ASSESSING ADOPTION AND ECONOMIC IMPACTS OF NEW BANANA VARIETIES ON LIVELIHOODS OF FARMERS IN KAGERA REGION, TANZANIA

BY

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ABSTRACT

In Kagera banana-based farming systems the introduction of new banana varieties has increasingly been one of the strategies to revive the declining banana production caused by increasing pests' infestations and low soil fertility. This study was conducted to assess adoption and socio-economic impacts of the new banana varieties on farmers' livelihoods in the region. The specific objectives of the study were: (i) to identify factors that influence farmers' adoption (demand) of new banana varieties among farming communities in Kagera region; (ii) to identify the intermediate and long-term impacts of new banana varieties on farmers' livelihoods across different agro-ecological zones and farmer characteristics; and (iii) to measure the accrued benefits of new banana varieties on farmers' livelihoods. Data for the study were collected using Participatory Rural Appraisal (PRA) and household survey from a total of 260 households randomly selected from 13 villages found in three agro-ecological zones: Bukoban Systems, Karagwe Ankolean low rainfall and Karagwe Ankolean high rainfall zones. The data were analysed using descriptive statistics, Logit and Tobit regressions, and Instrumental Variable (IV) methods. About 28.46% of surveyed households were adopters of the 25 new banana varieties introduced into Kagera region since 1997. Yangambi km5, SH3436-9, FHIA 17 and FHIA 23 were the most preferred varieties adopted by farmers. Adoption of new varieties varied by agro-ecological zone, household and farm characteristics. Empirical findings revealed that age, agro-ecological zone, banana field quality, cultivated land size, house type, household-asset value, number of mats of endemic cultivars and livestock ownership significantly influenced the adoption of new banana varieties. Adoption of the new varieties significantly reduced banana production losses from infestation of pests and diseases by 5%. Other impacts of the new varieties were on improved food security, increased banana income, improved quality of banana juices and brews, improved social relationships and improved banana biodiversity. Further monitoring and evaluation of the new varieties on farmers' fields is recommended, and this should go hand-in-hand with other banana management programmes. Also, banana marketing studies are recommended to investigate the banana attributes considered by farmers versus attributes considered by processors, traders and consumers.

DECLARATION

I, **Jackson Madulu Nkuba**, hereby declare to the Senate of Sokoine University of Agriculture that this thesis is my own original work, and that it has not been submitted for a higher degree award in any other university

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17/07/2007
Date

The above declaration is confirmed

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18/07/2007
Date

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DEDICATION

To my wife, Esther and daughters; Grace, Gloria, Flora and Faith

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ABBREVIATIONS, SYMBOLS

a.s.l	Above sea level
ARDI	Agricultural Research and Development Institute
AS	Alluvial System zone
BS	Bukoban Systems zone
DfID	Department of International Development
FAO	Food and Agriculture Organisation
FGDs	Focused Group Discussions
FHIA	Fundación Hondureña de Investigación Agricola
GDP	Gross Domestic Product
GO(s)	Governmental Organisations
IDS	Institute of Development Studies
IFPRI	International Food Policy Research Institute
IITA	International Institute of tropical Agriculture
IPDET	International Program for Development Evaluation Training
IPGR	International Plant Genetics Resources Institute
IV	Instrumental Variable methods
KAL	Karagwe-Ankolean Low rainfall zone
KAM	Karagwe-Ankolean High rainfall zone
KCDP	Kagera Community Development Program
kg	Kilogram
km	Kilometre(s)
m	Metres

MAFS	Ministry of Agriculture and Food Security
MOAC	Ministry of Agriculture and Cooperatives
MT	Metric Tonnes
NBS	National Bureau of Statistics
NGO(s)	Non-governmental Organisations
PRA	Participatory Rural Appraisal
PSH	Probability of selecting household
PSU	Primary sampling unit
ODI	Overseas Development Institute
SUA	Sokoine University of Agriculture
SSU	Secondary sampling unit
TSh	Tanzania Shilling
UNICEF	United Nations Children's Fund

GLOSSARY

Kibanja - (Plural *bibanja*) means a local name for a land use type that consists of permanent cultivation of coffee, bananas and beans; other minor crops may be found intercropped at scattered spaces.

Kikamba - A local name for a land use type for cultivation of annual crops including maize, beans, groundnuts, and root and tuber crops.

Rweya – A local name for land use type of grassland found between clusters of *bibanja*. It is a land use mainly used fro grassing cattle, cut grass for mulching *Kibanja* and planting trees.

CHAPTER ONE

1.0 INTRODUCTION AND BACKGROUND

1.1 Introduction

Agriculture is by far the most important sector in Tanzania in terms of employment, contribution to Gross Domestic Product (GDP) and foreign-exchange earnings. About 85% of the population live and earn their living in rural areas with agriculture as the mainstay of their livelihoods. During the 1998 – 2000 period, agriculture's share of real GDP and foreign exchange earnings were 50% and 54.2% respectively (MAFS, 2001). This implies that investments in agriculture are likely to yield improvement in farm food and income security of the majority of rural population. Tanzania government has adopted a series of adjustment programs and policies in attracting appropriate investments and interventions in the agricultural sector. At present, there is a continuing need for investment in the improvement of crops and livestock as a contribution to poverty reduction efforts (MAFS, 2001). However, as in other developing agricultural economies, despite the millions of dollars spent on development programmes each year, there is still very little known about the actual impacts of programmes on the poor (Baker, 2000). This situation poses challenging questions, such as whether the programmes were effective, efficient, and achieved the intended goals. Lack of answers to these questions is leading to insufficient understanding of the status quo in various sectors, the relative success of various types of interventions and how to proceed in the planning of future programmes. Doss (2003) has observed that in the development of agricultural sector, there is increasing challenge for agricultural researchers and extensionists to understand how and when new technologies used by farmers improve their livelihoods. This study investigates the case of banana (*Musa spp.*) crop cultivated by smallholder farm households of Kagera region, Tanzania.

Banana crop is one of the important staple foods in the humid tropics (INIBAP, 2002). Tanzania is the second banana producer in East Africa after Uganda and seventh in the world (KCDP, 2002). In Tanzania, about 350 000 ha of bananas are cultivated and produce about 2.6 million metric tonnes per year (MOAC, 2000). Kagera region is one of the major producing areas of bananas, with an estimated annual banana production of 1.26 million metric tons per year on 187,000 ha (Mbwana *et al.,* 1997). Other banana producing areas in the country are located in the highlands of Kilimanjaro, Arusha, and Mbeya and Kigoma regions. In Kagera, banana is a staple food for about 90% of the total population (Mbwana *et al.*, 1997) and a staple food to 20 – 30% of the total population in the country (Mbwana and Rukazambuga, 1998; Walker *et al.*, 1984). Since the crop is harvested throughout the year, it ensures food and income security particularly at household level. In the past 10 to 15 years, its contribution to household income has been increasing significantly whilst contributions of traditional cash crops such as coffee and tea grown in the same farming systems have been decreasing (Nkuba *et al.*, 2002).

1.2 Background

Kagera region is situated in the north-western corner of Tanzania, on the Western shores of Lake Victoria (Appendix 1 and 2). It lies just below the Equator between latitudes 10^0 0.5’ and 20^0 45’ South and between longitudes 30^0 25’ to 32^0 40’ East of Greenwich. The region borders Uganda in the North, Rwanda and Burundi in the West, and in the South, Kigoma, Shinyanga and Mwanza regions. The total area of Kagera region is estimated to be 39 258 square kilometres, with 1.85 million hectares of arable land. The area under water is 28 513 square kilometres. Until June 2005, the region was sub-divided into six administrative districts (Biharamulo, Bukoba Rural, Bukoba Urban, Muleba, Karagwe and Ngara)[1]. In the 2002 Census, Kagera region had 2,033,888 people (NBS, 2003).

The climate of Kagera region is very much influenced by its proximity to Lake Victoria. Rainfall received is bimodal, where short rains begin in September to November and long rains begin mid March to May. Agriculture is the dominant preoccupation of the region's inhabitants. About 90% of the economically active population depends on crops, livestock and fishing for subsistence and income. Major food crops grown are bananas, beans, maize, cassava, sweet potatoes, yams and sorghum. Banana is by far the most widely grown food crop in the area, covering about 33% and 26% of the total land under crops in Bukoba and Karagwe, respectively (NBS, 2003). Kagera region is one of the most well known banana-based farming systems in the country.

1.2.1 Agro-ecological zones

The banana-based farming systems of Kagera region can be subdivided into four agro-ecological zones that are classified based on topography/elevation, geology, soil types and rainfall (Baijukya and Folmer, 1999; Enserink and Kaitaba, 1996). The agro-ecological zones include Bukoban Systems (BS), Karagwe-Ankolean Low (KAL) rainfall, Karagwe-

[1] In 2005, Biharamulo and Bukoba Rural districts were sub-divided each one into two districts namely Biharamulo and Chato; and Bukoba Rural and Missenyi . Data presented in this study refers to former districts.

Ankolean Medium (KAM) rainfall and Alluvial system (AS) zones (Fig. 1). Agro-ecological zones are highly correlated with soil fertility, incidence and severity of most of the banana pests and diseases (Bosch *et al.*, 1996).

1.2.1.1 The Bukoban Systems (BS) zone

The Bukoban Systems zone can be sub-divided into three sub-zones: the Bukoban high rainfall zone, receiving annual rainfall above 1500 mm; the Bukoban medium rainfall zone, with annual rainfall ranging from 1000 mm to 1500 mm; and the Bukoban low rainfall zone, receiving an average annual rainfall between 750 mm and 1000 mm. It is situated at an average altitude of 1300 m to 1400 m a.s.l., the dominant soil parent materials in the Bukoban Systems are sandstones and shales (Enserink and Kaitaba, 1996).

The zone is found in east and central parts of Bukoba district, and has relatively low soil fertility due to poor parent materials and high leaching of soil nutrients due to high rainfall. In this zone banana production has been badly affected by the high incidence of banana weevils, banana nematodes, banana Fursarium Wilt (Panama) and Black Sigatoka (Mbwana *et al.*, 1997; Bosch *et al.*, 1996). Each local banana variety is vulnerable to one or a combination of these banana diseases.

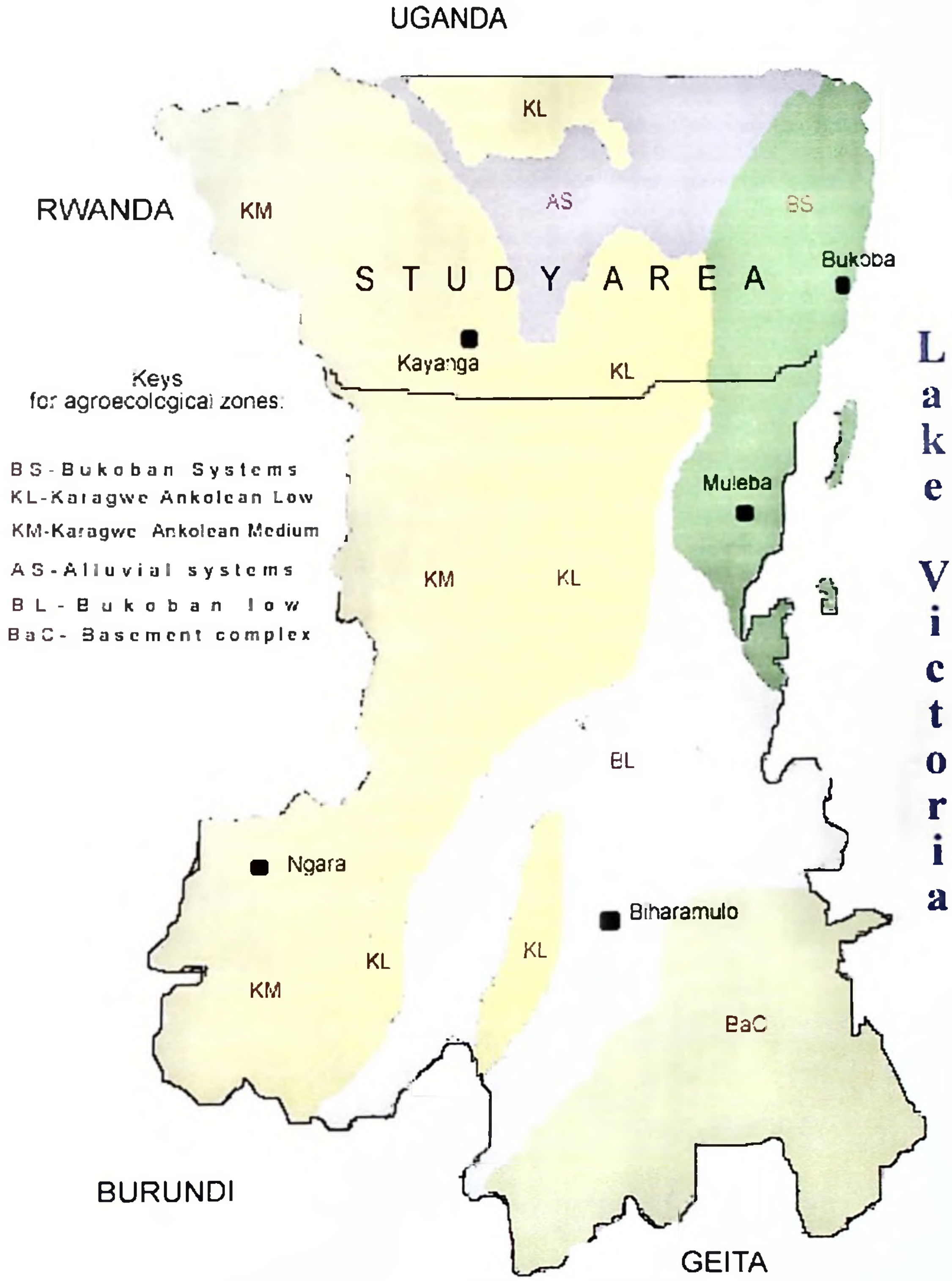

Fig. 1: Agroecological zones of Kagera Region

Source: Baijukya and Folmer, (1999).

Thus, it is an area that has received a lot of attention from research, extension, and non-governmental organizations in the form of on-farm testing, multiplication and distribution of planting materials of new banana varieties.

1.2.1.2 The Karagwe Ankolean Low (KAL) rainfall zone

The KAL zone is found in the lowlands of Kagera region including the western part of Bukoba District and eastern parts of Karagwe District that are situated at the altitude of below 1200 m a.s.l. The dominant soil parent material is a mixture of quartzite, quartzitic sandstones, shales and phylites with localised intrusions of granites, dolerite and gabbros (Touber and Kanani, 1996). This zone receives rainfall ranging from 750 mm to 1000 mm per year (Enserink and Kaitaba, 1996). Biotic and abiotic constraints to banana production are less than in the BS zone, and yield levels are higher. This zone is also one of the areas where dissemination of the planting materials of the new banana varieties was emphasized.

1.2.1.3 The Karagwe-Ankolean Medium (KAM) rainfall zone

Karagwe-Ankolean medium (KAM) rainfall zone covers high to medium altitudes of central and western parts of Karagwe District with the same parent material as that of KAL zone. The average annual rainfall received in this zone ranges between 1000 mm and 1250 mm (Enserink and Kaitaba, 1996). This zone is less affected by banana production constraints (Mbwana, *et al.*, 1997; Bosch *et al.*, 1996), and hence, less effort has been made to disseminate new banana varieties through formal institutions (KCDP, 2003).

1.2.1.4 The Alluvial System (AS)

The Alluvial System (AS) zone occupies the Northwest part of Bukoba District. Its parent soil materials include recent alluvium deposits, mainly of shales and sandstones (Enserink and Kaitaba, 1996). Annual rainfall in this zone does not exceed 1000 mm. The large scale farming of sugarcane and maize is practiced on well-drained soils found in this zone. This area is basically not suitable for banana production due to long periods of dry season and occasional floods. However, scattered clusters of banana fields can be found within the zone.

1.2.2 Land use types

Each agro-ecological zone of the banana-based farming system is comprised of three major land use types that are closely interlinked called *Kibanja*, *Kikamba* and *Rweya* (Reining, 1967; Rald and Rald, 1975; FSR Project, 1990). *Kibanja* is the most fertile land belonging to a household, and usually surrounds the house. Typically, *Kibanja* is planted with perennial and annual crops such as bananas (*Musa spp.*), coffee (*Coffea canephora*), beans (*Phaseolus vulgaris*), maize (Zea mays), yams (*Dioscorea spp.*), cocoyams (*Colocasia esculenta*) and cassava (*Manihot esculenta*). Sometimes trees including fruit trees are intercropped in a scattered pattern. *Kibanja* is a status symbol that provides the owner with dignity, and a sense of belonging and permanence. *Kikamba* is an area adjacent to the *Kibanja*, meant for cultivating annual crops such as maize, beans, cassava and sweet potatoes (*Ipomea batatas*). Sometimes this zone is left fallow for a period of 1 to 3 years.

The *Rweya* is an area of open grassland between clusters of farms. It is traditionally reserved for grazing livestock, as a source of mulch for *Kibanja*, planting trees and cultivation of seasonal crops such as bambaranuts (*Vigna subterranean*), cassava, sweet potatoes, finger millet and pineapples (*Ananas comosus*). The *Kibanja* and *Kikamba* are fully private lands but the *Rweya* land can either be privately or communally owned or both.

1.3 Problem statement and justification

Since the last three decades, banana production has been faced by increasing infestations by pests and diseases, and declining soil fertility (Baijukya and Folmer, 1999 and Bosch *et al.*, 1996). The major banana pests are banana weevils (*Cosmopolites sordidus*) and banana nematodes (such as Radopholus similis, *Helicotylenchus multicinctus* and *Pratylenchus goodeyi*). Banana diseases are banana fusarium wilt known as Panama – (*Fusarium oxysporum*), and Black and Yellow Sigatoka (caused by *Mycosphaerella fijiensis* and *Mycosphaerella muscola* respectively). Declining soil fertility is due to leaching from heavy rainfall and poor crop management practices.

Until the 1980s, people in the banana-based farming systems of Kagera region were relatively better off in terms of living standards compared to other areas in Tanzania (UNICEF, 1985). This was attributed to good income from the sale of coffee, and food stability from banana production. During the 1990s, the economic status of people in Kagera region dropped considerably. In 1999, Kagera was the region with the lowest (TSh. 149 828) per capita GDP compared to the highest (TSh. 554 287) per capita GDP for Dar es Salaam region (NBS, 2003). Continuous decline in banana and coffee yields was a consequence of increasing infestations by pests and diseases, and decreasing soil fertility. The prolonged coffee crises increased the proportional contribution of bananas to household income. At the same time, without cash revenues from coffee, farmers were unable to afford the farm inputs such as fertilizers, necessary to support production. In some cases, pest infestations increased the rate of perishing or complete loss of the local banana varieties (Bosch *et al.,* 1996 and Mbwana *et al.,* 1997). Furthermore, lack of farmers' awareness of the benefits of soil conservation makes them to continue with the same farm practices. Farmers have been coping with banana production decline by increasing planting of other crops such as cassava, sweet potatoes, yams and maize but their livelihoods have not revitalized.

Banana farmers, researchers, and extension agents sought to identify strategies for increasing banana production that are less capital and labour intensive (KCDP, 2002; Bosch *et al.,* 1996 and Mbwana *et al.,* 1997). One of the strategies was the introduction of "new banana varieties"[2] that are tolerant to most predominant banana production constraints faced by farmers.

The new varieties included FHIA 01, FHIA 02, FHIA 03, FHIA 04, FHIA 17, FHAI 18, FHIA 22, FHIA 23, FHIA 25, Yangambi km5, IC2, AAcv Rose, Bita 3, Cardaba, Paka, Pelipita, Pisang Berlin, Pisang Ceylan, Pisang Sipulu, Saba, SH3436-9, SH 3640, CRBP, KCDP 1 and Paka. These varieties were obtained from the International Network for the Improvement of Banana and Plantain (INIBAP) from Belgium. They were multiplied and

[2] Some times refers to improved or superior banana varieties, i.e., recent varieties (from 1995) introduced into the farming system for the first time.

disseminated to farmers by the Kagera Community Development Programme (KCDP[3]). The new varieties have more tolerance to one or various combinations of the major banana production constraints; weevils, nematodes, Panama disease, Black Sigatoka, low soil fertility and drought.

From 1997 to 2002 on-farm testing was conducted by Maruku[4] Agricultural Research and Development Institute that went concurrently with multiplication and dissemination of planting materials of these varieties (Nkuba *et al.*, 1999). Nkuba *et al.*, (2002) and Mgenzi *et al.*, (1997) showed that the new banana varieties on average yielded bunch weight of 18.9 kg while the local banana varieties had an average bunch weight of 9.7 kg. Farmer assessment revealed that these varieties are acceptable and have good marketability and multiple uses (for cooking, dessert, roasting and brewing).

Up to 2002, about 2.5 million of planting materials of new banana suckers were distributed to farmers in the region. By the time this study was conducted, it was almost 7 to 8 years since the introduction of the new banana varieties into the region but no study was conducted on adoption or impacts of new banana varieties on livelihood of people. There was a fairly limited understanding of the factors that influenced adoption and accrued benefits of the new banana varieties on farmers' livelihoods.

Therefore, this study aimed at assessing the adoption and socio-economic impacts of the new banana varieties on the livelihoods of people. Also, it aimed at providing information

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[3] KCDP was officially established in 1997 and closed in March 2003.
[4] Maruku is located in Bukoba District, as a sub-station of Lake Zone Agricultural Research and Development Institute with its Headquarters at Ukiriguru, Mwanza, Tanzania.

on future extension and research decisions, priorities setting and facilitating monitoring and evaluation process of the on-going multiplication and dissemination of new banana varieties and other programmes.

In line with the works of Baker, (2000) and Prennushi *et al.*, (2000), specific questions of this study included:

(a) Did the use of new banana varieties achieve the intended goals? Such as:
   - improving productivity and yield stability of banana yields (i.e., reduced yield vulnerability resulting from banana production constraints)
   - improving total production, income (price per bunch, net profits), and food security in terms of increased bunches harvested, consumed and sold

(b) Could the changes in livelihood outcomes be explained by the adoption of new banana varieties?

(c) Did changes in livelihood outcomes vary across different groups of intended households?

In order to address these issues, the study's general and specific objectives are as presented in the following section.

1.4 Objectives

1.4.1 General objective

The general objective of the study was to assess the socio-economic impacts of the use (adoption) of the new banana varieties on farmers' livelihoods in Kagera region.

1.4.2 Specific objectives

(i) To identify factors that influence farmers' adoption (demand) of new banana varieties among farming communities in Kagera region;

(ii) To identify the intermediate and long-term impacts of new banana varieties on farmers' livelihoods across different agro-ecological zones and farmer characteristics.

(iii) To measure the accrued benefits of new banana varieties on farmers' livelihoods

1.4.3 Research hypotheses

Hypotheses tested in this research were:

(i) The extent and intensity of adoption of new banana varieties has been influenced by biophysical and socio-economic factors surrounding the farmers such as income and wealth (household asset);

(ii) Changes in selected impact indicators can be attributed to the use of new banana varieties;

(iii) The use of improved new banana varieties has improved the livelihood indicators of farmers such as increased and sustained average banana yields, reduction in banana yields and variability and increased number of bunches harvested.

This study had reviewed the relevant theories and literatures, uses a statistically representative sample, and a combination of qualitative and quantitative methods, to document the use of new varieties, identify the determinants of adoption, and investigates the impacts of use of new banana varieties on household well-being. New banana varieties are defined as those banana varieties introduced into the region since 1995 by individual farmers, organisations or institutions.

1.5 Organisation of the study

This thesis is organised into five chapters. Chapter One explains the introduction and background whereby Kagera banana-based farming systems are described. Also, problem statement, justification and objectives of this study are presented. Theories and literature review are presented in Chapter Two, where definitions of important terms used are presented and explanation of issues involved in adoption and impact assessment of interventions are reviewed. This chapter also describes the diversity and dynamics of the Kagera region and the characteristics of banana farms. The chapter covers the theoretical models relevant to the study and the conceptual framework. Research methodology is explained in Chapter Three covers sample domain, survey instruments, and definitions of dependent and explanatory variables used and data analyses. Chapter Four presents the results and discussions, and the conclusion and recommendations are presented in Chapter Five. Lastly, literature cited and appendices are at the end.

CHAPTER TWO

2.0 THEORY AND LITERATURE REVIEW

2.1 Overview

This chapter reviews the adoption and impact assessment literature by explaining the nature of dissemination pathways of planting materials and related information, project participation (adoption), participants (adopters) and non-participants (non-adopters), and importance and approaches of conducting impact studies. It discusses some relevant literature on analytical tools used in impact assessment of development projects. In this chapter, the diversity and dynamics of the banana-based farming systems are described too. It follows by explanation of the economic importance of the banana on people's livelihoods. Finally, it describes the characteristics of banana farms, varieties grown and dissemination of the new banana varieties.

2.2 Adoption and impact assessment

2.2.1 Dissemination pathways

The seed systems of new varieties of a perennial crop such as banana differ with those of annual crops such as cereals. A new perennial crop variety can keep spreading from farmer-to-farmer with minimal efforts on the supply side while cereal-seed systems require assurance of supply source and several middlemen in between. However, for both system types, the spread of seeds or planting materials depends amongst others on the amount being supplied by the source, effectiveness and efficiency of dissemination pathways, creation of awareness and the vegetative propagation potential of the variety. The concepts and documentation of scaling-out and scaling-up of new technologies are therefore important to evaluation and impact assessment (Douthwaite *et al.*, 2002). Kuby (2000) defines scaling-out as a horizontal spread of an innovation from farmer to farmer, community to community, within the same stakeholder groups while scaling-up is an institutional expansion from grass-root organisations to policy makers, donors, development institutions and other stakeholders key to building an enabling environment for change.

Generally, any adoption decision made by farmers on a new technology or new variety is preceded by a period of creation of awareness and learning on the concerned technology (Jabbar *et al.*, 1998). Farmer's decision to adopt, reject or defer decision is postulated to be influenced by the belief derived from the knowledge and perception about the technology at that point in time. Therefore, the nature of dissemination pathways has a great influence on the extent of awareness of a particular technology and information (knowledge) attached to it. Subsequently, dissemination processes have a significant impact on who is reached with the new technology and how well they are able to take advantage of them (Meinzen-Dick *et al.*, 2003). In a situation like the introduction of new banana varieties there is a wide array of methods in which farmers are exposed collectively or farmer to farmer, which need to be documented for better understanding of adoption and impact situations.

2.2.2 Adoption

Technology adoption process is defined as a mental process an individual passes from first hearing about an innovation to final adoption (Rodgers, 1962; Feder *et al.*, 1985). Rodgers defined final adoption as the degree of the use of a new technology in the long-run equilibrium when the farmer has full information about the new technology and its potential. The dynamic nature of adoption decisions involves change as information is progressively collected. Adoption is conceptualised as a multi-stage decision process involving information acquisition and learning by doing by growers who vary in their risk preferences and their perceptions of riskness of an innovation (Feder *et al.*, 1985; Rosenbaum and Rubin, 1983).

The farmers' previous experience with other innovations may have been either positive or negative, and this will likely influence their perceptions of adoption. Doss (2003) pointed out that decisions in one period depend critically on decision made in previous periods. Hence, farmer's personal discount rate and time preference is likely to influence adoption. The number of years taken for the farmer to hear of the new crop or variety is likely to be negatively correlated with adoption (Adesina and Seidi, 1995).

Many adoption studies conducted show that the use of agricultural technologies is strongly linked to the asset base as indicated in the sustainable livelihoods framework (Adato and Meinzen-Dick, 2002). Similarly, Adesina and Seidi (1995) stated that amongst labour availability, farm size, contact with extension services, market access, credit availability, gender and technology characteristics are the most common factors that influence adoption and non-adoption. According to the economic constraints model, resource endowment is one of the major determinants of the observed adoption behaviour, where lack of access to capital and inadequate farm size could significantly impede adoption decisions (Rosebaum and Rubin, 1985). Thus, the use of agricultural technology by farmers is a function of livelihood assets owned by farmers that are influenced by policies, institutions and processes (Adato and Meinzen-Dick, 2002). The adoption of the new technologies, particularly in subsistence farming is governed by a complex set of factors such as natural, physical, human, financial and social capitals.

A number of authors have articulated that impact begins to occur only when there is a behavioural change among the potential users. Anandajayasekeram *et al.* (1996) stressed that the impact of any technology or project cannot be assessed without information about the number of users (extent) and the degree (intensity) of adoption of improved technologies. Adoption studies using cross-section analysis at micro-level provide useful background information about farmers who are adopters of a technology and those who are not (Doss, 2003). The cross-sectional analyses can tell about farmers' characteristics and preferences, technology characteristics, farmers' perceived benefits from technology adopted, farmers' perception of the constraints they face and the extent and patterns of adoption.

2.2.3 Adopters and non-adopters

Although there are several definitions of an adopter due to complexity of technology in hand, Doss (2003) defines a farmer as being an adopter if he or she is found to be growing any of the introduced improved crop varieties. Depending on the technology in consideration, the adoption could be measured as a discrete state with binary[5] (or dichotomous) variables (i.e., use or not use) or as a continuous measure at a particular time (Doss, 2003; Place and Swallow, 2000). A continuous measure helps to quantify the intensity of technology beyond simple presence or absence of the technology on farm. Examples of continuous measures are: number of mats of new banana varieties per household, density of new varieties per hectare, number of new cultivars planted per household, percentage share of new banana mats to the total banana mats and size of banana farms planted with new varieties.

Place and Swallow (2000) have asserted that sometimes it may be more important to study the traits or grouping together all species or varieties that are adopted by farmers to improve their agricultural production. They added that informal discussions and qualitative research can help to establish whether farmers adopted or were merely experimenting, particularly in areas where projects have had strong influence or have possibly provided incentives for farmers to use particular technologies. Dealing only with farmers who had direct contact to projects could lead to overestimating of the adoption and/or accrued benefits from project beneficiaries.

Several empirical studies on adoption of agricultural technologies generally divide a population into adopters and non-adopters and analyse the reasons for adoption or non-adoption at a point in time principally in terms of socio-economic characteristics of the adopters and non-adopters (Jabbar, 1998; Feder and Umali, 1993). They further stressed

[5] Variables or outcomes take on only two values (usually coded as 1,0)

that characteristics of both the user and the technology are considered important in explaining adoption behaviour and the pathway for adoption.

2.2.4 Counterfactual analysis

Many impact assessment studies have shown that "netting out" the effect of the projects from other factors is facilitated if treatment and control groups are well defined (Ezemenari *et al.*, 1999; Ravallion, 1994). The treatment group is a group of those who receive the intervention or project participants or adopters of a technology (in this case the new banana varieties). While control group is a group of those not receiving the intervention or non-project participants or non-adopters of a technology or control group but have similar characteristics as those receiving the intervention i.e., the treatment group. Defining these groups correctly is a key to identifying what would have occurred in the absence of the intervention. Control groups can be determined at different levels: region, district, village, community, household or intra-household depending on the coverage of a project or intervention.

Thus, in order to capture the net effects or outcomes of the new banana varieties one needs to find the difference between adopters and non-adopters. This will be facilitated if there are well defined expected outcomes which are contingent upon the intervention, clear outcome indicators for judging the performance of the project or intervention and well defined counterfactual evidence (Baker, 2000).

Similarly, Doss (2003) found that in adoption studies using cross-sectional data, it is important to define who are the adopters and non-adopters of a certain technology. The cross-sectional analyses can tell about farmers' characteristics and preferences, technology characteristics, farmers' perceived benefits from technology adopted, farmers' perception of the constraints they face and the extent and patterns of adoption. However, he noted that the cross-sectional data do not permit analysis of the dynamics of technology adoption due to lack of panel data and little variation of some variables within the samples if the coverage is not wide enough.

Place and Swallow (2000) emphasized that it is often necessary to quantify the intensity of technology adoption beyond simple presence or absence of the technology on a farm. For example, adoption of new banana varieties can be measured in terms of number of new banana mats per household or the density of new banana mats per hectare. They further elaborated that the absence of a technology at a particular time may be unrelated to farmer plans to adopt the technology at a future time and neither does it mean that the farmer has never used the technology. These could be covered if samples are selected in such a way that generalizations can be made about adoption and impact levels for a country or a region or agro-ecological zone or about groups of farmers (Doss, 2003). Appropriate counterfactual analysis enhances establishment of correct cause-effect relationships between the technology and the outcomes being measured because there could be co-founding factors that could have contributed to the outcomes being measured (Ravallion, 1994 and 2001).

Many empirical adoption studies have also shown that adoption of the new technologies is a function of technology characteristics, farming circumstances as well as farm- and farmers' characteristics (Adesina and Baidu-Forson, 1995). They compared farmers who adopted and those who did not adopt or rejected a certain technology at a point in time, using cross-sectional data, but say little on short-term or intermediate outcomes (impacts) of the concerned technologies on livelihoods of people. Most scientists agree that the data and results of adoption studies provide the baseline data for the evaluation of technology impacts on productivity, income, environment, equity and other goals of a particular project or programme.

