a. Farmer's involvement in decision making	Low (Rare involved)	1.0
	Medium (Involved)	2.0
	High (Full involved)	3.0
b. Farmer's frequencies of meetings attended	Low (1-4)	1.0
	Medium (5-9)	2.0
	High (>10)	3.0
c. Levels of farmer's contributions	Low	1.0
	Medium	2.0
	High	3.0
d. Types of contribution	Low (Negotiated)	1.0
	Medium (Required)	2.0
	High (Voluntary)	3.0
Total scores		**24.0**

Source: Developed by Author

Appendix Table 8: Scoring for Adoption and use of radical terraces.

Variable	Categories	Scoring
a. Years of experiences in constructing radical terraces (Binned)	< 5	1.0
	5 - 14	1.5
	15 - 24	2.5
	25 - 38	3.0
b. square meters of radical terraces constructed	1-99 Ares	1.0
	100-299 Ares	2.0
	>=300 Ares	3.0
c. Levels of maintenance of radical terraces	Low	1.0
	Medium	2.0
	High	3.0
Contributions to the exploitation of radical terraces	Yes	3.0
	No	0.0
f. Use of fodder	Yes	3.0
	No	0.0
e. Plantation of fodder in radical terraces	Napier grass	3.0
	Caliandra	3.0
	Setaria	3.0
d. Plantation of fodder in radical terraces	1-99 Ares	1.0
	100-299Ares	2.0
	>=300	3.0
Total scores		**41.0**

Source: Developed by Author

Appendix Table 9: Scoring for Adoption of crop farming / Food production.

Variable	Categories	Scoring
Planted food crops	Beans	3.0
	Irish potatoes	3.0
	Maize	3.0
	Wheat	3.0
Acreage of crop production (Binned)	<=100.00	1.0
	100.01 - 1413.33	1.5
	1413.34 - 2726.67	2.0
	2726.68+	3.0
g. Yield of crop production (in KG) (Binned)	80-200	1.0
	201 - 400	2.5
	401+	3.0
b. Seedbed clear	Traditional	3.0
	Modern	3.0
c. Type of seeds planted	Hybrid	3.0
	Local	3.0
d. Chemical fertilizers used	No	0.0
	Yes	3.0
e. Farm yield manure used	No	0.0
	Yes	1.0
f. clean weeding	Not clean	0.0
	Clean	3.0
Improved production	Low	1.0
	Medium	2.0
	High	3.0
Total score		**51.0**

Source: Developed by Author

Appendix Table 10: Scoring radical terraces Adoption for livestock.

Variable	Categories	Scoring
Important livestock kept by Household	None	0.0
	Cows	3.0
	Goats	3.0
	Pigs	3.0
a. Number of Livestock keeping local	0	0.0
	1-5	1.5
	6 - 10	2.5
	11+	3.0
a. Number of Livestock keeping improved	0	0.0
	1-5	1.5
	6 - 10	2.5
	11+	3.0
c. Yield of milk production	None	0.0
	1-10L	1.5
	11-20L	2.5
	>=21	3.0
d. Sales of farmer's livestock per year	< 100000	1.0
	100000 - 549999	1.5
	550000 - 999999	2.5
	1000000+	3.0
Total scores		**38.0**

Source: Developed by Author

Appendix Table 11: Scoring Food security

Variable	Categories	Scoring
a. Household's yield obtained for the next harvest	Yes	3.0
	No	0.0
b. Number of months of harvest lasting	None	0.0
	Less than 3 months	1.0
	4-9 months	2.0
	>=10 months	3.0
c. Selling the Surplus of milk	Yes	3.0
	No	0.0
e. Meal taken per day after the adoption of radical terraces	Once	1.0
	Twice	2.0
	3 times	3.0
Total scores		**18.0**

Source: Developed by Author

Appendix 12: Official letters

UNIVERSITY OF NAIROBI

DEPARTMENT OF SOCIOLOGY & SOCIAL WORK

Fax 254-2-245566
Telex 22095
Varsity Nairobi Kenya
Tel. 318262/5 Ext. 28167

P.O. Box 30197, Nairobi
Kenya
Email: dept-sociology@uonbi.ac.ke

May 10, 2019

TO WHOM IT MAY CONCERN

RE: EMMANUEL MURWANASHYAKA – C80/51623/2017

Through this letter, I wish to confirm that the above named is a bonafide Doctor of Philosophy student at the Department of Sociology & Social Work, University of Nairobi. He has presented his project proposal entitled; "**Radical Terraces: Its Effects of Food Production & Security in Nyamagabe District, Rwanda.**"

Emmanuel is required to collect data pertaining to the research problem from the selected organization to enable him complete his thesis which is a requirement of the PhD.

Kindly give him any assistance he may need.

Thank you.

Prof. C.B.K. Nzioka
Chairman, Department of Sociology & Social Work

Nyamagabe District
Gasaka Sector
Ngiryi Cell
Munyege Village
Phone: +250788416349
E-mail: emmamurwa@gmail.com

NYAMAGABE DISTRICT
RECEIVED BY
DATE 14.05.2019
SIGNATURE

Date: 10th May, 2019

To the Mayor of Nyamagabe District,
Southern Province,
Rwanda

RE: Request for permission of data collection on radical terraces

Dear Sir,

My name is Emmanuel MURWANASHYAKA, Assistant Lecturer at the University of Rwanda, Department of Social Sciences, Huye Campus. I am also a Doctor of Philosophy student at the Department of Sociology and Social Work, University of Nairobi, Kenya; and I would like to request for permission of collecting data on radical terraces in Nyamagabe District. The research project is entitled: **"Radical terraces": Its Effects on Food Production and Security in Nyamagabe District, Rwanda."** The Purpose of this study is to explore people's participation in food production and its relevance in the adoption of radical terraces in this district.

The significance of undertaking this study consists of contributing to the success of exploiting radical terraces for food security. Information collected through this research will benefit other researchers interested in carrying out similar research by providing them insights about radical terraces. The study will also look for lessons that policy-makers, developmental actors, local leaders and developmental projects reformers could draw. By analyzing the underlying causes and effects of the exploitation of radical terraces in Rwanda, this study will provide guidance to leaders, decision makers and planners in tackling food insecurity. The constraints, strategies and recommendations emerging from this study should be the basis for lessons drawing. You will also find To Whom It May Concern, The student card and, The table of sampled sectors enclosed to this letter.

I look forward to receiving a favorable reply.

Yours faithfully,

Emmanuel MURWANASHYAKA

REPUBLIC OF RWANDA

SOUTHERN PROVINCE

NYAMAGABE DISTRICT

Website: www.nyamagabe.gov.rw
E-mail: info@nyamagabe.gov.rw

Nyamagabe, on 22.../..05.../2019
No..1919...../07/02/05

Emmanuel MURWANASHYAKA
Gasaka Sector
+250788416349
NYAMAGABE

RE: Accepting your request

Dear Sir,

Reference is made to your letter received on 14 May 2019 requesting for permission of conducting the academic research by collecting data on radical terraces in Nyamagabe District specifically in Nkomane, Gatare, Kibilizi and Buruhukiro Sector with the research project entitled **"Radical terraces: Its Effects on Food Production and Security in Nyamagabe District, Rwanda";**

Nyamagabe District hereby certifies that your request of conducting forementioned research is acceptable.

Sincerely,

UWAMAHORO Bonaventure
Mayor of Nyamagabe District