2.2.5 Impact assessment

Impact assessment and impact evaluation are synonym terms where they are used in many different ways by different people. Impact refers to the broad, long-term economic, social and environmental effects resulting from an intervention or project, while evaluation is judging, appraisal or determining the worth, value or quality of an intervention (project or program), in terms of its relevance, effectiveness, efficiency and impact (FAO, 2000). Impact is defined more broadly whether the programme had desired effects on individual, households and institutions. A comprehensive evaluation is defined in the literature as an evaluation that includes monitoring, process evaluation, cost-benefit evaluation and impact evaluation. Impact evaluations differ from other evaluations in that they are focused on assessing causality (Baker, 2000).

DfID (2001) defines impact assessment as the process of identifying the anticipated or actual impacts of a development intervention on those social, economic and environmental factors which the intervention is designed to affect or may inadvertently affect. According to Anandajayasekeram and Martella (1996), the term impact assessment is defined as a special form of evaluation which measures the intended and unintended changes of an intervention or technology. Similarly Baker (2000) and Prennushi *et al.* (2000) defined impact assessment as an assessment of the extent to which interventions or programmes cause changes in the well-being of target populations, such as individuals, households, organisations, communities, or other identifiable units to which interventions are directed in social programmes. All these definitions emphasize measurement of the direct and indirect effects of the project on the targeted beneficiaries.

Impact assessment is done for several practical reasons including accountability, improving programme design and implementation. and planning and prioritizing (FAO. 2000). The results of monitoring and evaluation (M & E) at a project level provide continuous feedback into the impact assessment and priority setting at the programme and system-levels. Impact assessment can be undertaken before initiating the project (ex-ante) or during the project period (mid-term) or after the completion (ex-post) of the project or activity (FAO, 2000; Anandajayasekeram and Martella, 1996). In many agricultural extension and research programmes, the fundamental goal is to eradicate poverty and protect natural resources in order to achieve sustainable food security (FAO, 2000). Therefore, impact assessment examines differences between outcomes for project participants and non-participants.

However, it is difficult to evaluate impacts in terms of the ultimate broader goals of poverty alleviation and environmental sustainability. Instead, impacts can be measured using intermediate goals and objectives of an intervention or project. Intermediate goals such as increased sustainable agricultural productivity through development of improved technologies can be easily measured in terms of cause and effect, and impact (FAO, 2000). Objectives as well the outcome indicators of any project or development intervention should be clearly defined prior to its implementation. It is also very important to be clear about the time frame within which outcomes are to be expected. Both short and long-term outcome indicators should be specified clearly (Ezemenari *et al.*, 1999).

Improved crop varieties are not complex new technologies, but rather improvements of the existing ones. They do not require complex stages of learning, adaptation and negotiation. Hence, simple linear models adoption process and impact assessment have been used (Douthwaite *et al.*, 2002; Alston *et al.*, 1998).

2.3 Impact assessment approaches

There has been a continuous development in the impact assessment approaches from conventional through participatory to the livelihood approaches (Ashley and Hussein, 2000), all of which are interlinked or related to each other. The conventional-assessment approaches are focused excessively or exclusively on how much cash, how much increased production or how many jobs generated, rather than on a broad range of livelihood issues.

2.3.1 Conventional approaches

Previous impact studies mainly used conventional approaches in which measurement of impact tended to focus on tangible impacts such as on income, productivity, cost-benefit ratio, economic rate of return and assets which lend themselves to only quantitative assessment (Ezemenari *et al.,* 1999; and Ashley and Hussein, 2000). Only few parameters of economic issues were selected based on the knowledge of the outside experts (Ezemenari *et al.,* 1999). These conventional approaches failed to capture important benefits accruing to people as a result of the project because they tended to create a degree of distance between those assessing impacts and project participants or beneficiaries (Ashley and Hussein, 2000).

2.3.2 Participatory approaches

Participatory approaches make use of a range of techniques and tools to assess the impact of an intervention or project (Estrella and Gaventa, 1998). It involves all project actors including implementers, policy makers and beneficiaries to decide together on how progress or success should be measured and results acted upon (IDS, 1998). Outcome indicators are participatorily developed together and all actors are involved in data collection and analysis. Participatory methods are flexible and open-ended, and are not always restricted to a predetermined set of variables, outcomes or questions (Ezemenari *et al.,* 1999). They require involvement of different categories of stakeholders in all stages (Ezemenari *et al.,* 1999). However, the success of this type of approaches relies to a great extent on qualitative judgements made by beneficiaries (local people) and project staff rather than on the interpretation of quantitative data by outsider experts. Nevertheless, they concluded that even if the principles and general outlook of conventional and the participatory approaches are clearly different, but complementary to each other.

2.3.3 Livelihoods approaches

The livelihoods approach differs from conventional and participatory approaches in its central focus on people's lives rather than on resources or defined project outputs (Ashley and Hussein, 2000 and DfID, 2001). Impact assessment in this case is based upon a prior understanding of people's objectives, how their livelihoods are constructed and which factors are the essential causes and manifestations of their poverty. The sustainable livelihoods (SL) approach assumes that increasing access or entitlement to capital (or assets) is crucial for ensuring sustainable livelihoods (Carney, 1998).

A livelihood defined by Dorward *et al.*, (2001) comprises "the capabilities, assets and activities required for a means of living". A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in future, without undermining the natural resources base (Carney, 1998). Livelihood outcomes are the achievements of livelihood strategies. When it comes to impact assessment, this means that measurable changes (e.g. cash, yield) must be assessed not in their own right, but in terms of the contribution they make to livelihoods (Ashley and Hussein, 2000). As explained earlier, the contribution of technology may be direct (e.g. adding to household income, food nutritional and availability) or indirect (affecting their assets, activities and options, and ability to cope with shocks, i.e., reducing vulnerability). The approach draws on both conventional and participatory evaluation method aspects (Ezemenari *et al.* 1999; Ashley and Hussein, 2000).

2.4 Data sources and collection methods

Data sources for impact assessment can consist of longitudinal (panel data), cross-section, or baseline with follow-up and time series, for which each one can be selected depending on the available resources and the major objectives of the impact study. In principle, any of these types of data can be collected using quantitative or qualitative methods or both. Combining both quantitative and qualitative data collection methods yields effective impact evaluation (Kusek and Rist, 2004; Rao and Woolcock, 2001; Ezemenari *et al.*, 1999). The two methods strongly complement each other and their integration can be achieved due to the following reasons:

(a) Qualitative methods can be used to determine the design of the quantitative survey questionnaire;

(b) Qualitative methods can also be used to determine the stratification of the quantitative sample;

(c) Quantitative survey interview can be used to design the interview guide for the qualitative data collection;

(d) Quantitative survey can be used to determine the generality, volume or extent (in a given area or society) of findings or phenomena identified through qualitative methods in more limited areas or samples;

Given this, comparison means (for randomization) or econometric methods should be combined with client feedback from the qualitative methods.

2.5 Methods of impact assessment (evaluation)

As explained earlier impact evaluation intends to determine more broadly whether the project had the desired effects on individuals, households and institutions, and whether those effects are attributable to the project intervention. It can also explore unintended consequences whether positive or negative on beneficiaries. Any impact evaluation must estimate the counterfactual, that is what would have happened had the project never taken place or what otherwise would have been true (Baker, 2000; Ezemenari *et al.,* 1999; Ravallion, 1994). Thus, counterfactual evidence is at the core of impact evaluation analysis techniques. This is accomplished through the use of comparison or control groups (those who do not participate in a project or receive benefits), which are subsequently compared with the treatment group (individual who receive project benefits).

The easiest way to conduct such analysis is by comparing the differences in means or percentages of outcome variables between the two groups. However, outcome differences may reflect factors other than the impact of the programme – especially systematic differences due to the selection of adopters and non-adopters (DFID, 2002. Similarly, IPDET (2004), outline four factors that can be used to determine whether there is a causal relationship between outcome and intervention:

(a) A logical theory - that is, the connection between the intervention and outcome should have a causal relationship. For example, new varieties are likely to increase crop production;
(b) Time order - the intervention should come before outcomes;
(c) Co-variation - both the intervention and the outcome should have the ability to change. This means that if we compare adopters of new varieties against non-adopters

(variation[6] in programme participation) we would be able to discover (identify) whether there are changes in crop production (variation in the amount of crops produced);

(d) Elimination of rival explanations - we need to be able to establish if it is the intervention rather than other factors that explain the changes we have measured.

The literature about impact evaluation of programme intervention emphasizes the importance of establishing the appropriate counterfactual evidence. As stated by Ravallion (1994), the essential problem of impact evaluation is that we do not observe the outcomes for participants if they had not participated. The appropriate counterfactual evidence facilitates the measurement of the correct causal relationship between the technology and the outcomes being measured, since other confounding factors could also have influenced the outcome (Ravallion, 1994; Doss, 2003). Ravallion (1994) and Baker (2000) summarize and compare the five main methods available for evaluating programme impacts; randomization (experimental), matching methods, double difference methods, reflexive comparison methods and instrumental variable methods (see Appendix 3).

In randomization (experimental) method, individuals are selected into treatment and comparison groups at random, so that the only measurement errors are associated with sampling. Sampling errors can be reduced through larger samples. In this the project impact on the outcome being evaluated can be measured by the difference between the means of the samples of the treatment group and the control group. This is considered to be the optimum approach to estimate project impact but it is difficult to get an ideal

[6] The actual fluctuation in the value of an outcome or entity.

randomization due to influence in selection, political influence (driven), in and out of participants (i.e., attrition bias).

Matching methods or constructive controls refers to where the comparison group is matched to the treatment group based on characteristics measured in data from a larger, representative sample survey. "Propensity scores" are tabulated to support the selection of individuals. Thus, by propensity score matching the comparison group is matched on the basis of a set of observed characteristics or by using the propensity score (predicted probability of participation given observed characteristics).

Double difference methods occur when the treatment and comparison groups are compared both before and after the treatment. The reflexive comparison methods enable the "before and after" to be estimated for key parameters using a baseline, which serves as the comparison group. The fifth approach is the instrumental variable methods used in this study. The instrumental variables matter to participation, but not to the outcome, given participation. They enable the identification of exogenous variation in outcomes that can be attributed to the program. Matching and instrumental methods provide robust statistical techniques in reducing the selection bias (Baker, 2000; Ezemenari *et al.,* 1999). The instrumental variables are first used to predict programme participation, and then one observes how the outcome indicator varies with the predicted values. In this study, the participation variable is the decision to use new banana varieties. The econometric model for measuring the impacts of using these new banana varieties is explained in the conceptual framework and methodology chapter.

2.6 Diversity and dynamics of the Kagera region

In Kagera, the existence of various food and cash crops cultivated per household is an evidence of a farming system with good diversity. However, the banana-based farming systems are dynamic, such that between decades significant changes can be noted. Dynamics can be observed in the continuous differentiation of households, changes in crop patterns, diversification of crops, changes in human and livestock populations, the extent of engagement in on-farm and non-farm activities, improvement in socio-economic infrastructures such as tarmac road construction, mobile phones, institutional arrangements and agricultural policies.

Changing proportions in the three land use types (*Kibanja*, *Kikamba* and *Rweya*) over the past 2 to 3 decades provide physical evidence of these dynamics. For instance, in Bukoba district, the percentage of cultivated land to total land changed from 26% in 1961 to 36% in 1999 (Baijukya *et al.,* 2005). During the same period, the percentage of *Kibanja* lands to total area cultivated decreased from 90% to 67% and *Kikamba* increased from 1% to 33%. During the same period, *Rweya* lands (area not under crops or trees) decreased by 35 %. This implies that there has been reduction of cultivated area of banana plots and an increase in area cultivated with other crops mainly maize and root and tuber crops. Thus the most fertile lands, and the pride of the households, have declined, as well as the land available collectively i.e., the *Rweya* land. Such changes occur as a result of different responses made by households to various external factors, including banana production constraints. But it is important at any given time to note whether the performance of the farming system is increasing, constant or decreasing since the performance of any farming system can be measured in terms of its productivity, sustainability, stability and equitability (Norman, 1995; Pearson, 1995; Conway and Barber, 1990).

2.6.1 Productivity

Productivity is a measure of system efficiency measured per unit area, or per man-hour, or per unit of energy. Norman (1995) defined productivity as efficiency with which inputs are transformed into those outputs which reflect the system's purpose(s), while Conway (1987) views productivity as a measure of social value: the output of valued product per unit resource input. The productivity of any farming system may be constant or change under increasing agricultural intensity, depending on how the other system components adjust to the change. When the land is cultivated more frequently and for long periods of time its soil fertility will decline if no resources are added into the soil.

The productivity of the banana-based farming systems in Kagera region has been declining due to many factors, including increasing population pressure, unfavourable climate (such as high rainfall, which results in high leaching of soil nutrients) and the increasing incidence of plant diseases and pests. Other factors include lack of farmers' awareness of the benefits of soil conservation, which leads them to continue with the same farm practices, and government policies that work against the agricultural sector causing reduction in farmers' incentives to adopt soil conservation measures.

2.6.2 Stability

Stability, as a concept of system performance, measures the ability of a system to cope with short-term changes in its environment - that is, the constancy of productivity

(Conway, 1987; Pearson, 1995). System stability is measured by the coefficient of variation in productivity, determined from a time series of productivity measurements.

The stability of the Kagera banana-based farming systems is in the process of decreasing as a consequence of failing to cope with changes in both biophysical and socioeconomic factors. The frequency of occurrence of plant diseases and pests makes a farmer unsure of crop yields, and uncertain of reaching previous levels. Lack of sustainable input supply system and greater variation of prices of inputs lead to inconsistencies in the application of farm inputs such as fertilisers, pesticides and insecticides. This results in large variations in crop yields achieved by farmers. The variation between farmers is related to the ability of the individual farmer to cope with the situation. In the long run, the gradual adjustments made by farmers in response to economic stresses caused by both internal and external stimuli can result in the formation of different farmer categories (Nkuba, 1996).

2.6.3 Sustainability

Conway (1987) defined sustainability as the ability of an agro-ecosystem to maintain productivity when subjected to a major disturbing force (Conway, 1987). He emphasised that sustainability is a measure of the difficulty which management encounters in maintaining biological and economic resources. Ecosystems experience stresses: a highly sustainable system is one in which the stress is minimised or negated through relatively continuous, small inputs of management which are consistent with the goals of the ecosystem (Pearson, 1995). Sustainability is low where the management needed to avoid degradation of resources is large or economically or technically impracticable, where the timing of its input is crucial, and where the management of stress may not contribute to (or indeed, may detract from) the short-term goal of the ecosystem.

The Kagera banana-based farming systems are faced by the problem of declining sustainability because more nutrients are extracted from the systems than are added into it. The greater the delay in applying appropriate conservation measures, the higher will be the costs needed in future - that is, the higher will be the loss in future net benefit (user cost). There is a level that a farming system can reach, from which it will be unable to recover; yet its status can still be improved to a high level of capability (Steenhuijsen, 1995). The quality and capacity of the farming system usually increase when appropriate inputs (technologies) are used in agricultural production, and hence increase the system's sustainability. However, the issue of which inputs to add into the system depends on several factors including physical, social, cultural, economic, and political ones.

In these farming systems, many negative environmental changes have occurred and are expected to continue occurring in the near future if immediate measures are not taken. New crops (varieties and cultivars) cultivated by farmers are being increasingly grown. Old varieties and cultivars of beans and bananas are disappearing because they have become susceptible to plant diseases and pests, and are being replaced by new crops (varieties/cultivars). However, no one is sure that these new crops (varieties/cultivars) will perform better under the deteriorating agricultural environment. Probably, the farmers' attempt is a temporary solution only, if the cause of shifting from one type of crop to another is not rectified. Also, the importance of weeds on farmers' fields is changing. Two types of weeds, couch grass (*Digitaria scalarum*) and nut grass (*Cyperus aff. rotundus*) have decreased in importance in the past three decades because of successful eradication attempts, while two weeds (Wandering jew – *Commelina spp* and Black jack – *Bidens pilosa*) increased their importance during the same period (Mukandala *et al.,* 1994).

Intensification of agriculture can be noticed even within one generation. In the 1950s, *Rweya* grassland was used mainly for grazing cattle, cultivation of annual crops and as a source of mulch grass. In the 1970s, the decline of banana yield forced farmers to diversify their crops including increased cultivation of number of crops (perennials and annuals) on all land use types. In the 1980s, cultivation of trees on *Rweya* was started as a source of building materials, firewood and cash. At present, a number of crops are cultivated on *Rweya.* These include cassava, sweet potatoes, pineapples, maize, groundnuts and sometimes establishment of *Bibanjas* on marginal lands. The number of plant diseases and pests, and their importance, has increased to an alarming extent compared to what it was 30 years ago. All these additional activities on a particular land use type, with minimal application of farm input, puts the sustainability of the banana-based farming systems at a greater risk.

2.6.4 Equitability

Equitability is a measure of benefit distribution. There are many measures of equitability such as the Lorenz curve, the Gini coefficient and other related indexes. The measures available reflect different value judgements. Equitability is thus often the evenness of distribution of benefits (such as productivity) among the human beneficiaries according to need (Conway, 1987). A change somewhere in a system might leave someone with more wealth but less respect than previously; or someone else with more power but less self-respect and sense of well-being. The benefits from increased productivity are usually not equally distributed. New technologies will favour those who have the resources and access to use them. The benefits from increased productivity may spread disproportionately among the classes due to differences in access to resources and/or depends on the dissemination pathways of the technology.

Because of differences in access to resources among Kagera households, it is expected that there is significant income inequality between household categories. Income inequality is likely to be reflected in farmers' needs and priorities. Thus, farmers who are earning significantly different incomes may require different technologies even though they are located in the same farming system or same village. Apart from changes in biophysical factors, socio-economic factors are also changing. For example, traditional customs related to land inheritance are not the same as those of 50 years ago, due to the small size of farms, where subdivision of the farm is becoming uneconomic. New types of activities or occupations (increasing non-farm activities; trading and fishing) are becoming available to individual household members as a response to changes in socio-economic factors. All these changes influence the status of equitability of a particular farming system.

Changes in both biophysical and socio-economic factors make the productivity, stability, sustainability and equitability of the system in a dynamic state. The different responses made by farmers to the farming system changes result in stratification of the society into different household categories and thus increases society heterogeneity[7]. Identification of existing agro-ecological zones and household categories is important in any intervention programme. One way of dealing with increasing diversity in agriculture is to define small

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[7] Heterogeneity is the condition of being composed of parts of different kinds.

entities which could serve as more uniform units of diffusion. This avoids the major problem of precedent approaches of transferring general technology to a heterogeneous environment (Steenhuijsen, 1995).

As a consequence, data analysis of this study has covered the similarities and differences between and within the agro-ecological zones and household categories in terms of value of assets owned per household.

2.7 Economic importance of bananas

Bananas are mainly produced by smallholder farmers on an average field size ranging from 0.5 to 1.7 ha per household (Mgenzi and Mbwana, 1999). Bananas are largely grown for food consumption, with surpluses sold in urban areas and some village centres of the rural areas. In Tanzania, banana is the staple food crop of an estimated 20–30% of the total population (Walker *et al.*, 1984). Despite the persistence of biophysical and economic constraints, the role of banana as a cash crop, compared to a subsistence crop, has gained importance in recent years. Since the banana plant produces fruit throughout the year, it contributes in crucial ways to the food and income security of households in banana growing areas. In the heavily banana-based farming systems such as Kagera and Kilimanjaro regions, about 70 to 95% of households grow bananas for food and/or cash. In these areas, banana ranks first as major food staple, and second or third as a cash crop (Nkuba *et al.*, 2003). In other areas, households maintain only a few banana plants mainly for dessert and roasting. At the national level, banana ranks third in volume of production among food crops in Tanzania (NBS, 2001).

2.7.1 Banana growing areas

Kagera region forms part of the banana growing areas along Lake Victoria that stretch from the northeast portion of the lake through central and western Uganda. Farmers in this region grow many of the same banana types (genomic groups and clone sets) and similar cultivars (clones), though with different local names (Appendix 1). The other production areas in Tanzania are the highlands of Kilimanjaro, Arusha and Tanga in the Northern Zone, Mbeya, Ruvuma and Iringa in the Southern Highlands Zone, Coast and Morogoro in the Eastern Zone and Zanzibar Islands (Appendix 2). The Lake Zone has the highest banana production followed by Northern Zone and Southern Zone in that order. In 1997/98 and 1998/99, the Lake Zone produced about 45% and 43% of the total banana production (2.6 MT) in the country respectively (MOAC, 2000). In Kagera region, the East African highland banana (EAHB) is the dominant and endemic type grown.

2.7.2 Banana production

From 1992/93 to 2000/04, the total cultivated area under bananas ranged from 0.25 to 0.35 million ha, equivalent to 2.5% to 3.5% of the total cultivated land area in Tanzania. Over the same period, national average banana yields were from 2.4 to 3.5 tons per ha and production ranged from 0.7 to 2.6 million metric tons per year, depending on weather conditions (Fig. 2). Based on production records the banana crop ranks third after maize and cassava crops.

The total estimated annual production of bananas in Kagera region is 1.26 metric tons on 185 000 ha, which is equivalent to 6.81 tons per ha (Mbwana *et al.*, 1997). The attainable yields recorded by research at on-farm and on-station trials range from 25 tons per ha to

40 tons per ha, while the actual yields obtained by farmers ranges from 6 tons to 10 tons per ha (Mbwana *et al.,* 1997).

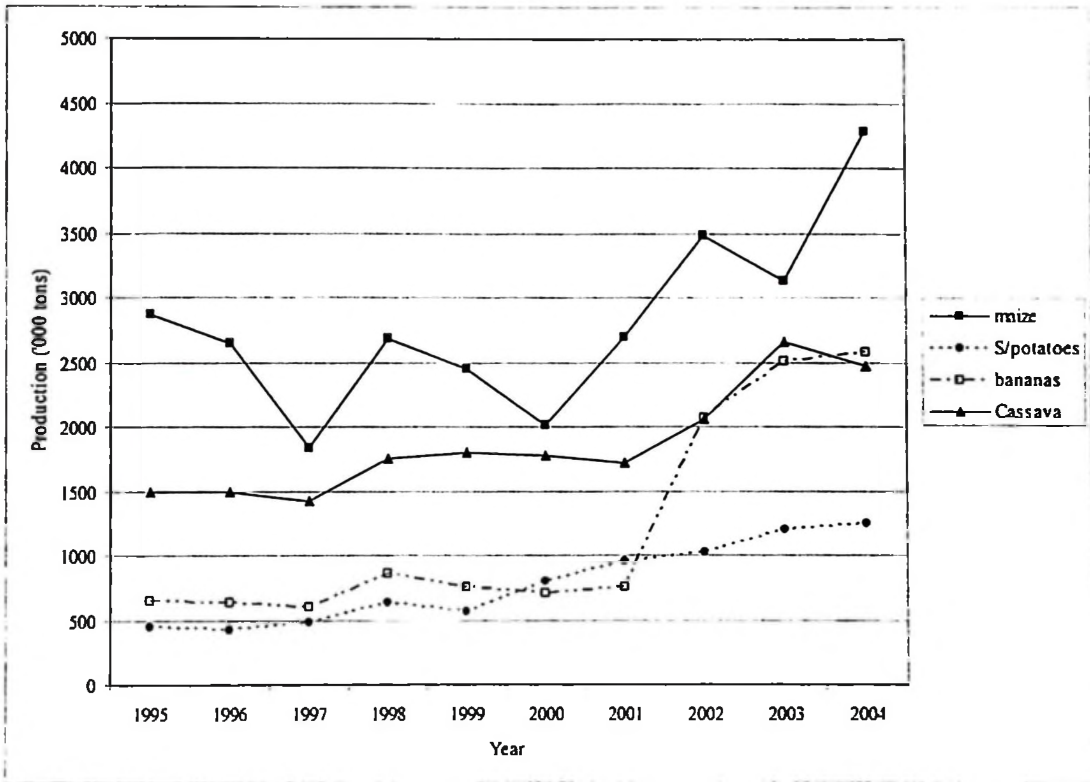

Figure 2: Annual production of selected major staple foods in Tanzania during the 1995-2004 period.

Source: (Vice President Office: Planning and privatisation, 2004).

Although banana is the most widely grown food crop in the region, its overall average productivity at smallholder level is still too low. Banana crop covers about 33% and 26% of the total land (478 115 ha) under crops in Bukoba and Karagwe respectively (Table 1). Cassava and beans are intercropped with bananas and maize follows in terms of crop area cultivated.

Table 1: Area (ha) under crop production by district, Kagera region during period of 1996/97 – 2000/01.

Crop type	Bukoba	Muleba	B'mulo	Ngara	Karagwe	Total	% of total
Food crop:			Hectares				
Bananas	47 830	36 807	1 870	25 549	41 289	153 345	27.64
Maize	11 490	4 440	25 445	4 347	25 523	71 245	12.85
Sorghum	-	-	8 675	3 056	2 500	14 231	2.57
Sweet potatoes	15 970	6 060	13 647	151	6 961	42 669	7.69
Cassava	15 551	15 401	33 570	9 524	34 763	108 809	19.62
Paddy	-	-	1 826	-	-	1 826	0.33
Beans	21 560	8 631	16 795	5 786	32 856	85 628	15.44
R/potatoes	-	-	-	-	361	361	0.01
Total (food)	**112 401**	**71 339**	**101 829**	**48 292**	**144 254**	**478 115**	**86.20**
Cash crop:							
Coffee	31 434	19 374	617	762	15 895	68 082	12.27
Tea	1 129	133	-	-	-	1 262	0.23
Cotton	-	-	7 191	-	-	7 191	1.30
Total (cash)	**32 563**	**19 507**	**7 808**	**762**	**15 895**	**76 535**	**13.80**
Grand total	**144 964**	**90 846**	**109 637**	**49 054**	**160 149**	**554 650**	**100.00**

Source: Regional Commissioner's Office, Bukoba, (2003).

Table 2 shows production trends of food crops harvested in the region between 1996/97 and 2000/2001. On average, more than 1.5 million tons of crops were harvested annually (NBS, 2003) in which bananas accounted for 60% followed by cassava at 17%. Karagwe District contributed about 45% of the regional banana production, Bukoba District (Rural and Urban) 23%, Muleba 20%, Ngara 11% and Biharamulo 1% (NBS, 2003). Surplus bananas are sold on local markets within the region and neighbouring regions of Mwanza and Shinyanga.

Table 2: Estimated production (in "thousand" Metric Tons) of major food crops Kagera region 1996/97 – 2000/01

Crop	Year					5 years	% of
	1996/97	1997/98	1998/99	1999/00	2000/01	average	total
Bananas	902. 57	885.34	925.56	941. 51	945.00	920.00	60.1
Maize	74.80	76.50	71.90	72.70	80.60	75.30	4.9
Sorghum	9.40	8.10	9.20	9.70	9.80	9.24	0.6
Sweet potatoes	151.30	204.60	243.30	184.15	192.90	195.25	12.8
Cassava	326.35	256.10	244.80	258.65	246.50	266.48	17.4
Paddy	0.89	1.09	0.79	0.72	1.08	0.91	0.1
Beans	53.20	65.30	68.30	54.77	55.80	59.47	3.9
Round potatoes	4.00	3.40	3.56	3.60	3.50	3.61	0.2
Total	**1522.51**	**1500.43**	**1567.41**	**1525.80**	**1535.18**	**1530.26**	**100**

Source: Regional Commissioner's Office, Bukoba. (2003).

The farm gate prices of banana bunch fluctuate within and between harvesting seasons, ranging from about 10 to 20 times the wholesale prices (Nkuba *et al.*, 2002). Large-scale traders receive the largest (40% to 60%) shares of gross marketing margins, followed by retailers, small-scale traders (20% to 30%) and farmers (5% to 10%). Banana export has not yet developed enough to exploit access through marine transport and make use of world markets (Spilsbury *et al.*, 2003), though the tastes and preferences of consumers in the world market would also need to be taken into account.

However, both the domestic and international demand for bananas is thought to have the potential to increase in the near future, mainly with growing populations and increasing per capita income. Improvements in road infrastructure, including main and feeder roads, will enhance market demand and enable traders to access supply areas easily. Application of appropriate processing technologies may also lead to differentiation in product demand. Effective market promotion of banana products could enhance the capturing of the available market niches in the world markets. Principal buyers for cooking bananas are consumers within the growing areas while buyers of roasting and frying bananas are mainly hotels located within or outside the banana growing areas.

2.7.3 Constraints faced by banana farmers

The major banana production constraints faced by farmers in Tanzania include increased pressure of pests, declining soil fertility and poor agronomic practices (Bosch *et al.*, 1996; Ndile *et al.*, 1999; Mgenzi *et al.*, 1999). The major pests of bananas found in Tanzania are banana weevils (*Cosmopolites sordidus*), nematodes (different species), Black Sigatoka (*Mycosphaerella fijiensis*) and Fusarium Wilt (*Fusarium oxysporum cv cubence*). Regardless of the banana farming system, local banana varieties demonstrate tolerance to Fusarium Wilt but none tolerate banana weevils and nematodes. Exotic banana varieties such as Kijoge, Kanana and Kisubi/Kainja are very susceptible to Fusarium Wilt but tolerant of banana weevils and nematodes. Banana-based farming systems receive high levels of rainfall, which contribute to leaching of soil nutrients (Baijukya and Piters, 1999). Large amounts of soil nutrients are removed through the harvested fruit bunches, especially if bunches are sold and taken away. Lack of nutrient replenishment in turn leads to declining banana productivity. Producer prices are too low to justify the use of chemical fertilizer in banana production. The situation is made exacerbated by inadequate extension and research services, poor farm input distribution systems, high prices of inputs, and lack of credit, for either farmers or traders (Bosch *et al.*, 1996; Ndile *et al.*, 1999; Mgenzi *et al.*, 1999).

Many producers and traders have no information about prevailing prices in markets within and outside the country (Nkuba *et al.*, 2002). Banana bunches are bulky in nature and perishable. Farmers often have little alternative but to sell bananas at "throw away" prices. Banana traders have no insurance coverage, therefore the risk is undertaken solely by the business and traders are obliged to charge high marketing margins in order to offset risks. Application of processing technology could support product differentiation, eliminating at least some of these problems. However, processing of bananas into products with longer shelf life products such as dried bananas, banana flour, banana biscuit and breads is not well developed in the country. Only an estimated 5% of all banana production is processed (Mbwana *et al.*, 1997).

2.7.4 Banana cultivars grown in the region

Cultivation of African Highland bananas in the Great Lakes Region (Tanzania, Uganda, Kenya, Rwanda, Burundi and Democratic Republic of Congo) is said to have started before 500 AD (INIBAP, 1996). It is said that banana replaced millet and yams, which were the staple food crops up to 15th Century in the region including western parts of Tanzania (Kagera region). Since then much evolution has occurred, resulting in the presence of 120 to 150 banana cultivars, which are unique to the Great lakes Region (Karamura and Karamura, 1994; INIBAP, 1996). In each banana growing community, new banana varieties have been informally introduced continuously by newcomers or villagers who visited other banana growing areas and return with banana planting materials. Farmers have introduced planting materials from other villages in the same regions, other regions of Tanzania, and other countries. Today, there are banana varieties regarded as ancestral to the community i.e., "endemic" cultivars, and those, which are considered to be new, or "non-endemic" cultivars. Non-endemic cultivars are introduced when the yields of ancestral (local) varieties decline due to disease or pests. The proportion of ancestral and new varieties varies by location and community. All banana cultivars grown in Kagera region can be categorized into four major use types (cooking, brewing, roasting and dessert), with the relative importance in the area planted also varying by agro-ecological zone.

2.7.4.1 Endemic banana cultivars

The common and dominant banana type grown in Kagera region is the East African Highland bananas (Baker and Simmonds, 1952; Rossel and Mbwana 1991). These cultivars are sterile triploids derived from *Musa acuminate* (A) and are regarded as endemic (traditional) bananas. These bananas thrived relatively well until late in the nineteenth century, due to availability of cattle manure (Bosch *et al.,* 1996). The situation changed dramatically when the cattle population was decimated by rinderpest. By the 1930s, production of bananas declined further due to water stress and increasing biotic pressures from banana weevils and nematodes, and Panama disease (Ndile *et al.,* 1999).

2.7.4.2 Non-endemic banana varieties

The continuous declining of the traditional bananas due to increasing banana constraints necessitated farmers in Kagera region to look for non-endemic banana cultivars within and outside the farming system to replace the dying banana cultivars. These banana cultivars are referred to as exotic that are either a diploid, triploid or tetraploid combination of *Musa acuminate* (A) and *Musa balbisiana* (B). The exotic cultivars include both landraces and hybrid cultivars. The period between 1960s and 1970s saw the introduction of the current old exotic bananas were introduced into the farming system from neighbouring countries (Uganda, Rwanda and Burundi), Eastern (coast areas), Northern and Southern Highlands of Tanzania. The exotic varieties include Kijoge (*Gros michel*), Kisubi/Kainja (Pisang Awak), Mtwishe (*Medium Cavendish*), Kiguruwe (*Short Cavendish*), Bluggoe, Plantains, and Mshale. These varieties appeared to withstand the most common banana constraints at that time and spread rapidly into areas where local bananas were perishing. These types later succumbed to other banana pests and diseases, such as Fusarium wilt (*Fusarium oxysporum*), known as Panama disease. In the 1980s, banana production again declined further, especially in Bukoba and Muleba Districts. Farmers began cultivating other (mainly annual) crops to fill the food and income gaps left by curtailed banana production. During the 1980s, farmers diversified their production into other food crops, including maize, roots and tubers. This implies that there was a reduction in the banana mats as the result of perishing of some of the endemic and non-endemic banana cultivars from increasing banana pressures.

2.8 Banana projects in combating banana constraints

The extension services aimed at improving the banana production goes back to the colonial era. The colonial government attempted to eradicate the banana weevils but farmers resisted the order of uprooting all bananas infested by weevils, partly because of misunderstanding the whole concept (Kabwoto, 1974). Towards the end of the 1960s, an insecticide (dieldrin) was recommended for the control of banana weevils. The insecticide was given free of charge and 60% of the farmers applied the insecticide (Rald and Rald, 1975). After dieldrin application, however, banana plants fell over more frequently than before and farmers complained that the insecticides killed their bananas (Ndile *et al.*, 1999; Bosch *et al.*, 1996; FSR, 1990). Most farmers have since been reluctant to apply chemicals of any type including artificial fertilizers in their banana groves (Ndile *et al.*, 1999; FSR, 1990). Since then, farmers have reacted negatively to the proposal of any banana management involving application of any artificial chemical. The introduction of new banana varieties into the region was therefore considered to be a remedy to the problem.

2.9 Introduction of new banana varieties

Since farmers have hesitated to apply any artificial chemicals on their banana fields up through the 1990s, there was a need to look for alternatives such as planting materials that are tolerant to the existing biotic constraints. In 1997, Kagera Community Development Programme (KCDP) was established with the goal of increasing household food and income security by improving banana productivity.

Major activities conducted by KCDP included the importation of tissue culture plantlets, hardening through primary nurseries, multiplication and dissemination activities. A total of 25 new varieties were imported as shown in Table 3. Concurrent to the dissemination activities, the programme facilitated the on-farm testing of the new varieties. From 1997 to 2002, KCDP contracted ARDI Maruku to conduct comparison studies of local banana cultivars to imported cultivars through on-farm trials conducted in all five districts of the region.

The on-farm trial included a total of 14 new varieties (Table 3). The International Transit Centre (ITC) of the International Network for the Improvement of Banana and Plantain (INIBAP) based at the Catholic University of Leuven, Belgium supplied the in-vitro plants. By July 2002, about 71,000 in vitro plants had been imported and by March 2002, a total of more than 2.5 million banana suckers were estimated to have been distributed to farmers either directly or indirectly (KCDP, 2003, Appendix 4 and 5). These efforts were responsible for the distribution suckers in 344 villages out of the 602 villages in the region (Weedrt, (2003).

Table 3: Names of new (superior) bananas disseminated by KCDP

Variety	Year multiplied for first time	Exotic/ hybrid	Origin	On-farm tested
FHIA01	1998	Hybrid	Honduras	1997
FHIA02	1998	Hybrid	Honduras	1997
FHIA03	1998	Hybrid	Honduras	1997
FHIA17	1998	Hybrid	Honduras	1999
FHIA18	2000	Hybrid	Honduras	No
FHIA21	2000	Hybrid	Honduras	No
FHIA23	2000	Hybrid	Honduras	1999
FHIA25	2000	Hybrid	Honduras	No
FHIA22	2000	Hybrid	Honduras	No
AAcv Rose	1998	Hybrid	Honduras	1999
Yangambi km5	1998	Landrace	DRC	1997
Pisang Ceylon	1998	Hybrid	IITA	1999
Pisang Berlin	1998	Hybrid	IITA	1999
IC2	1998	Hybrid	IITA	1999
Pelipita	1998	Hybrid	IITA	1999
Saba	1998	Hybrid	IITA	1999
Cardaba	1998	Hybrid	IITA	1999
Pisang Sipuru	1998	Hybrid	IITA	No
Bita3	1998	Hybrid	IITA	No
SH3436-9	1998	Hybrid	IITA	1999
Paka	1998	Hybrid	IITA	No
SH3640	2000	Hybrid	IITA	No
Kamaramasenge	2000	Exotic	Rwanda	No
CRBP	2000	Hybrid	-	No
KCDP1	2000	Hybrid	-	No

Source: KCDP, 2003

These high numbers were achieved through direct (nurseries to farmers) and indirect (farmer-to-farmer) diffusion. The KCDP project involved government extension services, non-governmental organizations (NGOs), religious groups, primary schools, and some individual progressive farmers in the establishment of nurseries and multiplication of planting materials (KCDP, 2003). Distribution of planting materials was mainly free although effort to commercialize was attempted in some selected villages, where a sucker was sold at TSh 100.

Figure 3 depicts the dissemination routes of 'superior' banana varieties and actors involved from the FHIA in Honduras to farmers in Kagera region. The dotted line indicates that there was little information used from on-farm testing before multiplication activities were conducted. The dashed line demarcates the direct and indirect diffusions of superior bananas. In direct diffusion, farmers obtained new planting materials from multiplication, trials or demonstrations. Indirect diffusion refers to farmer-to-farmer transfer of materials.

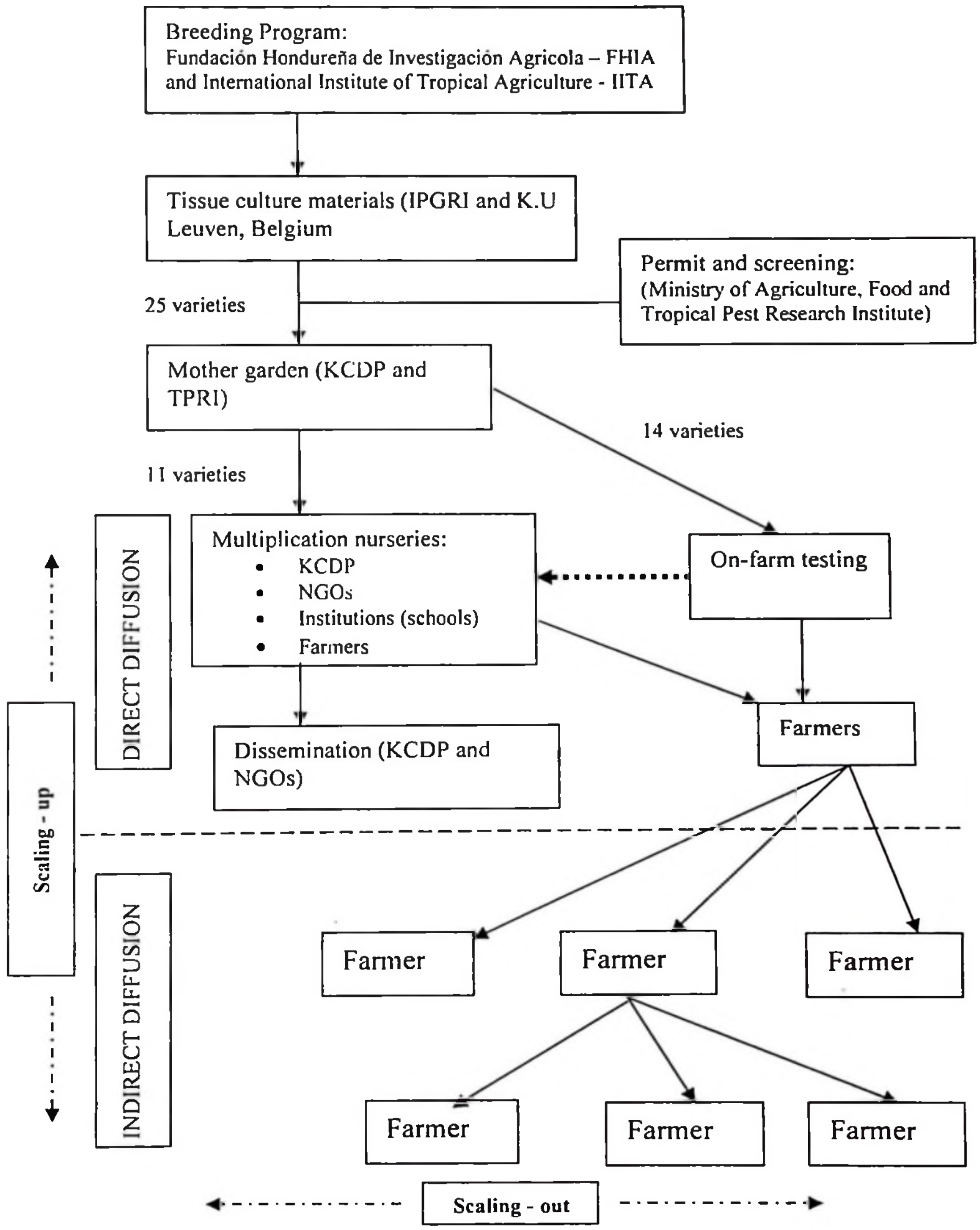

Figure 3: Dissemination routes of new banana varieties in Kagera Region

2.10 Agricultural household models applications

Although most formal models as reviewed by Feder and Umali (1985), depicting the adoption of new seed varieties, analysed farmers' choices in a profit-maximizing context with credit constraints, risk and uncertainty, recent approaches have been cast in the framework of the agricultural household (Singh *et al.*, 1986; de Janvry *et al.*, 1991; de Janvry and Sadoulet, 1995). This framework integrates production and consumption decisions to address the problem of incomplete markets, a common feature in developing countries. Widespread application of the approach in policy modelling enhanced the understanding of the manner in which agricultural households respond to various interventions, such as the marketed supply response to price changes (Singh *et al.*, 1986).

2.10.1 Market situations faced by smallholder banana farmers

If perfect markets exist for all products and factors, including all categories of family labour, then all prices are exogenous to the household, and all products and factors are tradable. Under this condition, all prices of bananas (P^b) and farm inputs such as fertilizers (P^f) and labour (P^w) are exogenous to the household, and there is no transaction costs involved in trading. The household makes its production and consumption decisions separately and sequentially - i.e., they are recursive (Strauss, 1986; de Janvry, Fafchamps and Sadoulet, 1991; Sadoulet and de Janvry, 1995). Thus, the production problem is solved without reference to consumption decisions and the consumption problem is solved by taking into consideration the outcomes from the production decision.

Subsequently, production decisions made by a household are taken to maximize profit and the household makes consumption decisions subject to budget constraints. The maximum profit (π) is used as a hinge between the production and consumption decisions. Therefore, under this condition, a banana household will choose to grow new varieties (Z) in order to maximise profit from banana production that corresponds to area under bananas (B^p) subject to the household (hc) and farm characteristics (fc).

$$\text{Max } \pi(P^b, P^f, P^w, B^p, Z \mid hc, fc) = [P^b B^p - C(P^f, P^w, B^p, Z \mid hc, fc)]$$

The reduced form model of supply (area) function can be expressed as:

$$B^p = f(P^b, P^f, P^w, Z \mid hc, fc)$$

In Tanzania, as in many other developing countries, households are typically located in an environment characterized by a number of market failures for some of their products. Market failure is mainly caused by high transaction costs, uncertain weather conditions and price risks (Singh *et al.*, 1986). Transaction costs result from high transportation costs associated with poor infrastructure and long distances from markets. They are also dominated by shallow local markets, which imply a high negative co-variation between household supply and effective prices (Sadoulet and de Janvry, 1995).

The banana-based farming systems of Kagera are characteristic of this situation. When the banana harvest is good and the household could have a marketed surplus, the price falls because all other households also have plentiful harvests and the subjective equilibrium price remains within the price band[8]. Price risks and risk aversion also influence the effective price used for decision-making. Bananas are typically produced with family labour and other inputs such as organic fertilizers that are mainly produced on the farm as by-products of other farm activities. Farmers make minimal use of inputs that require cash such as artificial fertilizers. Similarly, reliance on family labour in production implies that leisure is valued by its marginal worth to the household rather than as an opportunity cost imputed from a market wage rate. Banana produced on the farm is either consumed entirely or in part by the household, and the remaining part is sold to obtain cash, typically at farm gate prices.

Under such market conditions, the household production and consumption sides are no longer separable and must be estimated simultaneously i.e., the estimation of production and consumption behaviour must be in a non-separable household model (de Janvry *et al.*, 1991). All prices of bananas and farm inputs such as fertilizers and labour are endogenous to the household, rather than exogenous and are determined by the equation of within-household supply and demand (de Janvry *et al.*, 1991). Therefore, endogenous prices depend on all factors that influence household decision-making (Strauss, 1986).

2.10.2 Utility maximisation

Utility refers to desirability of an outcome (or process) to the consumer or beneficiary. A utility function summarises the preferences or satisfaction of the individuals own process or outcome that is affected by a variety of factors (Nicholson, 2002). In the context of

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[8] Shadow price obtained by a farmer in absence of markets that lies between the producer and consumer prices (Sadoulet and de Janvry, 1995).

banana farming, utility can be defined as a cardinal measure of a specific level of banana production or specific livelihood outcomes accrued from banana production and consumption. This implies that banana farming (production) along with the consumption of other goods, services and leisure is a fundamental determinant of the level of satisfaction or well-being.

A banana household problem in a given period is to maximize utility outcomes conditional on a set of farm (fc) and household (hc) characteristics:

$$\max \mu(c^b, B^p) \parallel fc, hc;$$

Where c^b denotes the final consumption goods including bananas and B^p denotes the banana production per household.

The introduction of new banana varieties to a farmer who is growing local banana varieties can be adopted provided the adoption will maximise the expected utility of the farm household. Consequently, the utility is a function of the farmer's choice between local and improved banana varieties or both at each time period subject to household and farm characteristics. The farmer's technology adoption is measured by a single binary variable; present or absent on a farm at a particular time. Hence, the response probability of the adoption of new varieties can be expressed as:

$$p(Z=1 \mid x) = p(Z=1 \parallel hc, fc \quad \text{......} \quad (1)$$

Therefore, the maximum expected utility of a household can be expressed as

$$\text{Max } \mu[(c^{b}, Z, B^{p}) \mid hc, fc]$$

However, banana production is affected by a number of factors including fixed land available (A^{b}), leisure time (labour) (L), variety choice (Z), exogenous income (E_{x}) and exogenous effective market (farm gate) prices for bananas sold (P^{fg}).

Production decisions regarding banana quantity B^{p} produced by a household can be expressed as:

$$B^{p} = [f(A, L_{t}, Z, P^{fg}) \mid hc, fc,] \quad \text{...} (2)$$

Hence, the maximum expected utility of a household can be expressed as:

$$\text{Max } \mu[(c^{b}, A, Z, L, E_{x}, P^{fg}) \mid hc, fc]$$

A banana household problem is also to maximize utility outcomes related to food and income security (i.e., consumption and profit) from use of new banana varieties subject to farm and household characteristics. Subsequently, a banana producer behaves as if he or she is maximising profit using the endogenous decision prices (P^{*}) of bananas. Hence, the optimum levels of products and factors yield maximum profit:

$$\pi = \sum P_{i}^{*} q_{i}^{*} \quad \text{...} (3)$$

On the demand side, decisions are also made in terms of endogenous prices (P^*), for which the income constraint can be expressed as:

$$\sum P_i^* c_i \leq \pi + \sum P_i^* E_i + k = y^* \quad \text{...} (4)$$

Where k denotes exogenous income of household and y^* as full-income constraint.

Therefore, the banana demand equation can be written as:

$$c = f(P^*, c^*, hc) \quad \text{..} (5)$$

On the consumption side, the household behaves as if it was maximising utility using the P^* prices and c^* consumption. Note that for bananas sold, the decision prices are effective market prices or farm gate price (P^{fg}), and for non-sold bananas, the decision prices are the shadow prices (P^{nt}).

Assuming that a household has an initial endowment of time L, variety choice and fixed land for banana cultivation, the time constraint requires that the time allocated to banana production L^b and home activities L^a does not exceed total time available to the household: $L \geq L + L^a$.

Likewise, the supply of other inputs used in banana production is fixed signifying the presence of market failures and also defining the linkage between the choice of the banana varieties (local and new varieties) and other farm activities. The household cannot demand more than it can supply from its own sources. A household has to make a choice between local and new banana varieties to grow; i.e., binary variable (1, 0). The two varieties compete for land allocated to banana production. The household can choose to continue growing all local bananas or all new bananas or allocate part of the banana land under local varieties and the remaining under new varieties. Therefore, the share of the banana field the farmer allocates to the new banana varieties ranges from 0 to 1. Given a binding land constraint, the sum of land allocated to local varieties (A^o) and land under new varieties (A'') should not exceed the total banana land available per household A.

Therefore, $A \geq A^o + A''$ and banana output B^p can be expressed as:

$$B^p = [f^o(A^o,..|\, hc, fc)] + [f''(A'',..|\, hc.fc] \quad \text{.................................} (6)$$

Production and consumption decisions are functions of the decision endogenous banana prices (P^*), value of consumption (y^*), endogenous income, (E_n), exogenous income (E_x), and variety choice (Z) subject to household characteristics (hc) and farm characteristics (fc) that are associated with production and consumption decisions. The endogenous P^* and y^* themselves are functions of the exogenous prices P^{fg} and household (hc) and farm (fc) characteristics. The fully reduced equations (by eliminating P^* and y^*) can be expressed as:

$$B^p = f(\bar{P}, A, Z, E, Ic \mid hc, fc)\text{, for production function} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

$$C = f(\bar{P}, A, Z, E, Ic \mid hc, fc)\text{, for consumption function} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

In contrast to the separable household model assumed under perfect market conditions, in the presence of incomplete markets, the income of the household is endogenous at the time of making decisions (the choice to grow or not to grow new banana varieties). However, the household's exogenous income (E_r) is the cash endowments or in form of net transfers from private assets includes bilateral transfers in form of gifts, remittances, or credits or informal loans from friends, relatives or farmer groups or associations.

2.11 Conceptual framework

2.11.1 New banana varieties and livelihoods of people

The outcomes (impacts) of new banana varieties on the livelihoods of people in Kagera were investigated by applying the theoretic framework of the agricultural household and econometric models of the variety adoption. Impacts of new banana varieties can accrue directly or indirectly to a household through the decision to grow them or through effects that "spill over" from other adopting households. This cause-effect relationship involves three parts. The first part is a decision to grow the new banana varieties (adoption). The second is the realisation of outputs accrued from planting the new varieties and the third is the impact on livelihoods.

The impact on livelihoods can be measured by a set of observable outcomes, such as changes in yield or yield losses, food security, income, household asset accumulation and the social relationship of individual households with vis-à-vis other households. As explained in section 2.2.8, since at least some of the observable and unobservable factors that influence adoption also influence the outcomes of the adoption process, these stages are best modelled simultaneously rather than sequentially. Thus adoption is embedded within the impact model.

2.11.2 Outcome (impact) indicators

The starting point in considering the possible outcome (impact) indicators (y) of adoption is the vulnerability context within which banana producers operate (Fig. 4) and described in detail at (DFID, 2002). As it explains in previous chapters, smallholder producers of bananas are vulnerable to a variety of constraints and shocks in their banana production that threaten their livelihood. These threats include increasing infestations of banana pests (banana weevils and nematodes, Black Sigatoka and Panama disease), declining soil fertility, low genetic vigour of local varieties and lack of markets. Growing local banana varieties that are susceptible to one or more of these threats leads to a decline of banana production and ultimately high vulnerability of livelihoods resulting into low production of bananas worsening the food and income security in the area. This situation has been compounded by prolonged price crises of coffee, the major traditional cash crop grown by smallholder farmers in the region. Expansion of cultivation of other crops such as cereals, root and tuber crops are also limited by lack of technical know-how to farmers, lack of marketing and cultural barriers. The possible outcome (impact) indicators of new banana varieties are portrayed in Fig. 4.

If improved banana varieties that are relatively tolerant to banana production constraints compared to the local ones are introduced into the community, then farming households have the choice to plant traditional or the improved (new) varieties, or some combination in their groves. The new varieties were expected to have immediate impacts on household livelihoods through increased yields, reduction in yield losses, increased food and income security and improved relationship among households. Sustained changes in losses from pests and diseases can lead to reduction in vulnerability of household to fluctuating or disastrous yield levels. In the long term, this can contribute to increased and sustainable food security.

If marketed surpluses also increase with improved marketing conditions, use of new varieties can contribute to greater security of cash income. Eventually, higher and more consistent returns from banana production can affect the formation of household assets, support the cultural aspects of banana production, and reduce the negative environmental impacts. Whether or not income inequality was increased or decreased within communities was not predicted.

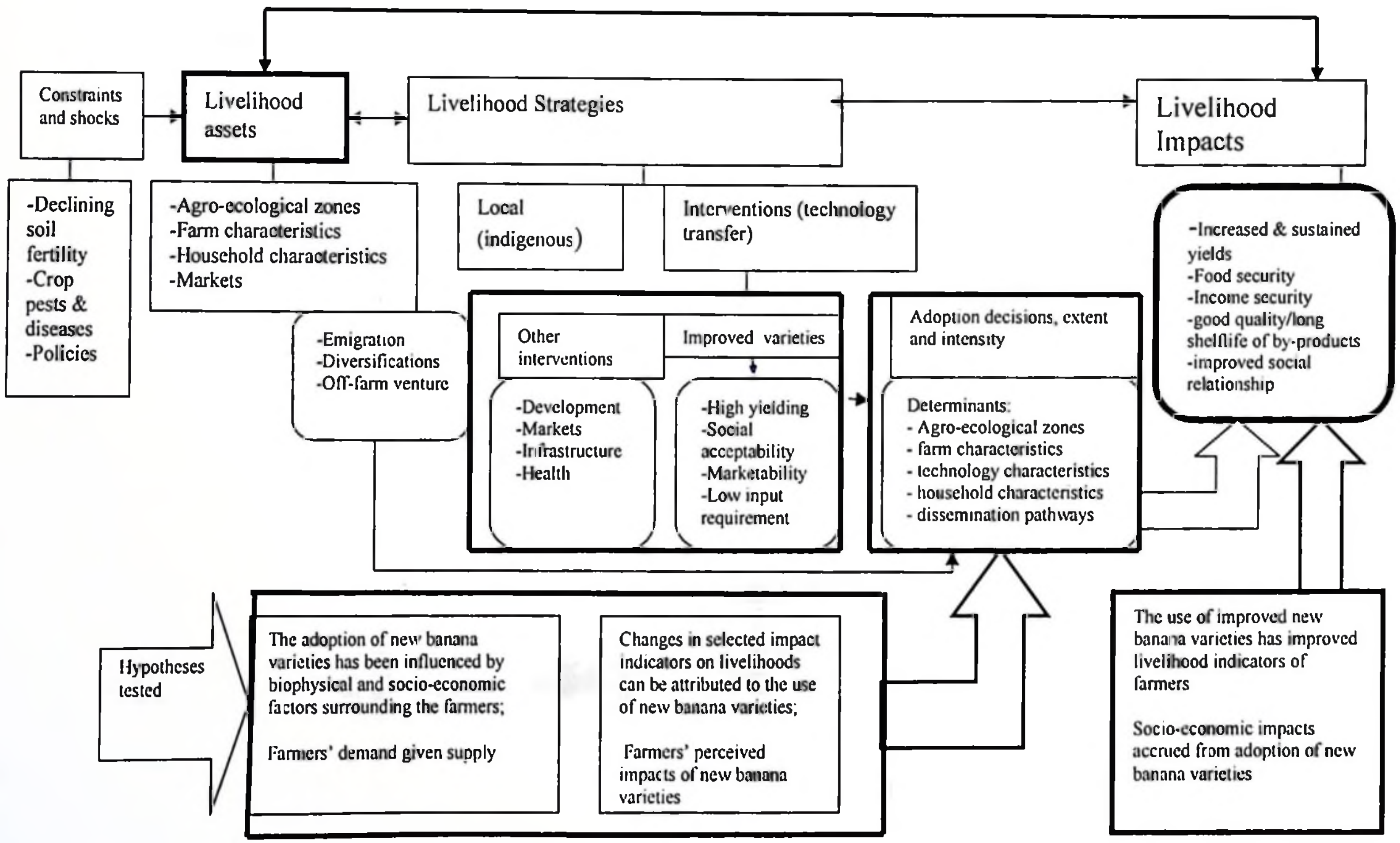

Figure 4: Conceptual framework of the study - some insights are from SL Framework (DFID, 2002)

In this study the agricultural household model was used to assess the effects of alternative choices: discrete choice i.e., to grow new banana varieties or not to grow, on the well-being of representative banana –farm households. Given this, equations (7) and (8) in section 2.8.2 can be collapsed into a single equation to read as:

$$y = f\{x, (Z \mid \Omega A)\} \qquad (9)$$

Where (x) is a set of independent variables influencing outcomes or impacts while (ΩA) is a set of independent variables influencing participation in planting new varieties (adoption) while outcome variable (y) is conditional on a dichotomous variable(Z). Therefore, the change effects (y) caused by use of new banana varieties can be measured by the difference between adopters and non-adopters.

Therefore, it can be concluded that in adoption and impact studies using cross-sectional data, it is important to define who are the adopters and non-adopters of a given technology, and establishment of the counterfactual – i.e., the treatment and control groups. Defining these groups correctly is a key to identifying what would have occurred in the absence of the intervention or technology. Adoption and impact studies are able to tell about the extent and pattern of adoption, farmers' characteristics and preferences, technology characteristics, farmers' perceived benefits from technology adopted and technology constraints.

Combining both quantitative and qualitative data collection methods yields effective adoption and impact studies. Depending on the nature of the study, data could be collected at individual, household, village/community, district/regional and national levels. The five main methods used in impact assessment studies are randomization (experimental), matching methods, double difference methods, reflective comparison methods and instrumental variable methods. The diversity and dynamics of the Kagera banana-based farming systems are clearly explained by the distinctive agro-ecological zones and land use types available in the region. Dynamics are observed in continuous differentiation of households, changing proportions of the land use types, changes in crop patterns, diversification of crops, changes in human and livestock populations, occupations, improvement in both physical and socio-economic infrastructures. However, the performance indicators of this farming system had experienced negative trends including production of bananas, a staple food crop in the region. In the past years, introduction of new banana varieties has been one of the coping strategies of reviving these trends.

Application of agricultural household models integrates production and consumption decisions to address the problem of incomplete markets, a common feature in developing countries. This enhances understanding of the manner in which agricultural households respond to various livelihood shocks. Banana production is affected by a number of factors including fixed land available, labour, variety choice, exogenous income, and exogenous effective market (farm gate) prices for bananas sold. Agricultural household models, econometric models and sustainable livelihood framework can be applied either singly or in combination when conducting adoption and impact studies. An econometric model on the other hand helps to explain technology adoption and the relationship between technology and the accrued outcomes on livelihoods. Sustainable livelihood framework, not only explains the cause-effect relationship in a broad context, but it enhances the identification of outcomes accrued from technology use.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Overview

This chapter explains the sample domain and weighting of sample units. It describes the survey instruments used in data collection and methods of data analyses. At the end, the definitions of the key variables (both dependent and independent variables) used in modelling are presented.

3.2 Sample domain

The study took place in the banana-based farming systems in Bukoba and Karagwe districts of Kagera region. This sample domain was purposively selected to cover major areas specializing in banana production as explained in Chapter Two. The history of banana cultivation, production levels and their trends (declining, constant or increasing) were taken into consideration. Bukoba district is dominated by areas with low and decreasing banana production while Karagwe district represents areas with high production that are stagnant or slightly increasing. Bukoba district has a higher incidence and severity of banana production constraints than Karagwe district. Although in both districts old and new banana fields can be found. Then, surveyed villages and households from each village were randomly selected.

The field survey was organised into two parts; Participatory Rural Appraisal (PRA) and household survey. The PRA was divided into phases; before and after implementation of the household survey. The household survey covered 13 villages that were randomly selected and from each village 20 banana farmers were randomly selected. This was conducted for a period of one year and a half, which was completed in April 2005 using structured questionnaires both single and multiple-visit schedules.

The first phase of PRA was aimed at gathering information from various key informants and stakeholders on multiplication and dissemination of new banana varieties, bio-physical and socioeconomic factors of banana production in the Kagera region. The information that was collected from various banana stakeholders in the region enabled the selection exercise of villages and farmers. The second PRA was implemented in May/June 2005 involving in-depth Focused Group Discussions (FGDs) on adoption and impacts of the new banana varieties. In each village general meeting of farmers attended were held to investigate the major problems and changes which have occurred in the community in past 7 – 10 years in banana sub-sectors and the players who have been instrumental in that changes occurring. This was followed by separate FGDs of men, women and youths to investigate in-depth the changes that might have occurred on farms and livelihoods of people as the result of adopting new banana varieties. The size of FGD was 8 to 12 farmers depended on the number of villagers attended the meeting. The formation of such groups also considered getting group that contains representatives of all sub-villages.

3.3 Sample stratification

Elevation and exposure to new banana varieties were selected as the two variables for stratifying the sample. The first was considered as one of the important environmental factors that affect adoption of new technologies. A critical parameter for the adoption of new varieties with improved resistance to pests (diseases) is the yield advantage attained relative to other banana varieties. A number of empirical studies indicate that elevation is highly correlated with soil fertility, incidence and severity of most of the banana pests and diseases (Tushemereirwe *et al.*, 2001; Bosh *et al.*, 1996; Speijer *et al.*, 1994). These factors significantly contribute to variation in productivity and probably the adoption of the new banana varieties. Elevation was delineated at 1200 m above sea level (a.s.l.), defining low elevation to be below 1200 m a.s.l. and high elevation above 1200 m a.s.l.

In order to predict the likelihood of adoption and to assess impacts of adoption of new varieties after the fact, it is important to compare the "factual[9]" (the actual case) with the "counterfactual[10]" (the situation in a comparable case where no adoption occurred). As described in the preceding section, the application of a treatment model for measuring impacts requires a "control" and "treatment" group. Thus, the second stratification variable considered was the institutional factor that affects adoption of new banana varieties in both exposed (treatment) and unexposed (control) areas.

Areas of "exposure" were defined as Villages/Wards where researchers, extension, or other programs had introduced improved planting material (banana suckers) in at least one community. Areas with no exposure are those where no organized programme designed to disseminate the improved planting materials but where some farmers could have got the new varieties through indirectly. Adopters represented the factual while non-adopters

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[9] The "factual" describes the state or situation in the presence of the technological change from the adoption of new technology (such as new crop cultivars or crop management).

[10] The "counterfactual" refers to the situation in the absence of the technology.

represented the counterfactual in predicting impacts of improved banana varieties. In each district, areas where new varieties were disseminated or not disseminated were identified using data provided by the District Agriculture and Livestock Development Office (DALDO) in collaboration with KCDP and ARDI - Maruku that is located in Bukoba district.

Geo-referenced data about banana production systems, a digital elevation model, maps of administrative units and information concerning previous diffusion of banana planting materials were used to disaggregate the domain into a total of four strata: 1) low elevation with exposure; 2) low elevation without exposure; 3) high elevation with exposure, and 4) high elevation without exposure. The domain and four strata were then mapped onto the administrative ward level (Smale *et al.*, 2005).

3.4 Selection of primary and secondary sampling units

Within each stratum, primary sampling units were drawn using systematic random sampling from a list frame with a random start and secondary sampling units were drawn using a list frame with a random start. The primary sampling unit (PSU) used was a ward and for the secondary sampling unit (SSU) was a village. Out of 13 PSUs (wards) selected, 9 were in Bukoba district and 4 in Karagwe district.

One SSU (village) was selected per PSU. The probability of selection (or sampling fraction) of a SSU varies by PSU and is denoted as $(1/M_p)$ where M_p represents the number of villages (exposed or/and unexposed villages) in the PSU. Where there is more than one exposed village per PSU, the SSU was drawn with a random number from the list of those villages. Whether or not a village selected in the sample had been properly classified as exposed or non-exposed was then verified at the site (Smale *et al.*, 2005).

3.5 Selection of households within a village

A constant sample size within villages was maintained due to time and financial constraints. The total number of households selected per village was 20, with variable probability of selection ($20/H$, where H is the number of households in a given village). If there was an order in the list of households, random numbers were used for selection. Otherwise, a random start with systematic random sampling from the list was employed. Households without banana farms were skipped. A total sample size surveyed was 260 households; 180 households in Bukoba district and 80 households in Karagwe district. The unit of observation and analysis for the sample survey was the farm household. A farm household is defined according to the culture of which the household is a part, and includes female-headed and child-headed (orphaned) households, as well as male-headed households with more than one wife. The overall probability of selecting a household in the village (sub-village) is denoted as PSH, a unique number and is defined as the product of the sampling fraction at each level:

$$PSH = [(n_i / N_i)(1/M_p)(20/H)].$$

For the descriptive analysis, weights per household were calculated as the inverse PSH and not for regression analysis as weights have no effect.

3.6 Post stratification of the sample by agro-ecological zone

During the implementation of the field work, it was observed that the diversity of Kagera region is not well reflected in elevation alone, partly because of existence of numerous and closest undulating surfaces from the East to West. Different levels of banana production and productivity can easily be observed between different agro-ecological zones as explained in Chapter 2 section 2.3. Although an elevation is one of the important factors in defining an agro-ecological zone, it does not suffice to be used alone. A selected village in a ward can be of high elevation or exposed when the ward is classified as low elevation or unexposed (or vice versa).

The sample domain was therefore post-stratified based on agro-ecological zones. Given that areas were sampled proportionately by elevation, and are therefore self-weighting on this stratification criterion, the agro-ecological zone was used instead of elevation in the empirical analysis in order to better capture the existing differences, without changing the sampling proportions. The post-stratification of the sample showed that of the 13 SSUs (villages) originally selected, four are in the BS, five are in the KAL and four are in the KAM. The PRA survey covered five villages, each one randomly selected to represent a zone and the level of interventions done by KCDP on multiplication and dissemination of planting materials of new banana varieties. Table 4 provides the names of the villages surveyed.

Table 4: Names of survey villages and their wards in parentheses by zone

Agro-ecological zone	Villages involved in household survey	Villages involved in PRA survey
Bukoban Systems (BS)	Minazi (Bujugo)	Minazi (Bujugo)
	Buhangaruti (Bwanjai)	Kiilima (Nyakato)
	Nyarugongo (Ishozi)	
	Butahyaibega (Kanyangereko)	
Karagwe-Ankolean Low (KAL)	Rubale (Rubale)	Minziro (Minziro)
	Minziro (Minziro)	Mushasha (Kyaka)
	Mushasha (Kyaka)	
	Kasharu (Kasharu) and	
	Ruhoko (Katoro)	
Karagwe-Ankolean Medium (KAM)	Nyakatera (Bugomora)	Bisheshe (Nyaishozi)
	Kishao (Bugene)	
	Kagenyi (Kyerwa)	
	Nyabwegira (Ndama)	

The names of villages surveyed in the PRA were Kiilima, Bujugo, Mushasha and Minziro located in Bukoba district and Bisheshe located in Karagwe district. Kiilima and Bisheshe were among the villages that were involved in the on-farm testing of the new banana varieties. Their characteristics are summarized in Table 5. The locations of the wards selected for the household and PRA surveys are shown on Fig. 5.

Table 5: PRA surveyed villages and their characteristics

District/ Village	Zone	Banana constraints	Market access	Level of dissemination activities
Bukoba district:				
Kiilima	BS	High	Medium	High: including on-farm trials, community multiplication garden, and other NGO's support
Bujugo	BS	High	Medium	Medium: Far from both multiplication and on-farm testing sites
Mushasha	KAL	Medium	High	Low: far from multiplication sites
Minziro	KAL	Medium	Low	High: multiplication sites, on-farm trial and other NGO's supports
Karagwe district:				
Bisheshe	KAM	Low	Medium	Medium: on-farm trials and processing technology support

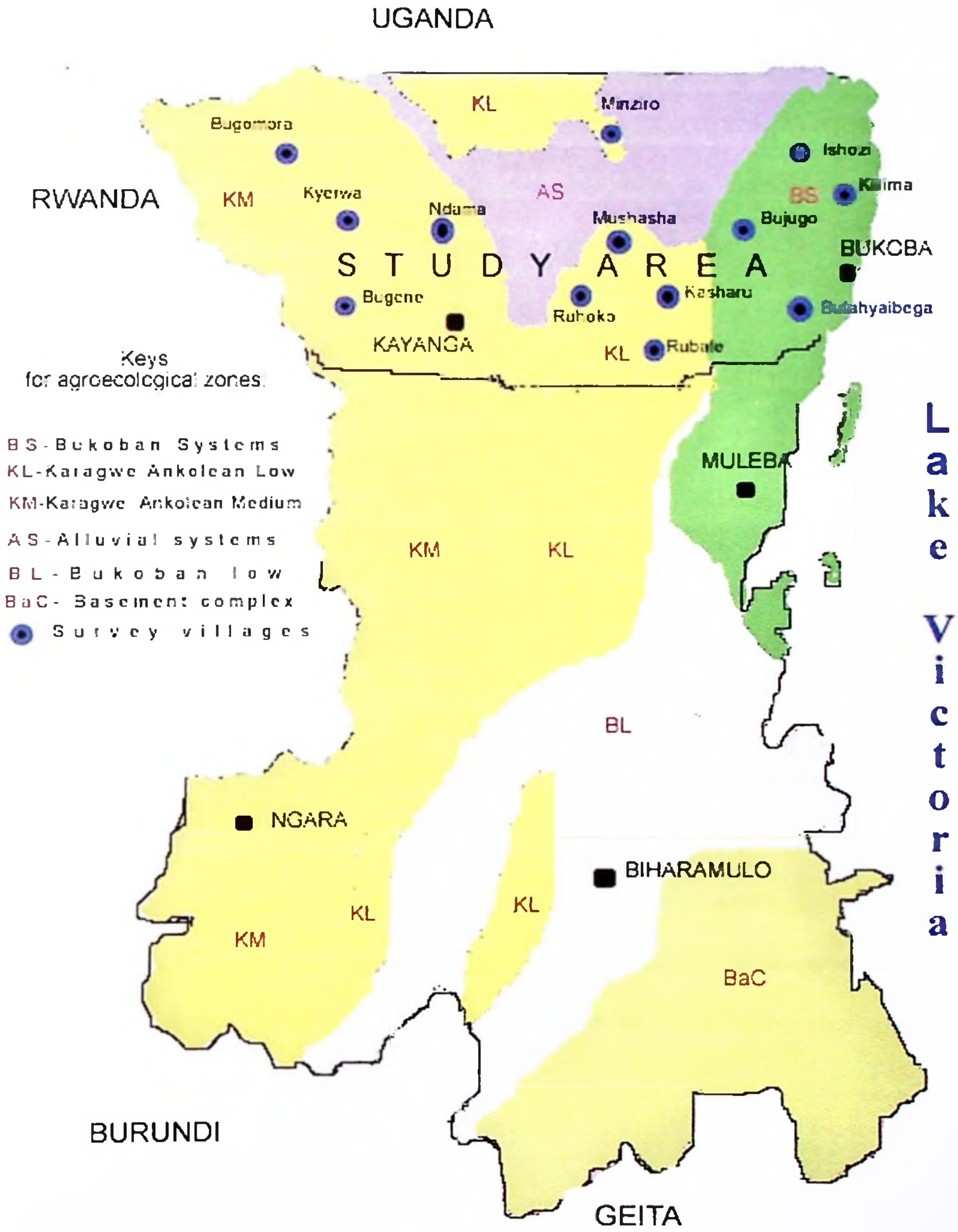

Fig. 5: Kagera: Map showing the survey villages

Source: Baijukya and Folmer, (1999).

3.7 Data collection

Both primary and secondary data were collected. Literature review of previous work conducted by research and extension programmes were the main source of secondary data. Some secondary data were collected from District Agricultural and Livestock Department Offices, KCDP and ARDI - Maruku. Primary data were collected using Participatory Rural Appraisal and in-depth household interviews. Both qualitative and quantitative survey instruments were used during data collection.

3.8 Survey instruments used for data collection

3.8.1 Participatory Rural Appraisal (PRA) survey

Participatory techniques were employed to collect qualitative data and insights into technology transfer pathways and farmers' perceptions related to the extent and intensity of adoption, and the benefits from new banana varieties. Thus, the qualitative data at level of community were collected and analysed using conceptual framework of sustainable livelihoods. The techniques included problem/causal, institutional and participation analyses. Key informants and FGDs were used to elicit information about the history of bananas in the village, trends in livelihoods, and the general perception of the socio-economic impact of new banana varieties. These methods were also used to map institutions in each village.

Both secondary and primary data were collected at three levels; district/regional headquarters, NGOs/community and village (as groups or individual farmers) levels using checklists. Data collected included types and number of organizations involved in dissemination of new banana suckers and other roles related to bananas. Other sources provided aggregate data on the type of varieties and number of suckers disseminated, number of villages and farmers which received the suckers, and the period they were received. Individual organizations that were involved in dissemination of banana planting materials were randomly selected after updating their list at regional/district level.

3.8.2 Household survey

The household survey was aimed at providing quantitative cross-sectional data that were used in statistical analyses addressing specific objectives. Data were collected using structured questionnaires that included household characteristics, number of parcels and plots of farms owned, farm sizes, crops/varieties grown and their number and acreage, crop production and yields, expenditure and incomes, level of pests and diseases, crop management levels, crop and livestock sales, pathways of acquiring the planting materials, types and banana bunches consumed and sold, banana uses by variety, labour and other inputs. For consistence, the exercise of data collection was organised into five instruments or schedules; household, general farm, banana plots, banana cultivars, expenditure and income (Appendix 6).

3.9 Methods of data analysis

Methods of data analysis used in this study were borrowed from tools and techniques of adoption and impact developed by Maddala (1983), Heckman (1995) and Wooldridge (2002).

3.9.1 Adoption analysis

Before the estimation of the impact indicators can be done, logistic regressions were estimated in order to examine the determinants of adoption of new banana varieties. This analysis was done to test the first objective of this study and thus to validate the first research hypothesis (Chapter One; section 1.4). Logistic regression is a linear probability model for binary response where the response probability is evaluated as a linear function of the explanatory variables (Maddala, 1983 and Wooldridge, 2003). The treatment decision is defined as a binary outcome of the use of new varieties by households in the sample, "1" being assigned for households who were adopters and "0" otherwise. Then the response probability is expressed as in equation (1). By assuming that the response probability is linear in a set of parameters, the Logit model can be expressed as:

$$\log\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_k x_k \quad \text{.......................................} (10)$$

Where $\beta_0, \beta_1, \beta_2 ... \beta_k$ denoted as estimated coefficients; $x_1, x_2, ... x_k$ denoted as independent variables and p denoted as probability of event (1, 0).

In addition, prior to impact analysis, analysis of determinants of the intensity of use of new banana varieties was conducted. The two dependent variables estimated the intensity of use were the number of new varieties in the grove and the number of mats of new banana varieties as a proportion of total mats in the banana grove (the mat share). The number of plants per hectare was not used due to the fact that the farm size was roughly estimated.

The same explanatory variables were tested to see whether they also determined the intensity of adoption. Since these dependent variables are limited outcome variables that are censored at one or both sides censored, Tobit regression model was used to estimate determinants of adoption intensity. This model fits well with a model of dependent variable on a set of independent variables where the censoring values are fixed (Maddala, 1983). Censored outcomes are those where observations are clustered at a lower threshold (left censored), an upper threshold (right censored), or both as shown below.

$y_i^* = \beta_i x_i + \mu_i$, if RHS > 0, and $y_i = 0$ otherwise .... (11)

Where, y_i^* is the latent variable, β is a (k x 1) vector of unknown parameters, x_i is a (k x 1) vector of known constant and μ are residuals that are independently and normally distributed. Given that y_i is the observed dependent variable, then

$y_i = L_{1i}$ if $y_i \leq L_{1i}$; $y_i = y_i^*$ if $L_{1i} < y_i^* < L_{2i}$; and

$y_i = y_{2i}^*$ if $y_i^* \leq L_{2i}$,

Being L_{1i} and L_{2i} are the lower and upper limits respectively.

The number of new varieties and their mats per household are right side censored while share of mats of new varieties to the total mats is truncated outcome ranges between 0 and 1 values i.e., neither right nor left censored.

3.9.2 Impact analysis

Analysis of the determinants of adoption was followed by estimation of the impact outcomes of adoption i.e., from using the new banana varieties – treating adoption as an exogenous variable (in order to find the reverse causal relationship). This analysis was done to quantify some of the identified expected outcomes of the new banana varieties on livelihoods of farmers (Objectives 2 and 3). The use of new banana varieties and their impacts on smallholder farmers were tested with a treatment effects model as defined and employed in different ways by Maddala (1983) and Heckman (1995). This model is widely known as Instrumental Variable (IV) method, which fits treatment effects models using either Heckman's two-step consistent estimator or full maximum-likelihood. The treatment effects model considers the effect of an endogenously chosen binary treatment on another endogenous continuous variable, conditional on two sets of independent variables. The endogenously chosen binary treatment is the choice to grow new banana varieties, controlling for exposure. The other endogenous continuous variable or set of variables are indicators of the impact of adoption; harvested bunches, percentage share of banana consumed and sold, average farm gate prices per banana bunch and total income obtained from banana sales.

The application of IV method helps to control for the potential endogeneity of use and outcomes. Variables are used as instruments that affect adoption but not the impacts of adoption. These include agro-ecological zone, biotic pressures, and exposure to planting materials of new banana varieties. The two-equation system enables the identification of the determinants of technology use (adoption of new banana varieties) as in logistic regression model, on the one hand, and the characteristics influencing impact (among them the use of technology), on the other.

3.9.3 Instrument variables model

The impact, or continuous outcome y_i, is conditional on a set of independent variables x_i and the endogenous dummy variable Z indicating whether the treatment has been assigned or not:

$$y_i = a + \beta x_i + \lambda Z_i + \varepsilon_i \quad \text{...(12)}$$

Equation (12) estimates mean impact indicators for adopters of new banana varieties and equation (13) estimates mean impact indicators for non-adopters.

$$y_i = a + \beta x_i + \varepsilon_i \quad \text{.. (13)}$$

Where a, β and λ are parameters. x_i stands for the control variables such as age, education, household size, farm size, agro-ecological zones, field quality, livestock ownership, asset values. ε_i denotes residuals that include other determinants of adopters and measurement errors. The estimates of λ give the impacts of adopting new banana varieties.

However, in order to get reasonable impact estimates appropriate methods of choosing the right control variables are needed. Based on Ravallion (1994), the expected mean of impact variables are allowed to vary by explanatory variables. The model was tested by adding an extra term of the interaction effects between adoption and observed characteristics to the regression equation. It was tested that the right-hand-side variables were all exogenously determined independently of adoption in new banana use and thus they were uncorrelated with the error term in the impact regression to avoid bias estimates. Therefore, during application of the instrumental variables method, at least one variable in that was not in y, and is not correlated with ε, were identified. Then, the instrumental variables estimate of the programme's impact is obtained by replacing y by its predicted value conditional on Z and under such situation, it is reasonable to apply ordinary least squares.

3.9.4 Definitions of dependent and explanatory variables

Based on the structure of the empirical approach and the goals of the analysis, two dependent variables were estimated in adoption analysis. The first dependent variable is the decision to grow new banana varieties as binary variable (1=grow any variety; 0=otherwise) that measures the extent of adoption and the second one is the number and/or percentage share of the mats of the new banana varieties that measures the intensity of adoption.

The impact dependent variables considered are average expected banana yield (kg) per bunch and average yield loss (percentage) that was generated based on the fact that the initial desired impact of using new varieties is a reduction in production vulnerability. Production vulnerability was measured on expected yield losses from pests and disease, and low soil fertility. Reduced vulnerability could lead to changes in consumption levels, either directly through meeting subsistence needs, or indirectly, through increased sales and market purchases. Unconditional expected yields were calculated using the marginal distributions of each disease separately. Once composed, the expected yield loss per constraint was averaged for each household. Subsequently, the maximum average expected yield across the three biotic constraints was chosen as a measure of production vulnerability. This specified one measure of yield loss per household, across constraints. Other dependent variables computed included banana bunches harvested, bunches consumed and sold, and banana income.

A list of explanatory variables covers demographic, wealth measures and agro-ecological zones (climatic conditions) that influence the adoption and/or impact of technology. In case of dummy variables, one variable was excluded to be used as reference category and avoid multicollinearity or dummy trap. The specific variables covered were:

a) Gender of household head and/or decision maker on banana management, dummy variables were used; 1=male and 0=female. The assumption made was that the head of the household was the primary decision maker; i.e., a farmer, head and decision maker. Also, where household head was not a decision maker, the gender of household member who was actually making the decisions on banana crop management was identified during the survey;
b) Age of household head and/or decision maker. Where it was applicable categorical variables (year ranges) were applied in the analysis;
c) Farming experience. This was measured in terms of years of household head and/or decision maker involved in banana management.

d) Education of household head and other household members measured in terms of formal schooling years. Variables computed under this were overall average education mean of education years of all adult household members and average education mean of household head's education years and the education of the person with the highest level of education in the household. It was assumed that banana production was enhanced by having someone in the household with more education, even if he/she was not the head;

e) Household size: According to the sample community, a household is defined as a group of people who reside and eat together. Thus household is a total number of household members in a given household who reside and eat together. Other variables computed on this are dependency ratio and labour available. The dependence ratio is the number of children below 15 years and aged persons above 64 years divided by the population of working age. Labour was computed by summing the number of working members with 15 to 64 years plus half number of both children and aged persons;

f) Farm size: During the household survey farm size owned per household was estimated covering total land owned and cultivated;

g) Quality of the banana fields were classified into four categories being "A" the best field and "D" the worst field (Appendix 6c);

h) Extension service that was measured restricted itself to number of extension visits received by a farmer. In some cases, dummy variables have been used being 1=farmer at least received one extension visit during the period of 6 months and 0=otherwise;

i) Number of banana varieties and mats per genomic group: number of banana varieties and number of mats per households were counted during the survey;

j) Livestock ownership: three types of livestock were identified cattle, small animals (goats, sheep and pigs) and poultry (chicken and ducks). Dummy variables used were 1=owner of livestock and 0=non-owner of livestock;

k) Value of livestock and other household assets were computed based on the current market prices of specific livestock type at the respective location;

l) House types: three types of houses owned by households were identified i.e., permanent, semi-permanent and temporal houses. Dummy variables of the first two variables were used and excluded the last variable to be reference category

m) Agro-ecological zones: Three agro-ecological zones identified were BS, KAL and KAM. Dummy variables of BS and KAL were used while KAM was reference category;

n) Access to credit both formal and informal;

o) Exogenous income: total income obtained by a household from crop and livestock sales, loans/credits and remittance;

p) Banana bunch size; obtained by summing lowest, highest and modal values divided by three, as per farmer's perceptions on banana yield per bunch;

q) Banana income: income obtained from sales of bananas and their products such as juice and local banana brews;

r) Farm gate prices of bananas were collected during the survey and calculated based on triangular distributions;

s) Adopter is a household found planted with at least one of the new banana varieties. Dummy variables were used: 1 = adopter and 0 = non-adopter

Therefore, it can be asserted that sample domain that represents the "population" or set of sampling units from which the sample is chosen, requires its boundaries (sample frame) to be clearly established. Sampling units are used to identify stratification criteria that vary according to research goals and prior information available. Usually stratification criteria include both bio-physical and socio-economic factors for identification of ideal control and treatment groups. Method of data collection depends on the nature of the study. Generally, in most research studies, both primary and secondary data are needed to be collected either by PRA and/or in-depth surveys using structured questionnaires. Similarly, both quantitative and qualitative information need to be collected. Analysis of data should cover from simple descriptive analyses to multiple regression analyses to provide comprehensive research reports.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Overview

This chapter provides a statistical description of the characteristics of households and banana farms in Kagera region, including the adoption of new banana varieties. The sustainable livelihood framework serves to identify the assets that are important in the banana-based farming systems of the region in respect to adoption and impacts of new banana varieties. The factors that explain the decision to adopt and the extent of adoption of the new banana varieties are tested statistically through the application of Logit and Tobit regression models as to address the first hypothesis of this research (Objective 1). Furthermore the chapter discusses the impact of new banana varieties on selected livelihood outcomes using qualitative analysis from data gathered from PRA where farmers' perceptions on impacts of new banana varieties on livelihoods are presented (Objective 2). The instrumental variables (IV) method developed by Heckman (1995) and Maddala, (1983) was employed to quantify the accrued benefits from new banana varieties using data collected from household survey (Objective 3).

Table 6 summarises the definitions of dependent and explanatory variables and their statistics (also see Appendix 7). The first two dependent variables were used in adoption analysis while the rest of the dependent variables were used in impact outcomes. Independent variables covered that define agro-ecological zone, farms and household characteristics.

Table 6: Definitions of variables used and their summary statistics

Variable	Description	Mean	Std. Dev.
Dependent variables:			
Variety use	Household grows any of the new varieties (dummy; Yes=1 and No=0)	0.30	0.0320
Mats of new varieties	No. of mats or share to total mats (%)	4.25	0.7599
Average yield	Overall average bunch weight	18.97	0.4664
Average yield loss (%)	Average expected yield loss to joint biotic pressures	4.72	0.5806
Bunches harvested	Number of bunches harvested per year	191.16	10.1440
Bunches consumed	Number of bunches consumed per year	132.83	8.2100
Bunches sold	Number of bunches sold and given gifts	57.08	4.9645
Exogenous income (10 000 TSh)	Total income obtained by a household from crop and livestock sales, loans/credits, remittances, etc	46.40	8.8249
Banana income (10 000 TSh)	Income obtained from sales of bananas	5.20	1.0292
Farm gate prices	Average prices of bananas offered to farmers	830.40	506.2272
Explanatory variables:			
Gender	Sex of household head (Dummy variable: male=1)	0.75	0.0308
Age	Age of household head	48.53	1.0140
Education	Education of household head	6.44	0.2020
Mean education	Average education years of adults	8.77	1.75
Number of extension visits	Number of extension service visits received by a farmer in period of six years in 2004	1.75	0.2980
Received extension visits	Contact to extension services (dummy; Yes=1)	0.4644	0.0357
Total mats	Total number of mats of all varieties	384.25	34.5627
Endemic mats	Number of banana mats of local varieties	300.12	31.645
Non-endemic mats	Number of mats of non-endemic (exotic) varieties excluding the new varieties	82.361	5.7758
Cattle ownership	Dummy; Yes=1 and No=0	0.3500	0.0347
Small/animals ownership	Dummy; Yes=1 and No=0	0.5240	0.0356
Household assets value	The aggregate value of all physical assets owned by a household (10 000 TSh.)	14.63	1.1571
Household size	Total number of households	6.60	0.2151
Dependency ratio	(Children + aged persons)/adults	1.12	1.29
Labour	(0.5 children + 0.5 aged persons + adults)	4.93	0.1619
Farm size (ha)	Total farm size per household	1.85	0.1176
Land cultivated (ha)	Acreage with crops (annuals and perennials)	1.22	0.0775

4.2 Description of households and banana farms

4.2.1 Demographic characteristics

Agriculture is the dominant preoccupation of the region's inhabitants. The importance of this sector is reflected by the fact that 90% of the economically active population depend on agriculture (NBS, 2003). The dominant tribes in the study area are Haya and Nyambo in Bukoba and Karagwe districts respectively. Banana is dominant crop in the agricultural system in the region, which is a staple food and increasingly becoming a source of income. BACAS (2005) estimated the contribution of bananas to total household income to be 37.4%. Based on this, bananas play an important role not only on food security but also as source of cash to most households in this region.

The important demographic characteristics influencing adoption of new banana varieties covered in this study included sex of household head, age of household head, education of household head and other members, household size and household dependency ratio. About 25% of the 260 households surveyed were female-headed households, though the percentage significantly differed among agro-ecological zones. The KAM zone had the lowest proportion of female-headed households compared to the other two zones. One reason could be that the more relatively productive agriculture in this zone encourages men to stay at home. Another reason could be the greater distance of this zone from Lake Victoria, which reduces the proportion of men who are involved in fishing business (Table 7).

The average age of the household head and household sizes were also significantly different among the three agro-ecological zones (Table 7). The BS zone had the oldest household heads among the three zones.

Table 7: Demographic characteristics by agro-ecological zone

Characteristics	Agro-ecological zone			Overall	Significance
	BS (A)	KAL (B)	KAM (C)		
Female headed households (%)	27.5	28.0	18.75	25.00	(A/B)vC
Age of household head (years)	53.34	45.84	47.41	48.52	Av(B/C)
Household size	6.02	5.79	7.77	6.60	(A/B)vC
Number of females (%)	51.77	51.80	54.90	52.96	
Children below 15 years old (%)	41.00	39.41	48.80	43.39	
Adults 15 – 64 years (%)	49.20	55.34	47.01	50.49	
Aged persons above 64 years (%)	9.80	5.24	4.19	6.12	
Dependency ratio	1.25	1.22	1.25	1.25	
Average education-years of HHH	6.34	6.42	6.58	6.44	
Average education-years of adults	10.24	9.56	6.67	8.89	Av(B/C)
Education level of HHH (%):					
Nil (no formal education)	8.16	5.60	7.17	6.90	
1 – 4 years	22.27	15.97	16.52	17.85	
5 – 8 years	57.09	67.24	64.36	63.32	
9 – 12 years	10.80	11.19	11.43	11.17	
Above 12 years	1.68	0.00	0.52	0.67	

Key: v - denotes versus (e.g. AvB/C means group A is significantly different from B and C, Group B and C do not differ) at 5% significance level; and HHH=household head;

This situation is attributed to the increasing land shortage that makes the household heads more reluctant to allocate land to their children. Due to land shortage, youths migrate to other areas where they can obtain rights to land. Other youths in the BS zone are increasingly engaged in the fishing industry as an alternative source of income. In the KAM zone, the average household size is higher compared to the other zones. This is attributed to the land sizes available for expansion of cultivation and the higher agricultural potential of this zone.

On average, about 6.9% of household heads had no formal education (Table 7). About 63% of the household heads had completed primary education. Only 12% had attended secondary school, and the majority of them were retired workers. On average, one adult member per household had no formal education. The aggregated average years of education per adult (15 years old or above) was different significantly between agro-ecological zones. This index of household education levels was highest (10.24) in BS zone followed by KAL zone (9.56) and KAM zone (6.67), reflecting the greater involvement of members in agriculture in the KAM zone. Other demographic characteristics, such as the percentages of children, adults, and aged persons in the household, the ratio of dependents to active members, and the education levels of household heads were not significantly different between the zones.

4.2.2 Adopters and non-adopters of new banana varieties

Of the 260 surveyed households, 74 households equivalent to 28.46% were found planting at least one of the new banana varieties introduced through KCDP. All of the adopters except two were either from BS or KAL zone (Table 8). Farmers located in KAM are still getting a reasonable production from local bananas compared to the other two zones.

Table 8: Number of adopters of the new banana varieties by zone

Adoption	BS	KAL	KAM	All
		Number (percentage)		
Adopters	35 (43.75)	37 (37.00)	2 (2.5)	74 (28.46)
Non-adopters	45 (56.25)	63 (63.00)	78 (97.5)	186 (71.54)
Total	80 (100)	100 (100)	80 (100)	260 (100)

Of the 195 male headed households, 60 households (30.76%) were adopters while out of 65 female headed households only 14 households (21.54%) were adopters. Female-headed households were less likely to be adopters (19% of 74 adopters) than non-adopters (27% of 186 non-adopters), while male-headed households were more likely to adopt (81% of 74 adopters) than non-adopters (73% of 186 non-adopters). This indicates that sex of the household head has influence on adoption of the new banana varieties. The average age of household heads and decision makers were significantly different between adopters and non-adopters. Years of education, household size and dependency ratio were not significantly different between adopters and non-adopters (Table 9).

Table 9: Demographic characteristics of adopters and non-adopters

Criteria	Adopters	Non-adopters	Overall
Surveyed households (respondents)	74	186	260
Female headed households (%)	18.92	27.42	25.00
Male headed households (%)	81.08	72.58	75.00
Average age of household head	51.66*	47.16*	48.52
Average age of decision maker	49.82*	45.99*	47.14
Average education-years of household head	6.85	6.26	6.44
Average education-years of decision-maker[11]	6.80	6.27	6.43
Average education-years of all adults	6.80	9.77	8.78
Household size	6.43	6.68	6.60
Dependency ratio	1.12	1.29	1.25

Key: * denote statistical significance at the 5% level, in the difference of means between adopters and non-adopters.

The age-group mode of non-adopters was 31 to 40 years while that of adopters was 41 to 50 years (Fig. 6). The relative percentage was computed as the percentage frequency of adopters (non-adopters) divided by the total number of adopters (non-adopters), with respect to each age class. Above the mode of age-group of the adopters, the percentage of adopters was relatively higher than that of non-adopters. Therefore, this implies that older heads of households were more likely to adopt new banana varieties than younger heads, particularly during the early stages of the introduction as observed during the FGDs. This is because the older household heads have more knowledge and experience regarding the

[11] In some cases, it was observed during the survey that a household head was not a decision maker of banana management, another household member was responsible.

performance of the local banana varieties given the increasing production constraints. In addition, they are the main decision makers and generally have more access to land.

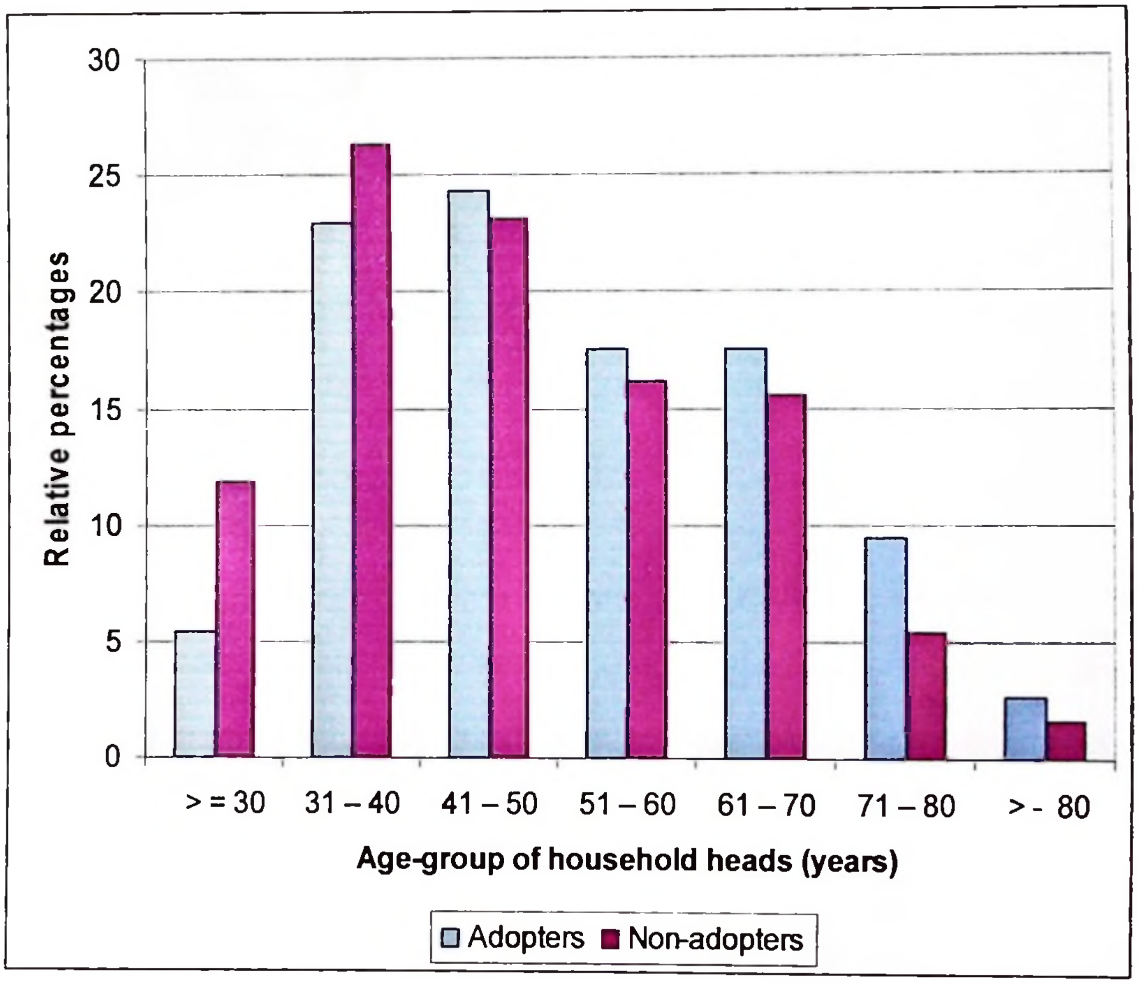

Figure 6: Age-group of adopters and non-adopters of new banana varieties

The distributions of education levels of household heads do not vary between adopters and non-adopters. Hence there is no systematic relationship between education levels of household heads and adoption of new banana varieties.

4.2.3 Land use types, number of parcels and farm size per household

Land is one of the important factors that influence adoption of new technologies and ultimately the accrued benefits to adopters. During the survey, farm size owned by a household was estimated per land use type. The farming system found in Bukoba and Karagwe districts comprises three common land use types, namely *Kibanja (bibanja in plural)*, *Kikamba* and *Rweya,* as presented in Chapter 2: section 2.3. A parcel[12] may include all types of land use. The overall average number of parcels owned per household was 1.94, which did not differ significantly between the zones (Table 10). A single parcel can consist of several plots[13] defined by cropping patterns.

The average farm size per household, as well as the land cultivated that is *Kibanja* and *Kikamba*, were significantly different between zones. KAM zone had the highest farm size and area under cultivated crops while BS zone had the lowest. The average farmer size owned by male-headed households (1.99 ha) was significantly higher than that of female-headed households (1.42 ha). Overall, about 66% of the average household farm was area cultivated with crops including *Kibanja* and *Kikamba* fields. *Rweya* covered 31% and settlement area was 3% of the total farm size. *Rweya* size per household was significantly lower in the BS zone than either in the KAM or KAL zones. The data also showed that in KAM zone, the percentage of households owned *Rweya* plots was higher than that of farmers in BS zone.

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[12] A parcel is defined as a field with continuous boundary, which may consist of one or more plots.
[13] A plot is land under cultivation as a segment of parcel defined by the perimeter of cropping system.

Table 10: Land use types and their estimated farm size per household by zone

Land use type	Agro-ecological zone			Overall	
	BS (A)	KAL (B)	KAM (C)		
No. of parcels per household	1.94	1.95	1.93	1.94	ns
Kibanja and Kikamba (ha)	0.77	1.11	1.66	1.22	AvB/C
Settlement (ha)	0.04	0.08	0.05	0.06	A/C/B
Rweya (ha)	0.40	0.68	0.61	0.58	A/C/B
Total farm size (ha.)	1.22	1.85	2.32	1.85	AvBvC

Key: v - denotes versus (e.g. AvB/C means group A is significantly different from B and C, Group B and C do not differ), at 5% significance level.

Adopters of the new banana varieties had a relatively low average farm size and area under crops (*Kibanja/Kikamba*). It was only the area cultivated that was significantly different between the adopters and non-adopters. Contrary to this non-adopters had higher averages of number of parcels and *Rweya* than that of non-adopters, but not significantly different between the two groups, perhaps because they felt the pressures of declining banana yields more heavily (Table 11).

Table 11: Household farm size of adopters and non-adopters

Land use type	Adopters	Non-adopters	All
No. of parcels per household	2.06	1.88	1.94
Kibanja/kikamba (ha)	0.93*	1.35	1.22
Rweya (ha)	0.69	0.53	0.58
Total farm size (ha)	1.65	1.93	1.85

Key: * - denotes statistical significance at the 5% level, in the difference of means between adopters and non-adopters.

4.2.4 Household equipments and implements

Ownership of household equipments and implements play an important role in influencing the adoption of new technologies (Adesina and Baidu-Forson, 1995). The most frequently owned household equipment (owned by at least by 50% of the households surveyed) were hand hoes, pangas, sickles, forked hoes, axes, gunny bags, radio, bicycles and furniture such as tables, chairs and beds.

Most households surveyed had at least one hand hoe. About 56.54% of all households had bicycles and 63.85 % owned radios. Household equipment owned by less than 25% of the surveyed households included wheelbarrows, pruning knives, bow saws and knapsack sprayers. All of these equipments are important in managing coffee fields. The low percentage of ownership of these equipments provides is evidence that farmers do not achieve the proper management of coffee fields. Ownership of bicycles was significantly different between adopters and non-adopters while ownership of radios was not. About 66.2% of adopters owned bicycles, compared to 52.7% of non-adopters. This indicates that bicycles, an important means of transporting either planting materials or banana bunches, are associated with the decision to use new banana varieties.

4.2.5 Types of houses

A house type is one of the criteria used in household classification in terms of well-being. Therefore, indirectly house type can be used to assess the adoption of the new technologies. Houses in the surveyed community were classified into three types; permanent, semi-permanent and temporary houses. Permanent houses have walls made of burnt bricks or concrete blocks, concrete floors and are roofed with iron sheets or tiles. Semi-permanent houses have walls made of non-burnt bricks or mud and roofed with iron sheets. Temporary housing consists of walls made of mud or wattle, mud floor and grass thatching.

Most households surveyed have either permanent or semi-permanent houses. About 11.11% were households with temporary houses (Table 12). Households located in BS zone have the highest percentage (55) of permanent houses while households in the other two zones had more houses of the semi-permanent type. Type of houses owned by a household is influenced by many factors including earnings from the farm (crops and livestock), off-farm income, remittance from migrant family members, inheritance and the health status of the household.

The type of house owned by a household was associated significantly with the adoption of the new banana varieties (Table 12). Farmers with temporary housing were more likely to adopt than those farmers with permanent houses. This is because farmers with permanent houses are the ones who still remain with enough resources to produce banana surpluses and hence are less attracted to the new banana varieties.

Table 12: Types of houses and adoption of new banana varieties

House type	Adopters (%)	Non-adopters (%)	Overall (%)
Permanent house	40.42	40.18	40.25
Semi-permanent house	40.68	52.08	48.64
Temporal house	18.90	7.74	11.11
Total	100.00	100.00	100.00

4.2.6 The role of livestock in the banana based farming systems

Keeping of livestock is one of livelihood activities carried out by farmers in Kagera region. Livestock play an important role in nutrients recycling among the three land use types (Bosch *et al.,* 1996). Major livestock types kept are cattle, goats, sheep, pigs, chicken and ducks. About 55.63% of all surveyed households were keeping chicken, 52.41% goats or sheep or pigs or any combination of these, and 34.95% were cattle keepers. The percentages of households keeping each type and the average number of animals per household varied significantly by zone. KAM zone had the highest average number of all livestock types per household (Table 13). They are mainly kept for farmyard manure, meat, milk and cash (Baijukya *et al.*, 2005).

Local cattle had the highest percentage of cattle keepers while for the small ruminants goats had the highest percentage of keepers. Keepers of improved cattle were about 12% of the total surveyed households and were not significantly different between the zones. It was also observed that in the study area, keeping of small animals dramatically increases with increasing land pressure. These animals require less food compared to cattle and feed on a wide range of feeds varying from pods and leaves of shrubs, barks of trees and grasses (Aganga., 1999). They have also the ability of surviving on low quality feeds or in difficult conditions with relatively small amounts of feed and they require simple management and labour to make them the choice of both rich-and poor-resource farmers.

Table 13: Percentage of livestock keepers and average number of livestock per household by zone

Livestock type	BS (A) N=80		KAL (B) N=100		KAM (C) N=80		Overall and significance N=260	
	%	Average	%	Average	%	Average	%	Average.
Cattle	26.73	3.14	33.12	5.50	42.72	7.00	34.95	5.47 AvBvC
- Local	18.75	3.7	19.00	7.5	33.75	8.1	23.46	6.8 AvB/C
- Improved	11.25	1.56	14.00	1.64	11.25	1.33	12.31	1.5 A/BvC
S/animals	38.24	-	53.36	-	62.05	-	52.41	-
- Goats	26.25	3.0	46.00	3.8	46.25	5.3	40.00	4.2 (AvC)/B
- Sheep	1.25	3.0	6.00	1.5	13.75	2.6	22.50	2.3
- Pigs	18.75	1.3	16.00	1.3	8.75	4.7	14.62	1.9 A/BvC
Chicken & ducks	64.25	4.3	56.64	5.4	48.63	8.3	55.63	5.9 A/BvC

Key: v - denotes versus (e.g. AvB/C means group A is significantly different from B and C, Group B and C do not differ), at 5% significance level; and Avg. – denotes abbreviation of the word average

4.2.7 Ownership of livestock and adoption of the new banana varieties

Keeping of livestock showed positively and significantly influence on adoption of the new banana varieties. Adoption rates were higher for the households owning livestock (Table 14), regardless of the type. Households that kept chicken and ducks had high percentage of adopters followed by small animals (goats, sheep and pigs) and cattle. As mentioned earlier, livestock is an important component in the banana farming system particularly in the nutrient recycling system. Manure is one of the essential requirements of planting new banana mats. Therefore, households with livestock had access to manure needed in planting new bananas.

Table 14: Percentage of livestock keepers by adoption of new banana varieties

Livestock type	Adopters N=74	Non-adopters N=186	All N=260
Cattle	40.57	32.51	34.95
Goats, sheep and pigs	64.05*	47.37*	52.41
Chicken and ducks	67.62*	50.44*	55.63

Key: * - denotes statistical significance at the 5% level, in the difference of means between adopters and non-adopters.

4.2.7 Value of household assets

Value of household equipments, implements and structures were estimated based on the prices in the year of purchase (Table 15). Equipment and implements included: hand hoes, forked hoes, pangas/cutlass, spades, wheelbarrows, sickles, axes, pruning knives, bow saw, gunny bags, knapsack sprayers, slashers, stable for livestock, radios, bicycles and house furniture (tables, chairs, beds, etc.). Household structures were stables for cattle, pens for small animals (goats, sheep, pigs and chicken).

Adopters had relatively higher values of most assets than the non-adopters. Total value of all household equipments, implements and structures per household had an overall average of 146 152.10 per zone, with the highest values in KAM zone and the lowest in BS zone (Table 15). In KAL, the average values of household assets estimated were significantly different between adopters and non-adopters for each category of asset. With the exception of the value of chickens, the same was true for the BS zone. In KAM zone, the average value of household equipments was significantly different between adopter and non-adopter groups. In this zone, only two households were adopters.

Table 15: Value of household (in thousand TSh) assets of adopters and non-adopters by zone

Values of assets	BS (A)	KAL (B)	KAM (C)	Overall
a)Equip/impl/structures (A/B/C, AvC)	136.453	139.350	159.566	146 152.10
Adopters	167.432*	186.210*	886.775*	186.238*
Non-adopters	102.047*	102.568*	151.857*	128.786*
b) Livestock (A/B)vC)	112.237	218.398	308.329*	222.621
Adopters	151.477*	372.430*	134.000	261.941*
Non-adopters	68.657*	97.498*	310.178	205.587*
(i) Cattle (A/B)vC	90.676	191.805	261.862*	189.950
Adopters	123.271*	328.928*	107.500	226.095
Non-adopters	54.475*	84.177*	263.499	174.292
(ii) Small animals (A/B)vC	16.232	22.317	39.825	27.210*
Adopters	22.551*	37.554*	17.500*	30.001
Non-adopters	9.214*	10.357*	40.062*	26.000
(iii) Chicken	5.329	4.276	6.642	5.461
Adopters	5.655	5.948*	9.000	5.846
Non-adopters	4.968	2.964*	6.617	5.294
c) a + b (A/B)vC	248.690	357.747	467.895	368.773
Adopters	318.910*	558.641*	1020.775*	448.180*
Non-adopters	170.704*	200.067*	462.034*	334.373*

Key: * denote statistical significance at the 5% level between adopters and non-adopters; and v - versus (e.g. AvB/C) means group A is significantly different from B and C, while Group B and C do not differ) across agro-ecological zones.

4.2.8 Types of annual crops cultivated and stored by farmers

In period of shortage of bananas, a household copes by eating more of the other foods such as annual crop food types. The annual crops cultivated by farmers in the two districts are beans, maize, groundnuts, bambaranuts, sorghum, cassava, sweet potatoes, coco-yams, and yams. It was anticipated that farmers with prolonged shortage of bananas kept more amount of storage foods and likely adopted the planting of new banana varieties. During the survey, farmers were asked to estimate the quantities of annual crops stored so that quantities of stored crops can be compared between adopters and non-adopters. The food crops mainly stored by farmers were beans, maize, groundnuts, bambaranuts and sorghum (Table 16).

Other minor crops stored by farmers were dried cassava, soybeans and cowpeas. Usually root and tuber crops are harvested on piece meals. For food crops stored, their quantities significantly varied by zone.

Table 16: Types of crops stored, their production (kg) and values (TSh) by zone

Crop	BS	KAL	KAM	Overall
(a) Production (kg):				
Beans	64.2	106.3	185.1	116.8
Maize	79.8	135.2	343.8	181.1
Groundnuts	36.9	52.5	73.2	50.9
(b) Crop value (TSh):				
Total value of crops stored	16 894.40	30 878.00	64 112.50	36 801.35
Bean share (%)	48.48	29.91	40.26	45.89
Maize share (%)	37.04	37.47	35.55	36.75
G'nuts share (%)	5.47	6.56	3.35	5.24
Others share	9.01	26.06	20.84	12.12
Total (%)	100.00	100.00	100.00	100.00

The quantities of crops stored in BS zone were below the average while those stored by households from other zones were above the average. On average, households stored beans about 64 kg in BS zone, 106 kg in KAL zone and 185 kg in KAM zone. The quantity of maize stored in BS zone was about 80 kg, 135 kg in KAL and 344 kg in KAM zone (Table 16).

In all zones, beans and maize were the crops most often stored by farmers. Beans had the highest share of the total value of crops stored in BS and KAM while maize had the highest share value in the KAL. The percentage share of beans, maize and groundnuts to total values of crops stored were highest for adopters than non-adopters but not significantly different between the two groups (Table 17).

Table 17: Percentage of households stored food crops by adoption category

Crop type	Adopters	Non-adopters	Overall
Total value of crops stored (TSh)	30 171.90	39 438.87	36 801.35
Beans share (%)	49.12	44.60	45.89
Maize share (%)	39.29	35.73	36.75
Groundnut share (%)	8.93	3.78	5.24
Other crops share (%)	2.66	15.89	12.12
Total	100.00	100.00	100.00

4.3 Banana production and varieties grown

Farmers allocate lands to several different banana varieties due to several reasons including diversification, resource endowment (input fixity), risk aversion from increasing production constraints, and for experimentation. There was great variation of number and varieties grown by farmers between households and locations.

4.3.1 Types of banana varieties grown

Like other banana growing areas in the Great Lakes Region, banana varieties grown by farmers in Kagera can be classified into four genomic[14] groups; endemic (AAA-EA), non-endemic which is classified into subsets exotic (AA, AB, AAB, AAA, ABB,) and hybrids (AAAA, AAAB). Endemic varicties are all East African Highland bananas grown in highlands of Uganda and Tanzania. Non-endemic varieties are either exotic, naturally-occurring from environmental interaction or newly bred tetraploid hybrids. Examples of exotic varieties are Akanana, Ekikonjwa, Enkonjwa, Kijoge (Gross Michel), Kisubi, Yangambi Km5, Mshale, Mtwishe, Pelipita and SH 3640. Hybrid bananas include FHIA 01, FHIA 02, FHIA 17, FHIA 22, FHIA 23, FHIA 25 and BITA 3. The new banana varieties considered in this thesis are those imported, multiplied and distributed to farmers in Kagera region from 1997 up to date. They are either landraces or hybrids. These are FHIA 01, FHIA 02, FHIA 03, FHIA17, FHIA18, FHIA21, FHIA23, FHIA25, Yangambi km5, Pisang Ceylon, Pisang Berlin, AACV Rose, IC2, Pelipita, Cardaba, Saba, Pisang Sipulu, Bita2, Bita3, Paka, SH3436-9, SH3640, Karamasenge, CRDP 39 and CRBP.

A total of 91 different banana varieties were recorded during the 2003/2004 household survey conducted in the region (Appendix 8). The majority of them, 71 (78%) banana varieties were endemic to East Africa (AAA-EA genomic group). The remaining 22% were non-endemic cultivars including old (8) and new (12) exotic cultivars (Table 18).

[14] Genomic group is a scientific classification of bananas. The genomic groups include East-African Highland Bananas (AAA-EA), plantains (AAB), Exotic sweet (AB & AAA), Exotic beer (AB & ABB) and hybrids i.e., tetraploid which can be used as beer, cooking, sweet, roasting or brewing.

Table 18: Number of banana cultivars grown and their mat shares by genomic group

Genomic group	Cultivars grown		Banana mats	
	Number	percentage	Number	percentage
Endemic	71	78.0	61 445	75.2
Non-endemic	20	22.0	20 271	24.8
Old	8	8.8	19 046	23.3
New	12	13.2	1 225	1.5
Total	91	100.0	81 716	100.0

The old exotic cultivars were Akanana, Ekikonjwa, Enkonjwa, Kainja, Kijoge, Mtwishe, Kisubi and Mshale and the new exotic cultivars were Acc Rose, Cardaba, Bita3, FHIA 01, FHIA 02, FHIA 17, FHIA 22, FHIA 25, Pelipita, SH3640 (Shilingi) and Yangambi km5. The endemic cultivars had about 75.19% of the total banana mats and the remaining share was for non-endemic cultivars, of which 1.50% was for new banana varieties.

Households grow simultaneously a set of different banana cultivars on their farms that comprises of cultivars with different uses including cooking, brewing, dessert, roasting or multi-purpose. However, major cultivars appear to be fairly uniformly distributed across households. Based on common use in the banana eating communities of Kagera region, 60.4% of all cultivars grown were for cooking, 15.4% for brewing, 3.3 for dessert, 3.3% for roasting and 17.6% recorded with multipurpose use and a single variety could have many uses in different locations. Table 19 and 20 show the first 20 most grown banana varieties by agro-ecological zone and adoption of new banana varieties respectively. The two most popular varieties in the BS zone were exotic varieties; Kijoge and Mtwishe and the third was endemic variety (Enyoya). In the other two zones, the first popular variety was endemic one (Enshakala) followed by Akanana and Kijoge in the KAL zone, and by

Entobe and Entundu (both endemic) in the KAM zone. Out of the 20 most popular varieties, Yangambi km5, FHIA 17 and SH 3436-9 were among the new banana varieties mostly grown in BS and KAL zones.

Table 19: The first 20 banana varieties most frequently grown by zone

Rank	Agro-ecological zone			Overall
	BS	KAL	KAM	
1	Kijoge	Enshakala	Enshakala	Enshakala
2	Mtwishe	Akanana	Entobe	Kijoge
3	Enyoya	Kijoge	Entundu	Akanana
4	Enshakala	Enchoncho	Akanana	Entobe
5	Enkonjwa	Enchoncho	Kainja	Enyoya
6	Entobe	Enjubo	Enchoncho	Enchoncho
7	Enshansha	Entobe	Ensikila	Mtwishe
8	Kisubi	Enshansha	Entente	Kainja
9	Akanana	Enkonjwa	Entalagaza	Enshansha
10	Yangambi km5*	Ekikonjwa	Enyoya	Enjubo
11	Embwailuma	Embwailuma	Enyitabunyonyi	Enjubo
12	Enjubo	Embilabile	Engagala	Embwailuma
13	Enchoncho	Kainja	Enshansha	Entundu
14	Ekikonjwa	Mtwishe	Embwailuma	Kisubi
15	FHIA 17*	Kisubi	Enkundakundi	Ekikonjwa
16	Embile	Ensikila	Engumba	Ensikila
17	Enshanshambile	Entalagaza	Kijoge	Entalagaza
18	FHIA23*	Yangambi km5*	Enjoga	Entente
19	Endumuza	FHIA 17*	Enjubo	Yangambi km5*
20	Entandala	Shillingi*	Enkonjwa	FHIA 17*

Key: * denotes new banana variety

The rank of the 20 banana varieties most frequently grown by farmers differed between adopters and non-adopters (Table 20). There was highest and lowest cultivation of exotic banana varieties in the BS and KAM respectively.

Table 20: The first 20 banana varieties most frequently grown by adoption

Non-Adopters	Adopters	Overall
Enshakala (167)	Kijoge (69)	Enshakala (230)
Entobe (125)	Enshakala (63)	Kijoge (184)
Akanana (115)	Yangambi km5 (50)	Akanana (163)
Kijoge (115)	Akanana (47)	Entobe (162)
Enchoncho (101)	Enyoya (45)	Enyoya (145)
Enyoya (100)	Mtwishe (45)	Enchoncho (133)
Kainja (86)	Kisubi (45)	Mtwishe (104)
Entundu (78)	Enkonjwa (43)	Kainja (103)
Enshansha (68)	FHIA 17 (39)	Enshansha (102)
Emwailuma (64)	Entobe (38)	Enjubo (98)
Enjubo (60)	Enjubo (37)	Embwailuma (97)
Mtwishe (59)	Enshansha (34)	Entundu (89)
Enkonjwa (55)	Enchoncho (32)	Kisubi (87)
Ensikila (52)	Ekikonjwa (31)	Ekikonjwa (62)
Entente (49)	Embwailuma (25)	Ensikila (50)
Entalagaza (47)	Kainja (17)	Entalagaza (43)
Kisubi (44)	FHIA 23 (17)	Yangambi km5 (39)
Ekikonjwa (37)	Ensikila (16)	Etente (37)
Engagala (33)	Embilabile (16)	FHIA 17 (36)
Embilabile (27)	Entalagaza (15)	Embilabile(34)

Note: Number in parenthesis is number of farmers found planted the variety.

Enshakala is one of the varieties with big bunch size, large fingers and good cooking and marketability attributes. But it has less tolerance to hard production conditions. For non-adopters, the first variety was Enshakala which is mainly used as a cooking variety while for the adopters Kijoge which has multiple uses (cooking, brewing and dessert) was the first variety. This indicates that adopters and non-adopters have different preferences of banana varieties, in general. Yangambi km5, FHIA 17 and FHIA 23 emerged among the most often grown by adopters (Table 20).

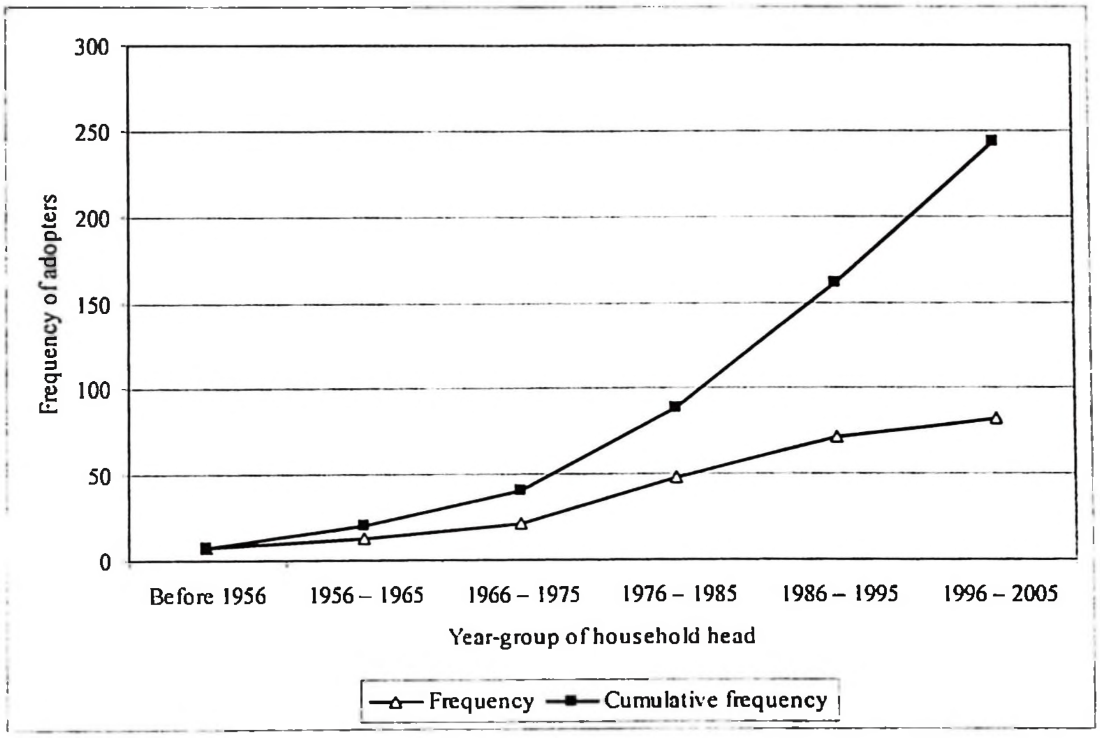

Figure 7: Number of farmers who planted old exotic cultivars by year-group first adopted

Since the 1970s, cultivation of the non-endemic varieties has been increasing due to increasing production constraints that lead to perishing of the traditional (local) varieties (7). Thus, the introduction of the new banana varieties was not a new practice to farmers. Farmers had experienced planting and adopting new varieties for decades. During the last decades, the old exotic varieties have showed an increasing trend in the materials planted by farmers. The number of farmers planting the old exotic cultivars is still increasing but at decreasing rate. Similarly, the frequency of farmers deciding to use new banana varieties has increased at an increasing rate in the BS and KAL during the period of 1995 - 2005 (Fig. 8).

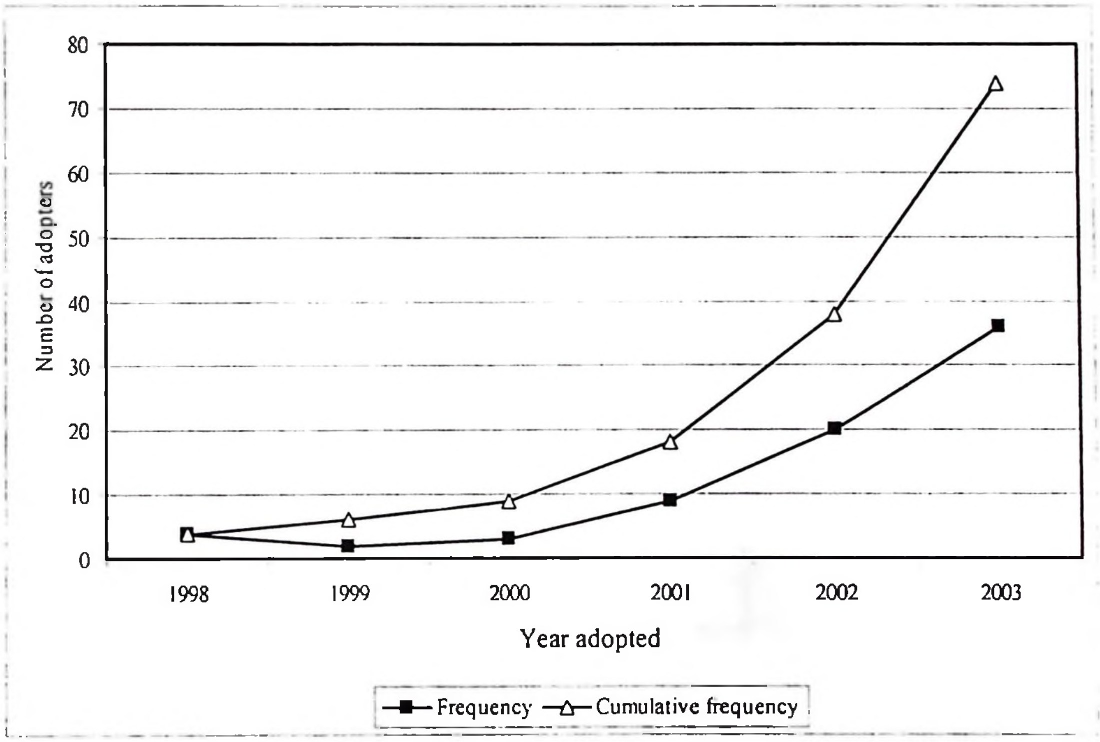

Figure 8: Frequency of adopters of new banana varieties by year first planted

4.3.2 Farmers' experiences in banana cultivation

The average number of years a variety grown by farmers ranged from 1 to 54 years. There was no association between the number of farmers growing a particular variety and the number of years a particular variety has been cultivated by farmers. Most farmers have inherited their banana fields from their parents and probably continued growing their preferred banana varieties among those varieties inherited. This implies that an old variety may not necessarily be the popular in the community although data showed that few farmers continued to grow the same varieties for as long as 30 years or more. On the other hand, some farmers are re-planting again the endemic varieties they had previously lost due to pests and diseases. Enyoya and Engagala were recorded being rapidly re-planted by farmers in all zones. These local banana varieties are preferred most by farmers but are susceptible to banana weevils, and nematodes. Farmers' habit of returning to their own traditional varieties can be regarded as informal in-situ conservation system of banana varieties, reducing genetic erosion of bananas from generation to generation. Farmers in KAM zone showed a higher average of years cultivating any particular variety compared to the other two zones. The KAM zone has good soil fertility and less extensive damage from banana pests and diseases.

4.3.3 Number of banana varieties grown and their genomic groups

The types of local banana varieties cultivated by farmers were distributed throughout the study area. However, there was a difference in the number of households cultivating a particular variety and number of banana mats per household between zones. The number of banana varieties per household ranged from 3 to 29 with an overall average of 10.42 banana varieties per household. The number per household was highest in KAL zone (Table 21). All except two farmers (one from BS and one from KAM), were found to be growing at least one of the endemic varieties. The number of endemic varieties per household ranged from 1 to 16, non-endemic varieties from 1 to 15, exotic from 1 to 13, and hybrids from 1 to 4. These ranges were not significantly different between agro-ecological zones. The number of farmers who were cultivating new banana varieties (exotic – i.e., landraces and hybrids) was significantly different between agro-ecological zones. There were a higher numbers of farmers who were growing new exotic varieties in BS and KAL zones than those in KAM (Table 21).

Table 21: Average number of banana varieties per genomic group by zone

Genomic group	BS (A)	KAL (B)	KAM (C)	Overall	Significance
Endemic	4.23	7.18	7.50	6.47	Av(B/C)
Non-endemic (exotic)	4.97	4.82	2.38	3.99	(A/B)vC
Old	3.91	3.87	2.37	3.38	(A/B)vC
New	1.06	0.95	0.01	0.61	(A/B)vC
All varieties	9.20	12.00	9.87	10.42	(A/C)vB

Key: v - versus (e.g. Av(B/C) means group A is significantly different from B and C at 5% level, Group B and C do not differ) across agro-ecological zones.

An average of 2.09 new banana varieties was grown per household, ranging from 1 to 7 varieties per household. In the BS and KAL zones, 43.8% and 41.0% (respectively) of the households surveyed had at least one of the recently introduced banana varieties (Table 22). The total number of varieties planted per household was significantly different between adopters and non-adopters. Adopters had a lower average number of endemic varieties but had significantly more non-endemic varieties by planting the new varieties. This implies that those who adopted the new banana varieties have added other varieties to what they already have, without replacing their local banana varieties – another indicator that adoption does not imply a loss of local materials, or genetic erosion, in the time period studied.

Table 22: Average number of banana varieties per household by adopters and non-adopters

Genomic group	Adopters	Non-adopters	All
Endemic	5.94*	6.70*	6.47
Non-endemic	6.26*	2.94*	3.99
Old	4.20	2.94	3.38
New	2.06	0.00	0.62
Overall	12.20*	9.65*	10.42

Key: * - denotes statistical significance at the 5% level in the difference of means between adopters and non-adopter

4.3.4 Banana varieties sold by farmers

The 15 banana varieties most frequently sold by farmers in 2003 differed significantly among the zones. Enshakala and Entobe both endemic cultivars were the two most often sold in the KAM zone. While Mtwishe and Kijoge, both exotic cultivars, were the most often marketed in BS zone, while in KAL the first two varieties were Enshakala (endemic cultivar) and Akanana (an exotic cultivar). This reflects the type of varieties most cultivated in each zone.

4.3.5 Banana mats per household

The banana variety most frequently cultivated by farmers is not necessarily the one most extensively cultivated per household (the highest number of mats). This is attributed to the existence of a wide range of environmental conditions, farm characteristics, farmers' preferences and market demand of each variety. The average number of mats per household was significantly different between the zones (Table 23). KAM and KAL had the highest and lowest banana mats, respectively.

Table 23: Sum and average number of mats by zone

Banana mats	BS (A)	KAL (B)	KAM (C)	Overall	Significance
Sample total mats per zone	20 046	17 954	43 716	81 716	-
Average mats per household	250.56	179.75	546.45	314.29	AvBvC

Key: v - versus (e.g. Av(B/C) means group A is significantly different from B and C at 5% level. Group B and C do not differ) across agro-ecological zones.

4.3.6 Banana mats per genomic group and variety

Table 24 shows that there is great variation in the variety with highest share of mats per zone. In BS the first three varieties were Kijoge, Mtwishe and Enshakala. The three varieties, Eyoya, Enshakala and Enshansha were most planted household in KAL, while in KAM Entundu, Enshakala and Entobe varieties were popular.

Table 24: Ranking share (percentage) of banana mats per variety by zone

Rank	BS (A)	KAL (B)	KAM (C)	Overall
	Variety and its percentage (%) of total mats			
1	Kijoge (20.3)	Enyoya (13.5)	Entundu (13.9)	Enshakala (11.1)
2	Mtwishe (12.7)	Enshakala (11.8)	Enshakala (11.6)	Enchoncho (7.7)
3	Enshakala (9.3)	Enshansha (8.6)	Entobe (11.3)	Entundu (7.7)
4	Enshansha (9.2)	Kijoge (7.9)	Enchoncho (12.2)	Kijoge (7.5)
5	Enyoya (8.6)	Kainja (7.3)	Entente (9.5)	Entobe (7.3)
6	Embwailuma (5.3)	Enchoncho (6.3)	Kainja (6.3)	Enyoya (6.3)
7	Kisubi (5.3)	Embilabile (5.7)	Entalagaza (6.2)	Entente (5.1)
8	Endumuza (4.1)	Akanana (5.2)	Ensikila (4.5)	Kainja (5.1)
9	Ekikonjwa (2.5)	Enjubo (3.8)	Engagala (3.8)	Enshansha (4.7)
10	Entobe (2.5)	Kisubi (3.0)	Akanana (3.6)	Entagalaza (3.7)
11	Enjubo (2.4)	Entobe (2.8)	Ekundakundi (2.6)	Mtwishe (3.5)
12	Others (17.8)	Others (24.1)	Others (15.5)	Others (30.3)

Note: Number in parenthesis is share percentage to the total mats

The first two varieties in BS were non-endemic (exotic) varieties while in the other zones all of the three varieties were endemic varieties. Endemic banana varieties are mostly grown in KAL and KAM zones and less grown in BS zone. Non-endemic varieties are more cultivated in BS zone. Improved banana varieties were found being grown in all zones, but they were mostly grown in the KAL and BS zones. Their percentage (share) of average number of varieties per household ranged from 9.87% to 23.29% with an average of 20.70% (Table 25).

Table 25: Average number and share of banana mats per household per genomic group by zone

Genomic group	BS	KAL	KAM	Overall	Significance
Average number of mats					
Endemic	103.85	122.94	606.58	299.70	AvBvC
Non-endemic	114.02	57.66	86.15	84.12	Av(B/C)
Old exotic	105.69	53.75	85.91	80.35	Av(B/C)
New exotic	8.33	5.30	0.24	4.24	AvBvC
Overall average	217.88	180.60	692.73	383.82	AvBvC
% share to total mats					
Endemic	37.84	67.35	86.41	66.29	AvBvC
Non-endemic	62.16	32.65	13.59	33.71	AvBvC
Old exotic	57.78	29.11	13.51	31.24	AvBvC
New exotic	4.38	3.54	0.08	2.47	(A/B)vC

Key: v: versus (e.g. Av(B/C) means group A is significantly different from B and C at 5% level. Group B and C do not differ) across agro-ecological zones.

In all zones, endemic bananas represented the highest average number of banana mats followed by non-endemic (exotic) bananas. However, endemic bananas were more extensively grown in KAM zone while exotic bananas were more grown in BS zone (Table 25).

4.3.6.1 Number of banana mats per household and adoption of new bananas

The number of banana mats per household showed great differences between the adopters and non-adopters. Also, the number and share of mats per genomic group indicated clear differences between the two groups (Table 26).

Table 26: Average banana mats per household and adoption of new banana varieties

Genomic group	Adopters	Non-adopters	All
Average number of mats per household			
Endemic	88.99*	390.98*	299.70
Non-endemic (exotic)	100.69*	76.94*	84.12
Old exotic	86.67	76.94	79.88
New exotic	14.02	0.0	4.24
All varieties	189.68	467.92	383.82
percentage share to total mats			
Endemic	46.47	74.87	66.29
Non-endemic (exotic)	53.53	25.13	33.71
Old exotic	45.34	25.13	31.23
New exotic	8.19	0.00	2.48

Key: * - denotes statistical significance at the 5% level in the difference of means between adopters and non-adopter

Overall, adopters have less average number of banana mats than non-adopters, and have less percentage of endemic varieties and more percentage of non-endemic varieties. The classification of banana mats showed different patterns in each zone (Table 27). The KAL zone had the highest percentage of farmers with less than 100 banana mats. About 81.25% and 89.0% of farmers surveyed from BS and KAL zones respectively had fewer than 300 banana mats per household.

Table 27: Classification of banana mats by zone (% households)

Mat class	BS	KAL	KAM	All
< 101	26.86	37.05	13.30	25.26
101 – 200	35.38	32.90	10.87	25.30
201 – 300	24.78	19.09	7.79	16.42
301 – 400	3.35	2.83	3.60	3.27
401 – 500	0.74	2.52	0.76	1.36
501 – 600	4.47	1.11	2.68	2.64
601 – 700	0.74	1.98	2.68	1.90
701 – 800	1.81	2.52	8.81	4.69
801 – 900	0.00	0.00	8.41	3.17
901 – 1000	0.00	0.00	17.98	6.77
> 1000	1.86	0.00	23.11	9.22
Total households	100.00	100.00	100.00	100.00

About 8.88% and 5.61% of households from BS and KAL respectively had more than 500 banana mats. The situation was different from the KAM zone where banana mats showed a bimodal distribution. In this zone, households with banana mats of not more than 300

were 31.96% while those with more than 500 and 800 mats were 63.68% and 49.50% respectively. The bimodal distribution of the banana mats in KAM zone could be attributed to the fact that some households still have land for expansion of banana farms while others do not leading to sub-division of their farms among family members. In the other two zones, the farm size per household probably had reached the minimum of an economic farm size.

Table 28: Banana mat-class by adoption of new varieties (% households)

Banana mats class	Adopters	Non-adopters	All
Less than 100	38.60	19.49	25.26
101 – 200	24.66	25.57	25.30
201 – 300	24.81	12.78	16.42
301 – 400	2.67	3.52	3.27
401 – 500	2.30	0.96	1.36
501 – 600	2.41	2.74	2.64
601 – 700	0.00	2.72	1.90
701 – 800	4.55	4.75	4.69
801 – 900	0.00	4.54	3.17
901 – 1000	0.00	9.70	6.77
More than 1000	0.00	13.22	9.22
Total	100.00	100.00	100.00

Relatively the majority of adopters had less banana mats compared to non-adopters (Table 28). About 63.26% of adopters had banana mats not exceeding 200 and none of them had more than 800 mats. While 45.06% of non-adopters had less than 200 mats while those with more than 800 mats were about 27.46%.

4.3.6.2 Banana mats of new varieties

Of all 25 new banana varieties, the varieties most planted by farmers were Yangambi km5, FHIA 17, FHIA 23, Cadarba, SH3436-9 and Bita3. The number of varieties and their mats varied from village to village, while the number of mats per household ranged from 1 to 153 with an average of 16.55 mats.

Farmers participating in the focus group discussions were asked to estimate the percentage of farmers who had planted at least one of the new banana varieties and their mats. In Kiilima, all households had planted at least one of the new varieties, Mushasha 50 to 60%, Minziro 40 to 50%, Bujugo 60 to 70% and Bisheshe (trial village) 80 to 90%. The results from the FGDs indicated higher percentages of adopters than the household survey. The difference was attributed to the fact that PRA was conducted in May 2005 – one year after the household survey was conducted. Another reason that contributed to differences is that the PRA participants were not randomly selected.

FGDs showed that there was great variation in the average number of mats and varieties planted per household between the villages. In Kiilima (trial village) that is located in the heavily pests affected banana production area, the new banana varieties amounted to 25 to 97% of the total mats per household, with an average of more than 65%. In other villages, the mat share of new varieties was still low, with the majority of farmers having only one to ten mats per household. However, because of increasing awareness of farmers about the advantages of these new banana varieties and availability of suckers, the number of adopters is likely to rise dramatically over the next two to three years. This is evidenced by the highest number of new banana mats per household of 62 recorded in Mushasha, Minziro 300 mats, Bujugo 32 mats and Bisheshe 100 mats.

4.4 Multiplication and dissemination of new varieties

The introduction, multiplication and dissemination of planting materials (suckers) of new banana varieties were done by KCDP from 1997 to 2003. The results of both the PRA and household surveys revealed that the central source of the new banana varieties was the mother garden that was established by KCDP at Kyakairabwa Farmers Extension Centre, about 4 km from Bukoba town. The centre received tissue culture materials from Belgium and hardened them before supplying the planting materials to demonstration and multiplication sites that were located in different locations of the region. On-farm testing of some of new banana varieties was conducted in all districts. Thus, the sources of new banana suckers to farmers were banana multiplication and demonstration sites, on-farm trials, direct from mother garden supplied by KCDP staff, farmer-to-farmer exchange and ARDI-Maruku's banana germplasm. For those villages where on-farm trials were established, the major source of suckers was on-farm trials while in others, the major sources were banana nurseries and demonstration plots.

In most areas, farmers received the suckers freely because they are accustomed to traditional exchange of local varieties. However, farmers purchased new planting materials in Minziro, Bujugo and Mushasha villages because the supply from the nearest nurseries was not enough to cover the demand. In turn, the need to purchase planting materials was reported to hinder the spread of new varieties because farmers are not used to buying banana suckers. In addition, the poorest households in these villages were not able to buy banana suckers either due to lack of cash or lack of awareness of the availability of planting materials of the new banana varieties.

Poor households have limited formal linkages and hence are less likely to learn through formal sources about any new practices or technology. In all study villages, the spread of the new banana varieties has been mainly from farmer-to-farmer network that is within a village or community. The sources of new suckers can be classified into direct and indirect diffusion. Direct diffusion is where farmers received suckers direct from the mother garden, multiplication and demonstration sites or from on-farm trials. Indirect diffusion is where a farmer received suckers from his/her fellow farmers.

About 58% of the suckers supplied were distributed directly in Bukoba district and only 6% were disseminated in Karagwe district (Table 29). FHIA 17 had the highest number of suckers supplied direct to farmers followed by SH3436-9, FHIA 23, Yangambi km5 and Pelipita. The varieties that were popular to farmers were Yangambi km5 and FHIA 17 due to good field performance and acceptability. The variation in amount of suckers per variety supplied to farmers was contributed by different quantities of tissue culture materials per variety received at the mother garden.

Table 29: Number of suckers directly supplied during 1997–2003 period

Variety	B'mulo	Bukoba	Karagwe	Muleba	Ngara	Others	Total
AAcv Rose	363	5 969	585	306	180	119	7 522
Bita-2	-	11	-	-	-	-	11
Bita-3	574	3 489	119	244	375	71	4 872
Cardaba	1 820	8 710	345	1 974	2 676	54	15 579
CRBP 39	85	94	-	-	25	-	204
FHIA 01	10 023	23 350	2 101	8 229	15 070	322	59 095
FHIA 02	1 186	3 788	259	1 533	383	28	7 177
FHIA 03	2 818	25 690	2 120	2 288	1 941	99	34 876
FHIA 17	13 930	79 357	8 257	8 406	14 147	2 604	126 701
FHIA 18	491	2 991	6	-	177	40	3 705
FHIA 21	262	1 269	5	47	178	40	1 801
FHIA 23	15 677	56 397	8 566	7 584	15 792	2 079	106 095
FHIA 25	652	5 049	72	303	1 092	52	7 220
I.C. 2	-	4 434	-	3	-	-	4 437
YangambiKm5	3 045	42 220	1 830	10 803	2 127	220	60 245
Paka	-	119	1	-	-	-	120
Pelipita	8 949	13 410	4 671	3 240	10 295	723	41 288
Pisang Berlin	-	29	-	109	-	-	138
Pisang Ceylan	81	211	15	3	-	-	310
SABA	445	1 993	544	111	286	52	3 431
SH3436-9	17 064	72 209	7 937	6 356	15 454	1 408	120 428
SH3640	228	3 353	10	-	198	90	3 879
Total	77 693	354 062	37 443	51 539	80 396	8 001	609 134
percentage	12.8	58.1	6.1	8.5	13.2	1.3	100

Source: KCDP, 2003

During FGDs farmers were asked to mention names of varieties supplied by KCDP. It was learnt that not all varieties produced by KCDP were disseminated and planted by farmers, particularly at the early stage of the programme, when there was low awareness of the new varieties by farmers. They explained that sometimes suckers were left at market places or at the meetings to be taken by whoever wished to try them. By 2002, at the time when the KCDP was drawing to its end, the majority of farmers were aware of the new varieties and their demand was on the increase.

4.4.1 Sources of banana suckers to farmers

Farmers' major source of banana suckers (planting materials) is from fellow farmers within or from surrounding villages because there was no formal system of distributing banana suckers in the region until 1997 when KCDP was established. One of the KCDP objectives was to multiply and disseminate new banana varieties to farmers. Currently and in most cases, banana sucker is given freely, but the situation is changing due to shortage of planting materials of some specific varieties and hence selling of varieties is becoming to experienced. In such situation, a banana sucker was found to sell at a price of TSh 50 to TSh 100.

Extension, farmer to farmer, and NGOs involved in multiplication and dissemination of banana materials were the main sources of suckers of new varieties received by farmers (Table 30). Some farmers obtained planting materials from more than one source. As explained earlier, dissemination of improved new banana varieties were concentrated more in BS and KAL zones and less in KAM zone.

Table 30: Sources of planting materials of new banana varieties by zone

Sources	BS	KAL	KAM	Overall
Farmer- to-farmer	30	17	2	49
Trader	2	0	0	2
Extension	24	34	0	58
Research	3	0	0	3
Direct from KCDP	14	28	0	42

4.4.2 Distance from source of banana suckers

Distance from the source of the planting materials to the recipient is an important factor in the dissemination process. The estimated distance from the source of planting materials (banana suckers) ranged from 0.01 km to 88 km with an overall distance of 2.8 km. These figures reveal that many farmers obtained suckers within their villages. However, some suckers of scarce varieties (not popularly cultivated) were obtained at a great distance, indicating a scarcity of banana planting materials in the immediate communities.

Assurance of clean planting materials is important in controlling spread of banana pests and diseases, and must be considered for the future because pests change with time. As stated above, traditionally, farmers obtained banana suckers free from other farmers. About 51% of the farmers obtained their suckers from farmers whom they had no kinship relationship. Friends accounted for 33% of sources of planting materials, which was significantly different between the zones. In BS zone, friendship plays an important role in obtaining planting materials since most households experience shortage of suckers, while in the KAM zone family provides higher percentage of planting materials from family members than from friends (Table 31).

Table 31: Source of suckers (local) and percentage of farmers received by zone

Relationship to the source	BS	KAL	KAM	Overall
Family member	3.68	10.87	26.23	13.44
Friend	46.25	34.93	17.91	33.00
Work relationship	5.05	1.37	1.39	2.38
No social relationship	45.02	52.83	54.48	51.19

Work relationship had significant contribution as a source of planting materials for the new banana varieties (Table 32). The pattern shows that after a certain period of their adoption, new banana varieties were also given free of charge. Farmers with no kinship relationship with the supplier have the same chance of getting banana suckers like those have this kind of relationship.

Table 32: Source of new banana suckers received by farmers (%) by zone

Relationship to the source	BS	KAL	KAM	Overall
Family	1.4	3.6	0.0	2.5
Friend	44.6	22.9	50.0	33.3
Work relationship	43.2	16.9	50.0	29.6
No social relationship	10.8	56.6	0.0	34.6

4.4.3 Means of acquiring banana suckers

The household survey data identified five means of acquiring banana suckers; free of charge, gift and aid, purchase/buying and exchange. For the local banana varieties, 94.1% of farmers acquired suckers free of charge, 1.37% by purchase, 2.85% by aid, 1.63% by gift and 0.04% by exchange (Table 33).

Table 33: Means of acquiring the local banana suckers by zone

Means of acquiring suckers	BS	KAL	KAM	Overall
Gift	5.59	0.00	0.38	1.63
Aid	0.95	5.94	0.00	2.85
Purchase	3.00	1.10	0.25	1.37
Exchange	0.00	0.08	0.00	0.04
Free of charge	90.45	92.87	99.37	94.12

Farmers who acquired suckers of new varieties free of charge were 77.9%, purchase 11%, aid 5.5% and gift 4.9% (Table 34). In KAM, adopters of the new banana varieties acquired suckers free of charge. Aid and exchange means were experienced only in KAL while purchase was recorded in both BS and KAL.

Table 34: Means of acquiring the new banana suckers (%) by zones

Means of acquiring suckers	BS	KAL	KAM	Overall
Gift	10.8	0	0.0	4.9
Aid	0	10.3	0.0	5.5
Purchase	12.2	10.3	0.0	11.0
Exchange	0.0	1.1	0.0	0.6
Free of charge	77.0	78.2	100.0	77.9

4.5 Farmers' acceptance of the new banana varieties

Farmer's perceptions on willingness to accept the new banana varieties were reported to vary by village depending upon three types of factors. The first is the extent of production constraints they faced. The second is the form and depth of dissemination in the area, including the information provided to farmers. The third are the external factors affecting price and demand.

In areas where banana production had been badly affected by banana constraints, the majority of farmers agreed to plant the new bananas without delay, while in areas where the traditional banana varieties were still producing enough bananas, the majority of farmers hesitated to plant the new varieties, instead waited and observed their performance from volunteer neighbours. During FGDs it was pointed out that farmers heard about the new banana varieties from various information sources. The dissemination mechanisms included on-farm testing, multiplication and demonstration sites, seminars conducted on banana management, soil fertility and conservation, and integrated pest management, and through provision of extension materials (leaflets and posters), agricultural shows, and radio programmes.

On-farm testing conducted from 1997 to 2002 was a particularly intensive mechanism of educating farmers on the new varieties. Farmers who participated in on farm testing essentially became partners in the research and dissemination processes, and through their participation received training on banana production, agronomy and pest management. They also received suckers and manure for the initial establishment of plots and were visited regularly by ARDI researchers. Through on-farm testing, farmers gained first hand experience in growing the new varieties and were able to learn directly from their own experiences about which varieties were best performers under what conditions. Presumably, these farmers became informants in their communities on testing results and assisted other farmers to make informed judgements about the new varieties.

Farmers who participated in on-farm trials reported having received enough information about the new varieties while farmers who had not participated in the on-farm trials felt that the information they received was inadequate. As a result of inadequate information on planting and husbandry requirements of the new varieties, some farmers planted the new banana varieties on poor soils or did not give them adequate care, and thus did not meet performance expectations.

When first introduced, many farmers rejected the new banana varieties versus local ones reducing the spread of the new banana varieties. However, after the new banana varieties had shown good performance, many farmers were encouraged to get the planting materials. This situation was observed in all villages, although in Minziro and Mushasha the situation was more evident where bunches of new banana varieties fetched a high price (more than TSh 3000 per bunch compared to the TSh 1500 for traditional varieties). This good market is a result of the proximity of these villages to Kagera Sugar Factory and the Uganda border markets.

Uganda border trade increased in the last two years due to two factors, the construction of permanent roads and particularly the tarmac road between Tanzania and Uganda, and the establishment of quarantine within Uganda to contain banana bacterial disease that restricted the supply of materials from the area infected with the disease. This made many youths establish banana plantations and began looking for planting material of the new banana varieties. Demand for suckers was high as illustrated by reports of increasing theft of banana suckers and bunches in the two villages of Minziro and Mushasha.

4.5.1 Uses of new banana varieties

It was reported by farmers that all the new banana varieties introduced could be used for cooking. However, choices are made by individual households depending on the quantity of bunches harvested and availability of other food. There was no variation in the way that farmers classified new bananas varieties into use classes among villages. The varieties preferred most for cooking are FHIA 17, FHIA 23, SH3436/9, Bita3, FHIA 01 and Yangambi km5. Farmers mentioned that Yangambi km5 if mixed with meat produced better soup than Mtwishe (Cavendish type). Varieties that were mentioned for making juice or/and brews were Yangambi km5, FHIA 25, FHIA 01 and FHIA2, while dessert varieties mentioned were Yangambi km5, FHIA 02, FHIA 17 and FHIA23, and Cardaba and Pelipita were the most preferred for roasting. In general, it was reported that Yangambi Km5, FHIA 01, FHIA 02 and FHIA 17 were more multiuse varieties compared to the other varieties.

4.5.2 Abandonment of banana varieties

Usually, when the performance of any banana variety becomes poor for a long period under farmers' fields, one of the farmers' copping strategies is to reduce the amount of mats or even drop that variety and plant other varieties that they assume can grow better under such situation, without first thinking of crop management improvement. During the past 15 years, on average, a household dropped four banana varieties in the BS and KAL zones, and two banana varieties in the KAM zone. Every genomic group had banana varieties that were dropped by farmers in the past 15 years.

The endemic group had the highest average number of banana varieties dropped per household since these were less tolerant to the new pests and diseases. Even some of the recent introduced banana varieties that are said to have tolerance to most banana production constraints including banana weevils, were reported to be abandoned by farmers in the first five years of use. The reasons for abandoning these varieties included their poor field performance, poor suitability for cooking, roasting, brewing and juice making. However, patterns in the types and numbers of varieties being discarded or set aside for some years varied by zone, village and household, depending in part on the banana management practiced by farmers (Table 35).

Table 35: Average number of varieties dropped by farmers

Genomic group	Number of varieties dropped			All	Significance
	BS (A)	KAL (B)	KAM (C)		
Endemic	2.96	2.31	0.77	1.91	AvBvC
Non-endemic	1.27	1.22	0.67	1.03	(A/B)vC
Old exotic	0.77	0.96	0.45	0.72	(A/B)vC
New exotic	0.50	0.26	0.22	0.31	Ns
Overall average	4.23	3.53	1.45	2.94	AvBvC

Key: v – means versus (e.g. Av(B/C) means group A is significantly different from B and C at 5% level, Group B and C do not differ) across agro-ecological zones.

Adopters of new varieties experienced significantly higher number of local varieties abandoned per household than the non-adopters. On average, adopters of new banana varieties dropped 4 banana varieties while non-adopters dropped 2 varieties during the past 15 years (Table 36).

Table 36: Number of varieties dropped in the past 15 years by genomic group

Genomic group	Number of varieties dropped		
	Adopters	Non-adopters	All
Endemic	3.00**	1.44**	1.91
Non-endemic	1.44*	0.85*	1.02
Old exotic	1.04*	0.58*	0.72
New exotic	0.40	-	0.40
Overall average	4.43*	2.02*	2.94

Key: * - denotes statistical significance at the 5% level in the difference of means between adopters and non-adopters

According to results of the household interviews and FGDs with farmers, there was no single variety that performed well in all agro-ecological zones. At least, every banana variety has been dropped by at least one farmer for one reason or another. Local banana varieties, which were more frequently dropped by farmers, were Emwailuma, Enjubo, Entobe, Enchoncho, Enshakala, Ensikila, Kijoge, Mtwishe, Engagala, Enyoya, Kisubi and Entundu.

Similarly, farmers dropped some of the recent introduced new banana varieties. Those most frequently reported by farmers to be dropped were Pisang Ceylon, IC_2, Cardaba, SABA, FHIA 03, PAKA, SH 3436-9 or SH 3640 (*Shillingi*) and AAcv Rose. This, therefore, requires further monitoring and evaluation of the performance of the new banana varieties grown by farmers under different environment and level of management. Several criteria have been used by farmers to assess the new banana varieties. The criteria included poor growth performance, the extent of resistance to Fusarium wilt disease and poor taste particularly for cooking and brewing (Table 37).

In addition, results from the FGDs revealed that a number of new varieties were not completely assessed by farmers because their supply of planting materials was currently limited. These varieties included FHIA 21, FHIA 18, FHIA 23, FHIA 25 and *Shillingi.* Thus, farmers were not able to adequately assess the growth, production performance and acceptability of these varieties.

Table 37: Varieties dropped by farmers

No.	Variety	Reason(s) for drop
1.	Pisang Ceylon	Severely affected by Fusarium wilt. It is strictly a brewing type, dwarf producing very small bunches
2.	IC_2	Bitter and produces stringent juice
3.	Cardaba	Recorded by farmers as susceptible to Fusarium wilt disease (in Kiilima, Minziro) and requires a lot of manure
4.	SABA	Produces small bunch
5.	FHIA 03	Susceptible to Fusarium wilt disease; small bunch; when ripe, fingers drop easily from the bunch
6.	Paka	Low yield and poor taste
7.	Shilingi (SH3436-9 and SH3640)	Delayed maturity (1.5 to 2 years) and produces very few suckers. As cooking banana, it is hard to eat compared to others.
8.	AAcv Rose	Small fingers (dropped in Minziro and Kiilima)

4.5.3 Advantages and disadvantages of new banana varieties

During the PRA survey farmers also discussed advantages and disadvantages of the new banana varieties. The outcomes of these discussions were crosschecked with the information collected from individual farmers during the household survey interviews. In general, it was mentioned by farmers that not all new varieties had good field performance and acceptable attributes. Varieties such as Yangambi km 5, FHIA 17, FHIA 23, SH 3436-9 and SH 3640 that were increasingly adopted by farmers had the following advantages and disadvantages:

(a) Advantages

(i) The leaves of new varieties do not drop (but remain green) even during the dry season. Because of this factor they provide good coverage of the soil. In addition, because of shading, the growth of weeds is hampered and the number of weeding is reduced from 6 to 4 times, making the weeding activity less laborious compared to that which is required for fields planted with traditional varieties.

(ii) Increased coverage of houses; thus reducing the hazards resulting from strong winds that may lead to the destruction of houses and premises.

(iii) New varieties have big and broad leaves, which are better for mulching the field.

(iv) New varieties have strong root anchorage and are not vulnerable to wind damage.

(v) New varieties are believed to produce two and a half bunches per year because the follower suckers come earlier and with vigour compared to local varieties, which usually produce one bunch per stool per annum.

(b) Disadvantages

(i) Yangambi km5 variety has hard corm that does not rot after bunch harvest and continue producing suckers. Thus extra labour is required to remove it and if it is not uprooted reduces the area for planting intercrops such as beans. In the FGDs, some farmers reported to have observed this situation and hence, increased plant spacing from three meters by three meters to four metres by four meters and di-suckered (pruned) to leave two plants per stool.

(ii) Most new banana varieties (except Yangambi km5) produce few suckers limiting the supply of planting materials for expansion of banana plots.

(iii) Sheaths of new suckers are brittle and thus not good for ropes, building materials, ornamental purposes and other craft work compared to traditional banana varieties.

4.6 Farmers' perceptions of the impacts of new bananas on livelihoods

Impacts on people's livelihoods were also investigated through FGDs that supplemented and complemented to the description of the household survey data on identifying the livelihood outcomes accrued from use of new banana varieties (Objective 2). The qualitative data analysis revealed that changes in selected impact indicators were attributed to the use of new banana varieties (Hypothesis 2). In villages with high adoption of the new varieties such as Kiilima in the BS zone realised the actual impacts of the use of new varieties. Some villages such as Bujugo, Minziro and Bisheshe are beginning to realise impacts since adoption in these villages has been moderately high. However, in Mushasha village, potential impact has yet to be realised by farmers and communities because adoption is still very low. Impacts are categorised on the basis of banana production, agricultural cropping patterns and social context (social status and relationship). These are summarised in Tables 38 and discussed in the following text.

Table 38: Farmers' perceived impacts of new banana varieties

Type of impact	Remarks
(a) Impacts to banana production and derived products:	
Increased banana production	Perishing local varieties replaced by new varieties; Increased number and size of bunches, increased number of hands per bunch and increased number of fingers per bunch.
Increased income	Income obtained from sales of new bananas
New products developed	Increased production of banana wine, improved quality of banana beer and juice
Food security improved	Increased number of banana meals
Reduction in production of traditional varieties	Due to increased competition within banana plots between new varieties and traditional varieties, with new varieties being better able to compete
(b) Impacts to the agricultural cropping patterns	
Reduced production of associated crops	Due to increased shade produced by new varieties making less favourable growing conditions for beans (and potentially coffee and maize to a lesser extent)
Reduced cultivation of root and tuber crops	Because production of new varieties of bananas is increasing, acreage of root/tuber crops under production decreases because banana replaces roots and tubers in the diet
(c) Impacts to social capital: social status and relationship	
Enhanced social status	Good banana fields conveys high social status, thus in those villages where banana production had suffered heavily, improved varieties have revived lost plots and thus built social status.
Enhanced contribution of banana to social functions	New varieties increasingly accepted as contributions to social functions such as weddings and funerals.
Improved social relationships	Increased banana production has positive effects on ability to form, maintain and enter into social groups. Related issues raised included greater ability to access loans; strengthening of women's social sector due to their ability to self-finance their social groups; and increased status of women due to their ability to control some of the multiple products from multiuse bananas

4.6.1 Impacts to banana production and derived products

4.6.1.1 Banana production

Those banana mats of local varieties that were not producing bunches have been replaced with the new banana varieties. The changes are very noticeable in any household that has planted and already started to harvest bunches in terms of increased number and size of bunches, increased number of hands per bunch and increased number of banana fingers per bunch (new varieties produce 30 to 35 fingers and local varieties produce seven to twelve fingers as mentioned by farmers from Kiilima, Mushasha and Bisheshe villages). One bunch of Yangambi km5 is equivalent to three to four bunches of local varieties. This was appreciated in all households in all villages who have cultivated new banana varieties.

In Kiilima village, farmers stated clearly that there was a significant increase in banana production from 1997 to 2005 while in the other villages banana production is still declining because adoption rates for new varieties is still low. In these villages, farmers are coping by increasing cultivation of annual crops such as maize, cassava, sweet potatoes, cocoyams and water yams.

4.6.1.2 Increased household income

Increased household income from selling bananas and/or local brews was mentioned by farmers in all villages. This has helped many households to cover their basic expenses. Indicators of this change include good clothes for all family members, uniforms for school going children and pupils and improved school attendance. This was pointed out in all the FGDs that were held.

4.6.1.3 Food security

Based on banana meals as a staple food, only Kiilima village reported improvement in food security accrued from planting of new banana varieties. In this village, the number of banana meals increased from one meal per month in 1995 to four meals per week in 2005. Villagers said that there was more food choices currently (bananas – local or new, cassava, sweet potatoes, coco yams, water yams, etc.) compared to the situation before the introduction of new banana varieties. This has improved the nutritional status and health of the family members. A biological event mentioned by farmers as an indicator of availability of food surplus in this village is an increase in the population of birds. Delay in harvesting ripen bananas allows birds to feed on them and thus their number has significantly increased in the past five years. Before the introduction of new banana varieties the population of birds had decreased because of migration.

In Mushasha, banana meals had decreased from three meals per day in 1970 to one meal per day in 1990 and one meal per week or month in 2005. In Bisheshe, banana meals have decreased from two meals per day in 1990 to one meal per day in 2005; farmers in Minziro mentioned that banana meals are on decline from three meals per day in 1970 to one meal per day in 1990 and one meal per week in 2004; in Bujugo, banana meals decreased from four meals per week in 1990s to four meals per month in 2004.

Food habits (taste) have changed in all villages surveyed. During the FGDs, it was reported that there was an increasing acceptance of eating other types of foods such as maize, root and tubers crops.

4.6.1.4 Increased number of banana varieties per household

In most cases, particularly where banana production constraints are less severe. farmers are filling gaps among their banana mats rather than replacing their old local bananas with new ones. In areas severely affected by banana constraints like Kiilima village, banana plots had few remaining bananas and farmers were not pruning their coffee trees as they did in the previous years in order to obtain more coffee per tree. With the introduction of new banana varieties, many farmers are again pruning coffee trees to reduce shading to their bananas. In other villages with minimal damages caused by banana pests and diseases, a few mats of new banana varieties are planted in the existing local bananas. Because Fusarium wilt disease damages brewing and dessert banana varieties, the FGDs in Mushasha and Minziro reported that Yangambi km5 was replacing Kainja varieties. Thus, the introduction of new banana varieties has helped increase the number of varieties cultivated per household.

4.6.1.5 Increased production of banana juice/beer

In Kiilima, Bujugo and Minziro villages, farmers remarked that the introduction of new banana varieties has contributed to increased production of local beer and juice (Mramba). They mentioned that the new banana varieties produce juice and brews of superior quality and longer shelf life than the local banana varieties. They also observed that beer production within the village has made farmers come closer and have discussions while drinking, which was different from the past five years when they were forced to travel long distances looking for local beer. This has therefore, improved social functions, which are important in strengthening social relationships among farmers. In addition, outside people are now coming into the village to get this service and hence the village earns some income. When asked whether the production of more local beer increases leisure or conflicts among households, farmers stated that these effects were outweighed by the benefits of improved relationships. In the other villages, there was no remarkable effect of new banana varieties on juice and local beer. They only reported that Yangambi Km5 produces sweeter juice than local bananas.

4.6.2 Impacts to the agricultural cropping patterns

4.6.2.1 Reduced cultivation of root and tuber crops

At the time the new banana varieties were introduced, cultivation of root and tuber crops was increasing because local varieties were not performing well. But the situation now is different because banana mats of new varieties are increasing and reducing cultivation of root and tuber crops. Similarly, *Kikamba* and some areas of *Rweya* are planted with new banana varieties, which are expected to change the crop pattern trend where banana plants are declining.

4.4.2.2 Reduced cultivation of associated shade grown crops

Because of good coverage of leaves by the new varieties, some branches of coffee trees are pruned to allow for more space for the bananas to grow. Before planting new varieties, particularly in villages of Bukoba district, coffee trees were not pruned because bananas were non-productive plants.

4.6.3 Impacts related to the social capital

4.6.3.1 Increased social status of a household

In Kagera region, a household with good banana fields has high social status compared to one with poor banana fields. In those areas where banana production was heavily affected by banana pests and diseases, planting new banana varieties revived social status. Also, even in areas where local bananas were performing well, new banana varieties were increasingly planted for sale and making local brews.

4.6.3.2 Improved social relationship

It was observed in all villages that the importance of joining social groups was increasing as a means to access informal loans and assistance from other farmers on farming activities and other activities. Increasing production of bananas has always been having positive effects on this process since for example, a household head could obtain a loan from his fellow farmers by hoping that he/she can pay back the loan after harvesting banana bunches. Increased production of bananas has strengthened women's groups in the villages because women are now able to pay annual membership fee or contributions on certain social functions such as weddings and funeral ceremonies.

New varieties have multiple uses that enhance the reduction of existing imbalances between men and women in the control and benefits accruing from products of new banana varieties compared to local varieties. Hence, the use of new varieties had positive indicators on improving social relationship and equality among households and household members. Traditionally harvesting of cooking bananas is controlled by women (wives) while men (husbands) controlled brewing bananas. Also, adoption of new varieties had improved the social stability by reducing theft of bananas, and reduced time for looking food and expenses of buying foods as pointed in Kiilima village.

4.6.3.3 Acceptability into the community

In the past, when local banana production was good, bunches of specific varieties contributed to social functions such as weddings and funeral ceremonies. Root and tuber crops and cereals replaced these when banana production had seriously declined. At present bunches of new varieties have become accepted in such functions and are preferred more by traders and consumers located in non-banana growing areas due to their large sizes of bunches and fingers.

4.6.4 Areas of negligible change

4.6.4.1 Soil fertility

The introduction and adoption of new banana varieties had little influence on improved soil fertility as reported by farmers during FGDs. However, farmers in all study villages explained that new banana varieties performed better on poor soils compared to local varieties. Villages that tested new varieties under ARDI Maruku and KCDP (Bisheshe, Minziro and Kiilima), were provided with 5 tins (a 20 litres container) of farm yard manure during planting. However farmers continued to use farm residues and those livestock owners used manures into banana plots. There was no sustained improvement of soil fertility because of planting new banana varieties.

Farmers in Kiilima noted change in soil fertility because banana bunches produced were becoming smaller compared to the time when they were first planted them. This implies that in long run, if farmers do not change their practices by not applying fertilizers both organic and inorganic, soil fertility will become more depleted in plots where new varieties were planted than in those plots that were planted with local varieties. However, further investigation on this is suggested.

4.6.4.2 Pests and diseases

New banana varieties are believed to resist banana pests. However, farmers in Kiilima and Bisheshe who planted new banana varieties since 1997 remarked that FHIA 01, FHIA 02 and FHIA 03 have succumbed to Fusarium wilt (*Fusarium oxysporum var Cubense*) disease leading to some farmers stop planting any more. In all the study villages, there was no mention of new banana varieties having been seriously affected by banana weevils (*Cosmopolites sordidus*), nematodes and Black Sigatoka (*Mycosphaerella fijiensis*). Hence, routine monitoring and evaluation of the performance of all new varieties disseminated under different farmers' environment is recommended.

4.6.4.3 Livestock keeping

Farmers were asked to discuss changes that occurred in livestock keeping. In all villages the number of livestock was particularly reported to have declined in the past 15 years. In the FGDs, farmers pointed out that those with livestock were in a better position to acquire and plant the new banana varieties because they have manure which is important for planting a new banana stool. Based on the time since the new varieties were introduced in the region, farmers who owned livestock before planting new banana varieties continued to own them and those without livestock did not make efforts to get them. There was no outcome indicators observed of farmer acquisition or ownership of livestock as of adopting the new banana varieties.

4.6.4.4 Changes in knowledge and practice

During the introduction of new varieties, agricultural departments in both districts trained farmers on good banana management. However, farmers continued to employ traditional banana management and there was no major changes in their banana knowledge resulted from adoption of new banana varieties. The only aspect noted during the FGDs was the farmers' observation on Yangambi Km5 as a prolific sucker producer and yet it has a hard corm. As such farmers are making more efforts to ensure they achieve routine de-suckering of Yangambi Km5 and adjusting plant spacing.

4.6.4.5 Credit and loan accessibility

Introduction of new banana varieties did not change farmers' access to formal credit facilities, although it clearly enhanced their capacity to obtain informal loans from other farmers. However, farmers explained that they have a growing desire to obtain credits to buy livestock and/or increase crop production acreage but have failed.

4.7 Determinants of the extent of adoption of new banana varieties

The descriptive statistics discussed in the previous sections of this chapter assist in understanding the household characteristics and farms of both adopters and non-adopters of new banana varieties. However, they do not offer much insight into the process of the technology adoption or the impact of new bananas on people's livelihood. Therefore, further multiple regression analyses were needed that can deal with issues of endogeneity and simultaneity of explanatory variables. These included Logit (Logistic) and Tobit regression analyses to identify determinants of the extent and intensity of the adoption of the new banana varieties (Equations 10 and 11) to test the first hypothesis.

The important explanatory variables covered under this type of analyses are defined agro-ecological zones, farm and household characteristics. Eleven out of twenty two explanatory variables tested were significant in explaining the adoption of the new banana varieties (Table 39). The significant variables were agro-ecological zone (dummy variables of BS and KAL), age of household head (Male=1), banana field quality (dummy variables for good, average and poor fields), size of cultivated land, household asset value, number of non-endemic cultivars, number of endemic mats, livestock ownership (cattle and small animals).

Age of household head was the only demographic characteristic which scored significant differences on the adoption of the new varieties. The positive association on age and adoption indicates that the older the household head, the greater the chances adopting the new varieties. Similarly, age of household heads was assumed to be positively correlated with the experience of banana cultivation.

Education of household head, gender of household heads (male=1), household size and dependency ratio were not significant variables in determining the adoption of the new varieties.

Table 39: Logit regression of adoption determinants of new banana varieties

Determinants	Coefficient	Standard error	P>|Z|
Log likelihood	- 92.3447		
Constant	- 7.5313**	1.5987	0.000
Zone (1=BS)	3.8443**	1.0709	0.000
Zone (1=KAL)	3.8739**	1.0828	0.001
Field quality (1=good field)	- 1.0049*	0.4788	0.036
Gender of household head (1=male)	0.5338	0.4868	0.273
Age of household head	0.0375**	0.0144	0.009
Education of household head	0.1061	0.0849	0.211
Household size	- 0.0308	0.0840	0.836
Dependency ratio	- 0.1267	0.2195	0.714
Extension services contact (1=Yes)	0.1276	0.4271	0.765
Farm size (ha)	0.0390	0.2990	0.896
Cultivated land (ha)	- 1.2166*	0.5900	0.039
House type (1=permanent)	- 0.1127	0.4346	0.795
Assets value	0.0470**	0.0152	0.002
Number of endemic cultivars	0.0155	0.0719	0.829
Number of old Exotic cultivars	0.2587*	0.1292	0.045
Number of endemic mats	- 0.0068**	0.0021	0.001
Cattle ownership (1=own)	1.3588*	0.5576	0.015
Cattle value	0.0051	0.0050	0.308
Ownership of goats, sheep and pigs	1.2350*	0.5632	0.028
Value of goats, sheep and pigs	0.1170	0.0940	0.213
Chicken ownership	- 0.0184	0.4449	0.967
Value of chicken	- 0.3607*	0.1805	0.046

Key: **, *, ^ - denotes statistical significance at the 1, 5%, & 10% level in the difference of means or distributions across groups

The first two had positive association while the last two recorded negative association with adoption of the new banana varieties. The fact that gender is not statistically significant indicates that when other variables that differ by gender are taken in account (such as asset ownership), these factors, rather than gender in and of itself, may explain adoption (Doss, 2003). The positive coefficient of years of schooling of household head implies that adoption increases with the increase in number of years of schooling. Furthermore, the positive association of male headed households and adoption suggests that male heads were more likely to adopt than female heads although this was not significantly different. Males had adoption rate that averaged 0.5338 points higher than females. The dependency ratio had negative sign that concurs with the fact that one of the characteristics of the rich-resource households is availability of family labour (adults) and owning good banana fields. The higher the value (fewer adults) the less chance of adopting the new varieties.

Adoption of the new banana varieties was significantly different in BS and KAL zones. These are zones which are faced by severe constraints of banana production leading to the perishing of the local banana varieties. The positive association implies that farmers from these zones are more likely to adopt the new banana varieties. For example, farmers in BS and KAL had, on average 3.8443 and 3.8739 more adoption points compared to farmers located in KAM respectively.

On the contrary, good banana fields (dummy variable: good field = 1, and otherwise = 0) that are well managed and that produce a reasonable harvest of local bananas is negatively associated with adoption of new varieties. Farmers with good fields above average had on average, 1.0049 less adoption points compared to those farmers who had poor banana fields. In the FGDs, it was learnt that local varieties have superior cooking taste compared to the introduced banana varieties. Thus in a situation where farmers have enough resources and technology to properly care for their banana fields against increasing banana production constraints, those farmers will naturally prefer to produce local banana varieties, particularly for home consumption. On the other hand, increasing awareness of the good marketability of the new banana varieties both within and outside the region could provide incentives for even those farmers with good banana fields to begin planting them.

Land is one of the important livelihood assets owned by rural farming households. However, farm size owned by household was not a significant determinant of adoption of the new varieties. It is not only the households with large farms who have taken up the new banana varieties, but also the households with small fields. Planting of the new banana varieties is mainly taking place within the existing banana fields by filling those gaps left by local bananas that are dying due to pests and diseases. Surprisingly, the size of area cultivated with bananas was significantly and negatively associated with the adoption of new varieties. This means that the larger the size of the banana field per household, the less likely the household would plant new banana varieties. Farmers with small banana fields have to make sure that each banana mat is productive in order to get reasonable production for home consumption and sale. The same relationship was observed in households with permanent house type that were unlikely to plant the new banana varieties.

With respect to value of household assets, the adoption of new varieties was highly significantly different from the total aggregate value of all assets owned per household. It has been a traditional assumption that new crop varieties such as banana varieties are regarded as neutral technologies that can be adopted by all household categories with different resources at equal rate (Conway and Barber, 1990). The logit regression analysis showed that those households with higher asset values have higher chances of adopting the new varieties. With an additional of TSh 10 000, the adoption rate goes up on average by 0.047 points. This supports the sustainable livelihood framework which claims that household assets play an important role in adoption of new technologies (DfID, 2000). This observation is also supported from literature on technology adoption during the Green Revolution. In that context, adoption of modern varieties was associated with certain lumpy investments such as tubewells and access to complementary inputs, such as fertilizer (Conway and Barber, 1990). In this study, access to information is likely to explain this relationship, since the suckers were distributed free, without other recommended inputs.

Adoption of the new varieties was not affected by the number of endemic cultivars but it was significantly affected by the number of old exotic cultivars. This means that farmers with more old exotic cultivars have become used to different tastes of bananas (endemic and non-endemic). The number of endemic mats, similar to the cultivated farm size, was negatively and significantly associated with the adoption of new varieties.

Ownership of livestock, including both cattle and small animals (goats, sheep and pigs), was a significant determinant of the adoption of the new varieties,. This tallies with the opinion observed in FGDs in which it was explained that planting of new mats (both local and new varieties) depend much on the availability of manure which is mainly obtained from livestock. Making of compost manure could be another source of the manure but it is not common in the study area. Farmers with livestock have access to cow-manure that can satisfy the needs of a portion of their farms including new mats. However, livestock numbers and their values were not important determinants of adoption of new varieties. Ownership and value of chicken showed negative association with adoption of the new varieties. Banana fields are within the homestead and chicken types kept are local, free range types. The greater the number of chicken kept the more destruction in the banana fields. The amount of the manure produced by the chicken does not offset the destruction caused by chicken during grazing around the fields.

Extension services had no significant effect on likelihood of adopting the new varieties. This means that much of the adoption of new varieties occurred through farmer-to-farmer exchange. As observed during the FGDs, this finding could mean that extension programmes carried out during the dissemination period of new varieties had no messages concerning the new varieties.

4.8 Factors that determine the intensity of adoption

Tobit regression analysis was conducted to determine the factors that influence the adoption intensity of the new banana varieties. As explained earlier, the Tobit regression model fits with a model of dependent variable on a set of independent variables where the censoring values are fixed. The adoption intensity was measured in terms of number and share of mats of new banana varieties planted per household (Table 40 and Table 41).
Eight variables were significant in explaining the number of mats of new banana varieties; agro-ecological zones (dummy variables of BS and KAL), field quality, number of old non-endemic cultivars (exotic cultivars), number of endemic mats, value of household assets, and ownership of cattle and small animals (Table 40).

Of the ten variables that were significant in explaining the decision to adopt new varieties, all except age and cultivated land area were also significant in explaining the intensity of adoption. This implies that age of household head would only affect the extent of adoption if new varieties required more labour on the part of the household head. Cultivated land area appears to be independent of the numbers of mats grown.

Households located in BS and KAL zones have on averages 57.7 and 48.4 new mats more respectively than farmers located in KAM zone. Those households with banana fields of good quality have on average less than 21.4 mats of new banana varieties. The more the mats of the exotic cultivars planted by a household, the more the number of mats of the new bananas. However, the number of endemic mats was negative and significantly associated with the number of the new mats. The ownership of livestock (cattle, goats and sheep) positively correlated with the number of new mats per household. As in the Logit regression, the number and value of each livestock type was not a significant determinant of the intensity of adoption.

Table 40: Tobit regression of determinants of new banana mats per household

Determinants	Coefficient	Standard error	P>|z|
Log likelihood	-352.3213		
Constant	-107.6795	24.5877	0.000 **
Zone (BS=1)	57.6987	14.3307	0.000**
Zone (KAL=1)	48.4142	14.2220	0.001**
Field quality (good=1)	- 21.4044	7.2544	0.003**
Age of household head	0.1197	0.2230	0.592
Education of household head	0.9754	1.3257	0.463
House type	2.3342	6.8649	0.734
Gender of household head (male=1)	7.9678	8.1788	0.331
Household size	- 1.4354	1.3605	0.292
Dependency ratio	- 4.6314	13.8497	0.738
Farm size	- 0.8182	4.3959	0.853
Cultivated land	- 2.4811	7.6787	0.747
Extension	9.54837	6.3498	0.134
Number of endemic cultivars	0.9901	1.1082	0.373
Number of old exotic cultivars	3.1256	1.8630	0.095*
Endemic mats	- 0.0552	0.0262	0.036**
Value of household assets	0.4877	0.1684	0.004**
Cattle ownership (yes=1)	24.3018	8.2142	0.003**
Ownership of goats/sheep/pigs (yes=1)	21.5198	8.2952	0.010*
Ownership of chicken (yes=1)	1.688537	7.0685	0.811
Value of cattle	0.033716	0.0817	0.680
Value of goats, sheep and pigs	- 0.067443	1.1316	0.953
Value of chicken	- 1.101664	2.8326	0.698

Key: **, *, ^ - denotes statistical significance at the 1%, 5%, & 10% level in the difference of means or distributions across groups

The same explanatory variables were tested to determine the percentage share of the new mats to the total banana mats per household (Table 41). The share of new mats for the households located in BS and KAL were 23.4413 and 21.5346% more respectively than that of households located in KAM. Likewise, the age of the household head was a significant variable in determining the share of the new mats. With each additional year of household head, the share percentage of the new banana varieties on average increases by 0.1458%.

Other variables that were significantly different influenced the share of the new mats included banana field quality, number of endemic mats, value of household assets and ownership of livestock (cattle and small animals). Variables that were not significantly different with positive correlation in determining share of mats of new varieties were gender (sex) and education of household head, extension services, number of varieties (endemic and non-endemic) and value of livestock. The non-significant variables with negative correlation were household type, household size, dependency ratio, farm size and cultivated area. Both Logistic and Tobit regression analyses showed that the was strong evidence by 95% confidence to accept the first hypothesis of the study i.e., the extent and intensity of adoption of new banana varieties has been influenced by biophysical and socio-economic factors surrounding the farmers.

Table 41: Tobit regression of determinants of share of new banana mats

Determinants	Coefficient	Std. error	P>|z|
Log likelihood	-341.6410		
Constant	-38.5291	9.5377	0.000**
Zone (BS=1)	23.4413	5.6727	0.000**
Zone (KAL=1)	21.5346	5.651	0.000**
Field quality (good=1)	- 7.5726	2.8321	0.008**
Age of household head	0.1458	0.0872	0.096^
Education of household head	0.7039	0.5293	0.185
House type (1=permanent & 0=others)	- 0.6305	2.6842	0.814
Gender of household head (male=1)	2.8791	3.0958	0.353
Household size	- 0.3679	0.5150	0.476
Dependency ratio	- 4.7073	5.3993	0.384
Farm size	- 0.3559	1.7644	0.840
Cultivated land	- 4.2297	3.2702	0.197
Extension	2.7800	2.5190	0.271
Number of endemic cultivars	0.3259	0.4402	0.460
Number of old exotic cultivars	0.5804	0.7438	0.436
Endemic mats	- 0.04274	0.0127	0.001**
Value of household assets	0.1841	0.0693	0.008**
Cattle ownership (yes=1)	8.9438	3.3053	0.007**
Ownership of goats, sheep and pigs (yes=1)	7.0675	3.2855	0.032*
Ownership of chicken (yes=1)	0.2221	2.7430	0.936
Value of cattle	0.0270	0.03406	0.428
Value of goats, sheep and pigs	0.2406	0.4539	0.597
Value of chicken	- 1.1788	1.1887	0.322

Key: **, *, ^ - denotes statistical significance at the 1%, 5%, & 10% level in the difference of means or distributions across groups

4.9 Estimated impacts of new banana varieties on banana productivity

Assessment of impacts of the new banana varieties on livelihoods of banana growers was one of the objectives of this study. As stated by Heckman and Smith (1995), in order to obtain good estimates of the impacts of a programme, it is important to understand the process by which participants ended up in the programme and non-participants did not get involved in the programme. Also, knowing that participation in use of new varieties depends on both observed and unobserved factors and in any impact evaluation there will always be some factors that are unobserved but could potentially result in selection bias. The results of participatory rural appraisal survey helped to provide qualitative information about programme participation in KCDP, and the characteristics of the participants and non-participants that were quantified in the household survey. Both the findings of participatory rural appraisal survey and the regression analyses of household survey data contributed to an understanding of adoption. The instrumental variables (IV) method was used to measure impacts quantitatively (Equations 12 and 13).

Before the IV method or the treatment effect model was estimated, the exogeneity of the dichotomous variable (use of new banana varieties) was tested in the impact equation (Equation 9). This was achieved in several steps. First, the Logit adoption equation was estimated, and the residuals were saved. Then, the impact equation was estimated using the actual observations for use of new banana varieties, as well as the saved residuals. The estimated dependent variables were average yield (kg) and average yield loss of bananas (percentage).

4.9.1 Average banana yield

On estimating the average banana yield the IV method showed that there was no statistical indication of correlation between the errors of the impact equation and use equation where the p-value was =0.202 for the residuals. This supported the inclusion of the use of new bananas as an explanatory variable in the impact equation. The treatment effect model, a specific type of IV method, is estimated by maximum likelihood methods. Statistical support for simultaneous estimation of both equations is evidenced by the significance of the hazard function (p-value=0.025 for lambda). Thus, information from one behavioural process (the treatment regression, or Logit adoption equation) influences the outcomes of another process (the impact equation), similar to the Mills ratio in a Heckman estimation approach using the two-step approach. Estimated coefficients of the IV method are presented in Table 42, separately for the use and impact equations.

Using the cross-sectional data measuring adoption in the fifth-year since the new banana varieties were introduced, the impact equation showed that the overall average banana yield per bunch of cooking type had three significant explanatory variables: size of land cultivated, ownership of cattle and adoption of new banana varieties. Larger fields of bananas were negatively associated with average yield per bunch because of labour requirements in managing bananas.

Table 42: Estimates for treatment effects model for average banana yield

Variable	Treatment equation (participation) Coefficient	Std. error	Impact equation (average expected yield) Coefficient	Std. error
Constant	- 5.59628	1.3397		
Gender (male=1)	0.17025	0.4075	- 1.4373	1.2705
Age of household head	0.0256	0.0119	0.02925	0.0372
Education of household head	0.08893	0.0729	0.0803	0.2172
Household size	- 0.0438	0.0834	- 0.1077	0.2030
Dependency ratio	0.1874	0.7712		
Extension service	0.2265	0.3905	1.3578	1.0690
House type	0.1543	0.3764	0.7061	1.1232
Cattle ownership	0.9361*	0.4868	2.0861^	1.2293
Small animals ownership	0.8339^	0.4686	- 0.2725	1.0961
Chicken ownership	- 0.2745	0.4084		
Value of cattle	0.0013	0.0058		
Value of small animals	0.1252^	0.0639		
Value of chicken	- 0.2994	0.1468		
Zone 1 (BS=1)	2.6524**	0.8394		
Zone 2 (KAL=1)	2.0378*	0.7985		
Field quality	- 1.0702*	0.4162		
Farm size	- 0.1605	0.3063		
Cultivated area	- 0.5051	0.5422	- 1.5763*	0.6867
No. of endemic cultivars	0.1111	0.0757		
No. of non-endemic cultivars	0.2305*	0.1043		
Endemic mats	- 0.0072*	0.0032		
Value of household assets	0.0236*	0.0105		
Adopters			4.6869*	2.1476
Hazard (Lambda)			- 3.4706	1.5505* (p = 0.025)

Key: **, *, ^ - denotes statistical significance at the 1%*, 5%, & 10% levels, respectively, in the difference of means or distributions across groups

Cattle keeping affected average banana yields positively, as expected, since cattle produce more manure than small animals such as goats, sheep and pigs. Similarly, banana yields were significantly higher for adopters than for non-adopters, controlling for other factors that influence impacts. Adopters are likely to get 5 kg per bunch more than yields obtained by non-adopters (Table 42).

Farmer's experience, which was measured in terms of his/her age, education of household head, household size and extension services had no significant effect on the banana yield. The effect of adoption of the new banana varieties on average banana yield was the same on these explanatory variables. The negative sign on household size implied that large households were likely to get less average banana yields even if they planted the new banana varieties.

4.9.2 Average yield loss

The new banana varieties were mainly bred as resistance to banana production constraints (banana weevils, banana nematodes, Black Sigatoka and Fusarium wilt). It was hypothesised that average banana yield would have improved by adopting the new banana varieties. Also, the banana yield loss would have been significantly reduced resulting in improvement of household food security and income. As it was with the case of average yield, Table 43 shows that there was no statistical indication of correlation between the errors of the impact and use equations was found (p-value=314 for residuals) and the statistical validity of simultaneous estimation is evidenced by the significance of the hazard function (p=0.086).

Table 43: Estimates for treatment effects model for average banana yield loss

Variable	Treatment equation (participation)		Impact equation (Expected yield loss %)	
	Coefficient	Std. error	Coefficient	Std. error
Gender (male=1)	- 0.6782	0.7715	1.1683	1.8201
Age of household head	0.0669**	0.0285	0.0152	0.0441
Education of household head	0.2769^	0.1669	0.2432	0.3048
Household size	- 0.0001	0.1250	0.3064	0.2587
Dependency ratio	- 1.0473	1.2806		
Household-asset value (in 10 000 TSh)	- 0.0242	0.0241	0.1957**	0.0385
Household type	- 0.8323	0.6511	- 2.5044	1.5682
Exogenous income (in 10 000 TSh)			- 0.0030	0.0073
Cattle ownership	- 0.3146	0.7500	- 1.0371	1.7198
Small animals ownership	0.3362	0.7159	1.7020	1.5126
Ownership of chicken	0.3365	0.6470		
Value of cattle	0.0279^	0.0145		
Value of small animals	0.2085^	0.1189		
Value of chicken	- 0.3893*	0.1766		
Probability Black Sigatoka			30.8255**	4.6385
Probability Fasarium wilt			-1.8725	3.5321
Probability banana weevils			6.6726**	2.2328
Agro-ecological zone (BS=1)	19.6636**	0.9054		
Field quality	- 0.5932	0.6227	- 2.8320^	1.6100
Extension services (Yes=1)	1.09435	0.7863		
Farm size (ha)	- 0.6335	0.4863		
Cultivated area (ha)	- 0.1260	0.7667	- 2.9641**	1.0988
Number of endemic cultivars	0.2194	0.1391		
Number of non-endemic cultivars	- 0.0037	0.1750		
Endemic mats	- 0.0118*	0.0054		
Adopters			- 4.7550*	2.2116
Hazard (Lambda)			314	(p = 0.086)

Key: **, *, ^ - denotes statistical significance at the 1, 5%, & 10% levels, respectively, in the difference of means or distributions across groups

Assessment of impact of new varieties on production vulnerability was also one of the focuses of this study. Adoption of new varieties reduces the expected percentage yield loss by 4.75 percentage points. Controlling for adoption and the factors that influence it, production vulnerability measured in terms of yield loss, appears to be significantly affected by the total area under crops, field quality, value of household assets owned, probability of Black Sigatoka disease and banana weevils, and adoption of new varieties (Table 43).

With an additional of one hectare of cultivated land, the percentage of yield loss goes down by 2.96 percentage points, when other factors are held constant. A better field above average reduces yield loss by 2.83 percentage points. The value of household assets and probability of Black Sigatoka disease and banana weevil was illustrated to increase the extent of banana yield loss. By increasing the value of household assets by TSh. 10 000, average banana yield loss increases by 0.1957%. A unit increase in probability of Black Sigatoka disease and banana weevils increase banana yield loss by 30.83% and 6.67% respectively. Sex of the household head (male=1), age and education level of household head, household size, dependency ratio, exogenous income and livestock ownership proved by regression coefficients to have no significant effects on the banana yield loss.

Similarly, impact analysis revealed that the was strong evidence to accept the third hypothesis of this thesis i.e., the use of improved new banana varieties affected average banana yields and losses, number of bunches harvested, consumed and sold.

4.10 Comparisons of likely adopters and non-adopters

First, the fitted model was used to predict use of new banana varieties for the 260 households in the sample. The top and bottom tails of the distribution of predicted values for new variety use were used to represent the profiles of likely adopters and non-adopters of the new varieties, considering initially only the subset of 180 households located in BS and KAL agro-ecological zones (Table 44).

All the 80 households located in the KAM zone, were excluded in this analysis. The cut-off point used was 30%, with 54 households representing each group, respectively. Mean comparisons are summarized in Table 44 for outcomes related to productivity, consumption and sale of bananas, as well as general household-related characteristics.

The use of treatment model made it possible to use predicted values for the estimated outcome variables to control for the effects of the treatment on the outcome. Hence both comparisons of the actual and expected values of average yield loss were made. The average bunch weight was significantly different between the adopters and non-adopters. Potential adopters were obtaining 5.27 kg per bunch more than the non-adopters.

Also, the average yield loss was significantly different between the two groups, although potential adopters had yield loss of more than 4.11% compared to non-adopters. The potential adopters are the ones whose bananas have succumbed too much to pests and diseases and the number of new mats planted had not offset the effect. As a consequence, they have less banana mats, harvest less bunches and consume fewer bananas than the non-adopters. The share percentage of selling banana bunches was higher for adopters than for non-adopters.

Table 44: Mean comparisons between likely adopters and non-adopters

Variables	Non-adopters (N=54)	Adopters (N=54)
Average bunch weight (kg)	16.32**	21.59**
Average yield loss, in % (actual)	2.43^	6.54^
Total banana mats	288.85	157.50
Total bunches harvested	177.45	116.64
Number of bunches consumed per year	104.93^	76.20^
Number of bunches consumed per person	27.21**	13.27**
Number of bunches consumed per adult	50.74**	26.21**
Number of bunches consumed/dependent	57.05^	32.98^
Share of bunches consumed (%)	71.09	66.11
Number of bunches sold	73.48	48.56
Share of bunches sold (%)	29.23	36.79
Farm income obtained (10 000 TSh)	28.81	27.79
Banana income obtained (10 000 TSh)	7.12	5.18
Household expenditure (10 000 TSh)	53.48	44.07
Age of household head	45.37*	52.93*
Education of household head	6.30	6.85
Household size	5.94^	6.20^
Household dependency ratio	0.47	0.48
Farm size (hectares)	2.07	1.50
Land under crops (Kibanja and Kikamba)	1.40	0.87
Number of extension service visits at least once in 6 months (1=Yes and 0=No)	1.26	2.70
Proportion of male headed households	0.74	0.85
Cattle ownership (Yes=1)	0.22*	0.35*
Value of cattle (in 10 000 TSh.)	12.57*	15.85*
Goats/sheep/pigs ownership (Yes=1)	0.26**	0.63**
Value of goats/sheep/pigs (in 10 000 TSh.)	0.68**	3.56**

Key: **, *, ^ - denotes statistical significance at the 1*, 5%, & 10% levels, respectively, in the difference of means or distributions across groups

Significant differences were found between levels of banana bunches consumed per household, bunches consumed per person, bunches consumed per adult and bunches consumed per dependent of adopters and non-adopters. Non-adopters have higher per capita consumption of bananas than adopters. There were no significant differences observed on farm income, banana income and household expenditure between adopters and non-adopters, although non-adopters had higher averages. Other variables that were significantly different between adopters and non-adopters were education level of the household head, household dependency ratio, farm size, cultivated area, number of extension visits received by a farmer and proportion of the male headed households. In each of these variables, adopters have higher average than non-adopters.

Other variables that indicated significant difference between potential adopters and non-adopters are age of household head, household size, livestock ownership (Yes=1 and No=0) and values of livestock. Household heads of adopters were older than the non-adopters. The average household size of adopters was slightly larger than that of non-adopters. The proportion of the households keeping livestock was higher for the adopters than that of non-adopters. Similarly, adopters had relatively higher values of livestock than the non-adopters.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Overview

This chapter concludes the explanations and discussions made in the preceding chapters. It provides the lessons learnt by farmers about adoption and impacts of new banana varieties, and the likely challenges to emerge in the banana cultivation in Kagera region. Finally recommendations for further interventions are presented.

5.2 Conclusion

5.2.1 Dynamics of Kagera based banana farming systems

The agricultural performance of Kagera banana-based farming systems had experienced a declining trend during the past years due to increasing pests' infestations, declining soil fertility and low use of improved technologies on crop husbandry practices. The area proportions of land use types are changing over time. The survey data revealed that the estimated average area cultivated (i.e., *Kibanja* and *Kikamba*) per household ranged from 0.7 ha in BS zone to 1.7 ha in KAM in which about 60% of it was occupied by banana fields. Other crops grown include coffee, beans, maize, cassava, sweet potatoes, yams, coco-yams and sorghum. However, the area covered by bananas was decreasing while cultivation of non-traditional crops was increasing.

The percentage of female headed households, age of household heads and household size were significantly different between the agro-ecological zones. Households headed by females were 25% of the total surveyed households in which KAL had the highest percentage of female headed households (28.0%) while KAM had the lowest (18.75%). The overall average age of household heads was 48.52 years, being 53.34 years in BS, 45.84 years in KAL and 47.41 years in KAM. Other variables that were significantly different between agro-ecological zones were ownership of cattle and small animals, and types of houses owned. About 35% of households had local or improved cattle or both. Ownership of small animals (shoats and/or pigs) was about 52%. The percentage of households with permanent houses was highest (55%) in BS zone while the KAL zone had the highest (17) percentage of households with temporal houses. Dependency ratio and education of household heads were not significantly different between the agro-ecological zones.

5.2.2 Determinants of the adoption of new banana varieties

Up to 2004, the adopters of the new banana varieties were 43.75% in BS, 37% in KAL and 2% in KAM with an overall average of 28.46%. There was strong evidence to accept the first hypothesis by 95% confidence that the extent and intensity of adoption of the new banana varieties was influenced by agro-ecological zone, and farms' and farmers' characteristics. Also, the qualitative data analysis revealed that adoption was influenced by the extent of the intervention of the dissemination activities. BS and KAL in Bukoba district received the highest number of planting materials of new banana varieties. Villages that were involved in the on-farm trials had better adoption rates than those which were not involved or located far away from the multiplication and demonstration plots of new banana varieties. The adoption of the new banana varieties was significantly different between agro-ecological zones indicating that where banana constraints predominate, the adoption rates were relatively high compared to areas of low pressure of constraints. Rich-resource households adopted more the new banana varieties than poor-resource households. Age of the household heads, area cultivated per household, ownership of livestock (cattle, shoats and pigs), value of chicken, value of household assets, number of exotic cultivars and number of endemic mats per household were significantly different between the adopters and non-adopters. All of them except area cultivated and number of endemic banana mats had positive correlation. Factors that significantly influenced the intensity of adoption were agro-ecological zone, quality of banana field (1=best quality), number of exotic cultivars, number of endemic mats, value of household assets, and ownership of cattle and small animals. During FGDs, it was learnt that farmers do not just value yield of banana varieties, but they consider other criteria, for example, tastes, shelf life, tolerance to bad weather and pests. Therefore, considering farmers' priorities is a key aspect of ensuring positive impacts.

5.2.3 Impacts of the new banana varieties on livelihoods

The new banana varieties showed several positive outcomes on livelihood indicators that varied by agro-ecological zone; and farm and household characteristics that led to acceptance by 95% confidence of the second hypothesis of this thesis. The BS zone indicated to have received greatest impacts of the new banana varieties compared to the other two zones. The impacts included improved productivity of bananas (bunch yield), food security, increased juice and brew making, income from selling banana bunches or juice/brew, house-sheds and on social relationships.

The magnitude of outcomes was very noticeable in households that have started to harvest the new banana varieties. Under farmers' conditions, the new varieties produce bunches twice per banana stool per year while the local varieties usually produce one bunch per year. Household adopters who planted enough number of mats of new banana varieties had significantly improved their food security.

The adoption of new banana varieties had reduced the area planted with cassava and sweet potatoes. Consequently, it has also increased the sustainability of the farming systems through improved biodiversity of the banana farming system and gained social values to farmers from revived banana plots that were almost lost. The vigorous growth and well establishment of new varieties improved houses' sheds.

The increased banana production has improved social relationships of household heads in the community and hence access to assistances and loans. Also, it has strengthened women groups because women are now able to pay their annual fees and other contributions required by their groups or associations. New bananas and their products are increasingly becoming acceptable into the social functions (such as offering them as gifts or contributions during funerals and weddings) and other traditional value practices in the community.

Most of the new banana varieties (such as Yangambi km 5 and FHIA 17 and FHIA 23) have proved to have multipurpose uses; cooking, brewing, dessert and roasting and their by-products such as juice and brews have better quality than those made from local banana varieties. They have also good marketability that has proved to fetch good prices within and outside Kagera region ensuring households with regular income throughout the year.

5.2.4 Lessons learnt by farmers on the new banana varieties

5.2.4.1 Acceptability of the new varieties

All new varieties showed to have a higher probability of being adopted and accepted by farmers at different rates that vary by agro-ecological zones, farm and household characteristics. The new banana varieties that were adopted more were Yangambi km5, FHIA 17 and FHIA 23. Farmers assessment of new varieties include high yielding potential, tolerant to pests and diseases, good marketability and good tastes of fresh bananas and their bi-products as a criteria set for adoption.

5.2.4.2 Fertilizer requirement

It was also noted during the FGDs sessions that of the new banana varieties introduced, there are those which require heavy application of fertilizers and those that require less application of fertilizers (manure). Varieties that require heavy application of fertilizers are FHIA 17, SH 3436-9, FHIA 23 and Bita3, which without application of fertilizers register poor yields dramatically. Varieties that showed less requirement of fertilizer application are FHIA 25, FHIA 01, FHIA 02 and Yangambi Km5 since these were performing well under the same conditions in which the local varieties are grown and thus they are increasingly adopted by farmers

5.2.4.3 Creation of awareness of new varieties

Considering the number of local banana varieties available in the region, the objective of introducing the new varieties was too general, i.e., to increase food and income security. The content of awareness creation programme was supposed to cover specific characteristics of each individual variety. Lack of clear specific messages on varieties reduced the rate of adoption as farmers hesitate and wait for the results from volunteers' fields.

5.2.4.4 Banana genetic conservation

Farmers noted that the new banana varieties have robust behaviour and strong roots that are competitive for nutrients compared to the local varieties. If they are massively adopted, they can in long run, suppress the local varieties leading to banana genetic erosion unless appropriate measures on crop practices such as plant spacing and in situ conservation are taken.

5.2.5 Challenges

Further adoption of the new banana varieties and their impacts on livelihoods are subject to the following challenges:

(a) During FGDs farmers expressed that in high peak periods of banana supply local markets are not able to absorb all bananas being sold by farmers. At present, even markets outside the region cannot absorb the banana surpluses either. This situation lowers bunch prices despite of its large bunch sizes of the new bananas and reduces the adoption rate.

(b) Current farmers are constrained by lack of appropriate post harvest technologies. Thus, increasing the banana production per se without proper post harvest technologies will not really benefit farmers.

(c) Banana market system of selling per bunch and not by weight is a disadvantage to farmers because irrespective of bunch size, sometimes a common price is given for all bunches. Some banana varieties such as Yangambi km5 have compact-bunches and hence more weight per unit volume.

(d) Some of the new banana varieties showed high demand of application of fertilizers/manure compared to local ones as indicated by farmers during FGDs. Hence, high investments on establishing and maintenance of new banana fields are required. But making compost manure is considered as cumbersome and labour intensive and artificial fertilizers are not available at village level.

(e) Supply of planting materials of new varieties that are free from diseases and pests contamination is not easily feasible if there is no concrete planting material system. The importance of cleaning of suckers is not known to the majority of farmers and/or is regarded by farmers as a cumbersome activity. Dissemination of unclean planting materials increases spread of pests.

5.3 Recommendations

The following are recommendations suggested for better improvement of the banana sub-sector in Kagera region and elsewhere they cultivate bananas.

(a) The research results revealed that some banana varieties are increasingly planted by farmers while others are discarded, therefore effective monitoring and evaluation system on the field performance and uses of the new banana varieties is required. This can be implemented in jointly efforts of researchers and extension staff, and its results communicated to all banana stakeholders. This can help in updating the individual characteristics of the new varieties;

(b) The data analysis revealed adopters of the new banana varieties were rich-resource households compared to non-adopters. Also, the household heads of adopter households were older than heads of non-adopter households. If new banana varieties are left to diffuse by themselves, the poor and young household heads are likely to be the last to benefit. Special programme intervention specifically aimed at targeting all household categories including the poor and/or young households should be considered. This could be done through the existing NGOs and CBOs in each respective community;

(c) Adoption of the new banana varieties was significantly different between agro-ecological zones indicating that where banana constraints predominate, the adoption rates were relatively high compared to areas of low pressures. It is suggested that efforts of multiplication and dissemination of new varieties be targeted more in areas with high pressures of banana production constraints

(d) Not all farmers have proper skills and knowledge on banana crop husbandry. The dissemination of new banana varieties should go hand-in-hand with strengthening of farmers' training sessions on banana management practices by improving extension services and availability of Village Agricultural Extension Officer (VAEO) in each village;

(e) The benefits accrued from new banana varieties could be well tapped if appropriate post harvest technologies will be introduced into the communities. The new bananas shown to produce super bi-products of juices, beer and wine. Therefore, processors including NGOs based into the communities should be encouraged by district councils to start processing the banana surpluses so that their products can be kept for future uses or sold at far markets

(f) In Kagera region, banana markets system requires to be improved to be able to absorb the emerging surpluses. Therefore, marketing study focusing on banana attributes and their uses is recommended in order to investigate the attributes considered by farmers versus attributes considered by processors, traders and consumers. Formation of marketing groups or associations can strengthen the empowerment of farmers to access markets and bargaining;

(g) Data analysis showed a number of new varieties were dropped by farmers that varied by location. Therefore, in the future verification of banana varieties followed by intensive awareness creation to farmers before mass dissemination is required: Farmers and other stakeholders should first have a clear understanding of which varieties are best in specific location or for home consumption or marketing or a combination of these before engaged in mass multiplication and dissemination of their planting materials;

(h) There would be a tremendous influence on the adoption of the improved technologies aimed at alleviating household food insecurity and improving income, if the positive adoption determinants such as training of farmers, credit access and extension services are properly addressed in future projects

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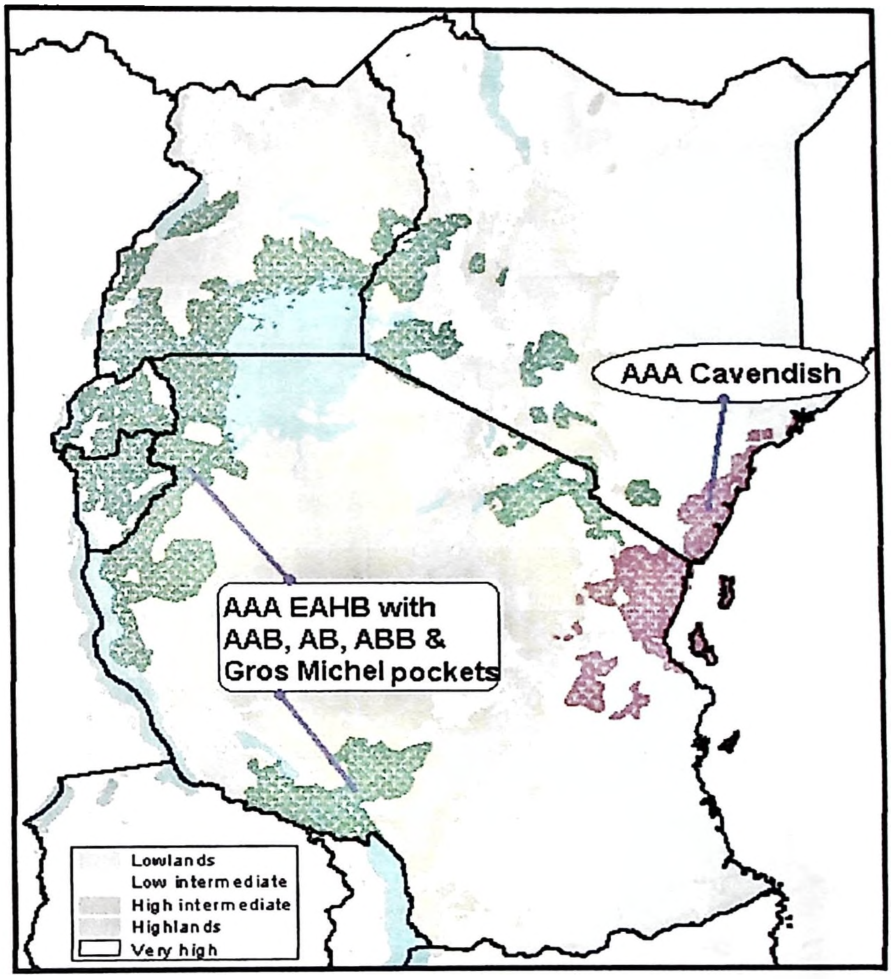
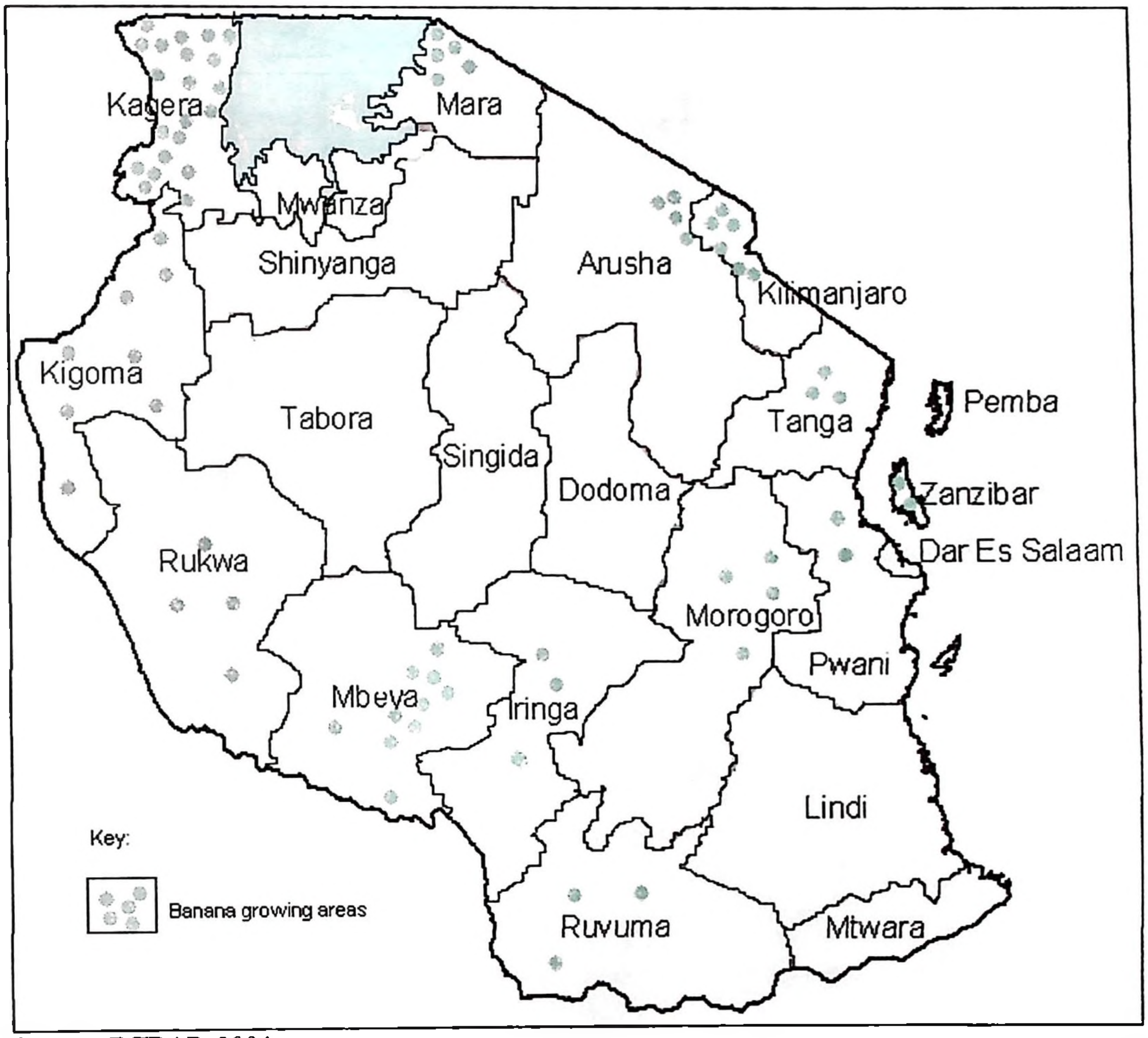
Appendix 1: Principal banana growing areas in the Great Lakes Region



Source: INIBAP, 2004

Appendix 2: Banana growing areas in Tanzania



Source: INIBAP, 2004

Appendix 3: Methods for evaluating programme impact (Ravallion, 2004)

The essential problem of impact evaluation is that we do not observe the outcomes for participants if they had not participated. So evaluation is essentially a problem of missing data. A "comparison group" is used to identify the counter-factual of what would have happened without the programme. The comparison group is designed to be representative of the "treatment group" of participants with one key difference: the comparison group did not participate.

The main methods available are as follows:

(a) Randomization, in which the selection into the treatment and comparison groups is random in some well-defined set of people. Then there will be no difference (in expectation) between the two groups besides the fact that the treatment group got the programme. (There can still be differences due to sampling error; the larger the size of the treatment and comparison samples the less the error).

(b) Matching. Here one tries to pick an ideal comparison group from a larger survey. The comparison group is matched to the treatment group on the basis of a set of observed characteristics, or using the "propensity score" (predicted probability of participation given observed characteristics); the closer the propensity score, the better the match. A good comparison group comes from the same economic environment and was administered the same questionnaire by similarly trained interviewers as the treatment group.

(c) Reflexive comparisons, in which a "baseline" survey of participants is done before the intervention, and a follow-up survey done after. The baseline provides the comparison group, and impact is measured by the change in outcome indicators before and after the intervention.

(d) Double difference (or “difference in difference”) methods. Here one compares a treatment and comparison group (first difference), before and after a programme (second difference). Comparators should be dropped if they have propensity scores outside the range observed for the treatment group.

(e) Instrument variables methods. Instrumental variables are variables that matter to participation, but not to outcomes given participation. If such variables exist then they identify a source of exogenous variation in outcomes attributable to the programme – recognizing that its placement is not random but purposive. The instrumental variables are first used to predict programme participation, and then one sees how the outcome indicator varies with the predicted values.

No method is perfect. Randomization is fraught with problems in practice. Political feasibility is often a problem. And even when selection is randomized, there will still be a problem of latent heterogeneity, leading to a possible bias in estimating programme impact. Selective attrition plagues both randomization and double-difference estimates. It is always desirable to triangulate methods.

Appendix 4: Number of tissue culture plants received by cultivars

Variety	1998	1999	2000	2001	2002	Total	Rank
AAcv Rose	1186					1186	14
Bita-3		53		901		954	15
Cardaba	1461	700				2161	8
FHIA01	1125	600	762			2 487	7
FHIA02	584	840				1424	10
FHIA03	1120	8545				9665	4
FHIA17	19	2610	13983	9786		26398	1
FHIA23	5	4755	6674			11434	3
FHIA25		10		1379		1389	11
I.C.2	20	1410				1430	9
Yangambi km5	2643					2643	5
PAKA		9				9	24
Pelipita	1238	1100				2338	6
Pisang berling	20					20	22
Pisang ceylong	702					702	17
SABA	5	700				705	16
SH3436-9	5	3740	9298	8294		21337	2
CRBP				41		41	21
Kamalamasenge	630					630	18
Pisang Sipulu		8				8	25
SH3640				1200		1200	13
KCDP1			50	54		104	20
FHIA21			379			379	19
FHIA18			1308			1308	12
Bita2		12				12	23

Source: KCDP, 2003

Appendix 5: Number of new banana suckers supplied under direct diffusion in Kagera region during the 1998 – 2004 period.

Variety	1999	2000	2001	2002	2003	2004	Total
AAcv Rose		4259	830	460	1973		7522
Bita-3			3	183	4686		4872
Cardaba		9830	1493	599	3657		15579
FHIA01	16756	14784	6891	3907	16780		59118
FHIA02	651	4835	1606	85			7177
FHIA03	908	33252	560	156			34876
FHIA17		2959	12959	9497	101286	25812	152513
FHIA23		4617	15998	8045	77435	19719	125814
FHIA25				451	6769	5200	12420
I.C.2		4437					4437
Yangambi km5	20500	30154	8065	1539	10487	40506	111251
PAKA				120			120
Pelipita	11340	9852	5609	3448	11189		41438
Pisang berlin	119	19					138
Pisang ceylong		373					373
SABA	2568	274	419	170	1350	238	5019
SH3436-9	43679	4706	17888	10476	57300	15018	149067
CRBP					204		204
Total	96521	124351	72321	39136	293116	106493	731938

Source: KCDP, 2003

Appendix 6: Explanations of the survey instruments of the study

The following is the explanations of the instruments of household survey that were used in data collection either on single or multiple visit(s):

(a) Household schedule

A household was defined as a group of people who reside and eat together. For polygamous households, if all wives residing on the farm, they were considered part of the household. Wives residing on other farms or in other villages were not considered part of the household. Head of household who is defined by local culture could be a man, a woman, or a child (orphan). Data collected under this schedule included demographic characteristics of households such as household composition, age, gender, ethnic identity, and information on farm characteristics such as farm size, number of parcels and plots, land use type and crops cultivated. Other data collected were household assets including livestock kept, furniture and farm equipment owned by a household; information on stored food crops; information on credit or loan (purpose and length of time to obtain, sources, amount and interest); and type and geographical location of the household.

(b) General farm schedule

This schedule focuses on the composition and estimation of the farm size of each parcel and plot; and identification of the crops cultivated on each plot for the prior growing season, estimation of plot share of total cultivated area in each parcel, identification of major or minor crops, and the cropping patterns (pure or mixed stand or intercrop) for each plot cultivated.

(c) Banana plot schedule

In this schedule, questions related to banana production were put to farmers. When several banana plots were identified, each plot was separately considered making the collected information plot specific. It covered banana management practices, decision making in banana activities, list of varieties grown per plot, their mats, number of banana plants per mat, years a farmer had been growing bananas, years experienced by banana problems with diseases (Panama and Black Sigatoka) and pests (Banana weevils and nematodes), estimates of the minimum, maximum and most frequent bunch weight with and without the occurrence of a disease or pest. This was used in triangular distribution of estimating banana bunch weight for each variety in the presence of and in the absence of a disease or pest problem.

The banana fields owned by households were ranked using the following four categories (Mbwana *et al.,* 1997):

A. Tall, healthy plants with big bunches throughout. Forms a complete cover. No fall downs. No nematodes root necroses and no weevil damage.

B. Generally healthy plants with big bunches. But occasional stunted plants are observed bearing small bunches with or without fall downs (less than 10% with root necrosis and/or 25% with substantial weevil damage)

C. Reasonable plant growth but with small or moderate bunches. Slight stunting or yield in general noticeable decline, poor plant cover. Common fall downs (10 – 50%) associated with moderate to severe nematode root necrosis, more than 25% and /or serious weevil corm damage. Otherwise no other observable constraints to production.

D. Banana in a serious decline to the point of non-productivity, small or no bunch, very weak or non-existent flowers, very poor plant cover, very common fall downs (more than 75%) and or weevil corm damage. Often occurring in areas of poor soil fertility

(d) Banana cultivar schedule

Data collected under this schedule included perceptions of farmers on production and consumption, banana attributes; bunch size, resistance to pests and diseases, perishability, cookability (combination of taste, colour and texture) and suitability for juice/beer extraction. Other data collected included quantity of planting materials supplied and obtained by a farmer, sale of banana bunches covering number of bunches sold, farm gate price, market price and distance from home to the market place).

(e) Expenditure and income schedule

The expenditure and income schedule collected information on consumption and production patterns of the household for banana and other agricultural crops and activities. Farmers were asked to estimate the proportional use of banana cultivars by type use – cooking, juice/beer, roasting and dessert. It also included food purchases including bananas and other food types, sales of crops and livestock and their products, other sources of income such as wages, salaries, remittances and loan.

Appendix 7: STATA model used for impact analysis and variables

This presents the STATA steps of data analyses and description of the variables used.

(A). Steps

1. Running new banana use (adoption) with instruments and controls:

   logit adopters bukoban kalzone qualtdmy agehh educhh hstype1 maledumm hhsize depratio farmsize sharecro extsvc endemctv oldexot endmats eqimpst owncttl owngsp vcattle vgspigs ownchkn vchcken

2. Saving the residuals from the use equation: predict ad_res, res

3. Regressing the impact variable (average expected bunch yield and yield loss in percentage) on endogenous (actual) new variety use variable, among other variables, and the predicted residuals:

(a) Banana average (bunch) yield:

   regress avyield maledumm agehh hhsize educhh extsvc sharecro hstype1 owncttl owngsp ad_res

(b) Banana yield loss (in percentage):

   regress avloss maledumm agehh educhh sharecro hstype1 pbs pfw pwe adopters ad_res

4. Testing the errors (tests whether the errors from the use equation are correlated with the impact – if β_{ad_res}=0 then this is a good set of instruments): test ad_res

5. Treatment effects model:

(a) Banana bunch yield

   treatreg avyield maledumm agehh hhsize educhh extsvc sharecro hstype1 owncttl owngsp, treat(adopters= bukoban kalzone qualtdmy agehh educhh hstype1 maledumm hhsize depratio farmsize sharecro extsvc endemctv oldexot endmats eqimpst owncttl owngsp vcattle vgspigs ownchkn vchcken)twostep

(b) Banana yield loss (in percentage)

treatreg avloss maledumm agehh educhh hhsize eqimpst owncttl owngsp sharecro qualtdmy hstype1 totalinc pbs pfw pwe, treat(adopters= bukoban kalzone qualtdmy agehh educhh hstype1 maledumm hhsize depratio farmsize sharecro extsvc endemctv oldexot endmats eqimpst owncttl owngsp vcattle vgspigs ownchkn vchcken)twostep

6. Getting marginal values for the impact equation (expected average bunch yield)

mfx, predict(xb)

7. Getting marginal values for the treatment equation (adoption/use)

mfx, predict(xbtrt)

8. Prediction of the probability of adoption (i.e. Pr(treatment=1))

predict use, ptrt

9. Keep only the predicted values for those in exposed areas:

10. Sort the predicted probability of adoption (use):

11. Then, list the values to make sure that they are sorted in ascending order:

Cut off the top 30% and the bottom 30% of the distribution of predicted values in exposed areas (that is 30% of 220 observations, which leaves us with 66 observations on top and 66 observations on the bottom)

12. Then we generate a variable called "p" that equals 0 for those in the top 66 observations and it equals 1 for those in the bottom 66 observations

13. Crosschecking if it is done it right

14. First, the data was fitted into the svy (sample weighting) command by identifying weight (and strata, if necessary): svyset [pweight=weight]

15. Then the svy: mean was ran to see the weighted means of interest:

svy: mean VARIABLE, over(p)

16. Weighted t-test was used to test the equality of the weighted means:

(B) Variables used in adoption and impact analyses

logit	– stata command for running logit regression
treatreg	– stata command for running treatment effects model
twostep	– stata command for running treatment effects model
adopters	- adopters of new varieties
avyield	– average bunch yield (kg)
treat	– stata command for identifying an variable as exogenous in the equation
avloss	– average banana yield loss (in percentage)
bukoban	– bukoba systems zone
kalzone	– karagwe ankolean low rainfall zone
qualtdmy	– banana field quality (dummy variable 1 = best field, 0 = otherwise)
agehh	– age of household head
educhh	– education (inyears) of household head
meaneduc	– average mean education of adults per household
hstype1	– house type (dummy variable: 1 = permanent house, 0 = otherwise)
maledumm	– sex of household head (dummy variable: 1 = male 0 = female)
hhsize	– household size
depratio	– household dependency ratio
farmsize	– farm size owned per household

sharecrop – cultivated land

extsvc –household visited by an extension officer (dummy variable: 1= yes, 0 = no)

endmectv - number of endemic banana varieties cultived by a farmer

oldexot – old non-endemic banana varieties

endmats – number of banana mats of endemic varieties

eqimpst - value of household assets

owncttl – cattle ownership (dummy variable: 1 = yes, 0 = no)

owngsp – ownership of goats, sheep or pigs (dummy variable 1 = yes, 0 = no)

vcattle – value of cattle

vgspigs – value of goats, sheep and pigs

ownchkn - ownership of chicken (dummy variable: 1 = yes, 0 = no)

vchcken - value of chicken

totalinc – total household income

pbs – probability of getting banana yield loss from black sigatoka

pfw – probability of getting banana yield loss from fusarium wilt (panama)

pwe - probability of getting banana yield loss from banana weevil

totbnch – estimates of total bunches harvested per year

cbnch – number of bunches consumed

cshare – share of bunches consumed

sbnch – number of bunches sold; and sshare – share of bunches sold

farminc – total farm income

farmexp – total household expenditure

exoginc1 - household exogenous income

vstcrop1 – value of crops stored

Appendix 8: Banana taxonomy in the study area, Kagera region

Key: Genomic Group: 10=endemic (AAA-EA); 20=Old exotic (non-endemic); 21=new exotic (non-endemic); 22=hybrid (non-endemic) and * = new banana variety or hybrid

Household Share: Proportion of households that grow this cultivar out of 260 households in the sample

Cultivar Share: Proportion of mats planted to this cultivar out of 81,716 mats in the sample

Common use: 1=cooking; 2=brewing; 3=dessert; 4=multi-use and 5=roasting

Culticar	Genomic group	Common use	Number of households	Household share	Number of mats	Cultivar share
Enshakala	10	1	226	86.923	9078	11.109
Kijoge	20	4	189	72.692	6080	7.440
Akanana	20	3	178	68.462	2732	3.343
Entobe	10	1	168	64.615	5958	7.291
Enyoya	10	1	145	55.769	5167	6.323
Enchoncho	10	1	130	50.000	6281	7.686
Mtwishe	20	3	114	43.846	2851	3.489
Enshansha	10	1	108	41.538	3852	4.714
Kainja	20	2	99	38.077	4164	5.096
Enjubo	10	1	93	35.769	1459	1.785
Embwailuma	10	1	90	34.615	1978	2.421
Enkonjwa	20	5	90	34.615	574	0.702
Kisubi	20	2	82	31.538	1641	2.008
Entundu	10	2	81	31.154	6266	7.668
Ekikonjwa	20	4	75	28.846	960	1.175
Ensikila	10	1	67	25.769	2364	2.893
Entalagaza	10	1	60	23.077	2996	3.666
Embile	10	2	51	19.615	997	1.220
Entente	10	1	49	18.846	4198	5.137
Yangambi km5*	21	4	47	18.077	531	0.650
Engagala	10	1	37	14.231	1706	2.088
FHIA 17*	22	4	34	13.077	204	0.250
Engumba	10	2	26	10.000	361	0.442
Enkundakundi	10	2	26	10.000	1160	1.420
Enyitabunyony	10	1	25	9.615	593	0.726
Embilabile	10	1	24	9.231	1055	1.291
Entandala	10	1	21	8.077	422	0.516
Kyayaya	10	5	20	7.692	170	0.208

Appendix 8: (cont'ed)

Culticar	Genomic group	Common use	Number of households	Household share	Number of mats	Cultivar share
FHAI 23*	22	4	19	7.308	118	0.144
Endumuza	10	1	15	5.769	830	1.016
SH3640*	21	4	15	5.769	97	0.119
Enjujuzi	10	1	13	5.000	110	0.135
Entebateba	10	4	12	4.615	162	0.198
Kibuzi	10	1	12	4.615	1161	1.421
Kintu	10	4	12	4.615	62	0.076
Pelipita*	21	4	12	4.615	45	0.055
Enyamaizi	10	2	11	4.231	156	0.191
Basiga	10	2	10	3.846	63	0.077
Mshale	20	5	10	3.846	44	0.054
Enjoga	10	1	9	3.462	86	0.105
Enyakasa	10	1	9	3.462	238	0.291
Empigi	10	1	8	3.077	40	0.049
Enkila	10	2	8	3.077	130	0.159
FHIA 01*	22	4	8	3.077	88	0.108
Embululu	10	1	7	2.692	72	0.088
Enjuta	10	1	7	2.692	87	0.106
Enzirabushera	10	1	7	2.692	99	0.121
FHIA 02*	22	4	7	2.692	42	0.051
Empindwi	10	1	6	2.308	200	0.245
Enyalihonga	10	1	6	2.308	53	0.065
Enzilabahima	10	1	6	2.308	140	0.171
FHIA 25*	22	4	6	2.308	56	0.069
Emfumbo	10	1	5	1.923	235	0.288
Enjoki	10	1	5	1.923	85	0.104
Enshanshambil	10	2	5	1.923	206	0.252
Ensowe	10	2	5	1.923	40	0.049
Entama	10	1	5	1.923	19	0.023
Kinyamtuku	10	1	5	1.923	25	0.031
Mpima	10	1	5	1.923	39	0.048
Ensaka	10	2	4	1.538	62	0.076
Ensenene	10	1	4	1.538	23	0.028
Kinunu	10	1	4	1.538	16	0.020

Appendix 8: (cont'ed)

Culticar	Genomic group	Common use	Number of households	Household share	Number of mats	Cultivar share
Acc Rose*	21	3	4	1.538	17	0.021
Cardaba*	21	4	3	1.154	13	0.016
Chiliga	10	1	3	1.154	14	0.017
Enyaisheshe	10	1	3	1.154	43	0.053
Enyamawa	10	1	3	1.154	9	0.011
Kyomulutwa	10	1	3	1.154	37	0.045
Endemela	10	2	2	0.769	20	0.024
Enganda	10	1	2	0.769	405	0.496
Entabula	10	2	2	0.769	23	0.028
Enyamwonyo	10	1	2	0.769	29	0.035
Enyonza	10	1	2	0.769	40	0.049
Enzimola	10	1	2	0.769	204	0.250
Enzinga	10	1	2	0.769	11	0.013
Kyanabalya	10	1	2	0.769	6	0.007
Lwekilo	10	1	2	0.769	4	0.005
FHIA 21*	22	4	2	0.769	9	0.011
Bita3*	22	4	1	0.385	5	0.006
Bushwela	10	1	1	0.385	10	0.012
Echibetenga	10	1	1	0.385	5	0.006
Empilwa	10	1	1	0.385	15	0.018
Endekula	10	1	1	0.385	1	0.001
Enjuma	10	1	1	0.385	4	0.005
Enshalila	10	4	1	0.385	15	0.018
Kauni	10	1	1	0.385	3	0.004
Mashule	10	1	1	0.385	1	0.001
Mwanamwana	10	1	1	0.385	26	0.032
Nyabwehogola	10	1	1	0.385	5	0.006
Nyarujoju	10	1	1	0.385	10	0.012
Rwakagoye	10	1	1	0.385	5	0.006

Key: Genomic Group: 10 = endemic (AAA-EA); 20 = Old exotic (non-endemic); 21 = new exotic (non-endemic): 22 = hybrid (non-endemic); and * = new banana variety (hybrid or landrace)

Household Share: Proportion of households that grow this cultivar out of 260 households in the sample

Cultivar Share: Proportion of mats planted to this cultivar out of 81,716 mats in the sample

Common use: 1=cooking; 2=brewing; 3=dessert; 4=multi-use and 5=roasting