Getting partnerships to work

A technography of the selection, making and distribution of improved planting material in the Kenyan Central Highlands

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Thesis

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Abbreviations and acronyms

ACK	Anglican Church of Kenya
ADC	Agricultural Development Corporation
AKIS	Agricultural Knowledge and Information System
ASK	Agricultural Society of Kenya
ATC	Agricultural Training Centres
BecA	Biosciences for eastern and central Africa
CBD	Convention on Biological Diversity
CBO	Community based organisation
CDF	Constituency development fund
CIG	Common interest group
CIMMYT	International Maize and Wheat Improvement Centre
CIP	International Potato Centre
CRD	Completely Randomized Design
DAP	Di-ammonium phosphate
EAPC	East African Pentecostal Church
EUR	Euro
FFS	Farmer Field Schools
FSA-RET	Farming Systems Approach to Research, Extension and Training
FSP	Farming Systems Perspective
FSR	Farming systems research
FURP	Fertilizer use recommendation project
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GPS	Geographical Positioning System
GTL	Genetic Technologies limited
IAR4D	Integrated Agricultural Research For Development
ICRA	International Centre for Development Oriented Research in Agriculture
IDRC	International Development Research Centre
ILRI	International Livestock Research Institute
IPR	Intellectual property right
ISAAA	International Service for Acquisition of Agri-biotech Applications
ITSC	Institute of Tropical and Sub-tropical crops
JKUAT	Jomo Kenyatta University of Agriculture and Technology
K	Potassium
KACC	Kenya Anti-corruption Commission
KACE	Kenya Agricultural Commodity Exchange
KARI	Kenya Agricultural Research Institute

KENFAP	Kenya Federation of Agricultural Producers
KEPHIS	Kenya Plant Health Inspectorate Services
KSH	Kenya Shillings
LMZ	Lower medium zone
MASP	Ministry of Agriculture Strategic Plan
MoA	Ministry of Agriculture
MoGSCSS	Ministry of Gender, Sports, Culture and Social Services
MoNRM	Ministry of Natural Resources Management
MP	Member of parliament
NBDP	National Biotechnology Development Policy
NGO	Non-governmental organisation
NHIF	National Hospital Insurance Fund
NRM	Natural resource management
OFR	On-farm Research
PCA	Presbyterian Church of Africa
PDA	Provincial director of agriculture
PLAR	Participatory Learning and Action Research
PPB	Participatory plant breeding
PPP	Public–private partnership
PRA	Participatory rural appraisal
PTD	Participatory Technology Development
PVS	Participatory variety selection
R&D	Research and development
RF	Rockefeller Foundation
SHG	Self-help group
SHOPMAP	Smallholder Horticulture Marketing Programme
SRA	Strategy for Revitalising Agriculture
TC	Tissue culture
UK	United Kingdom
UMZ	Upper medium zone
USAID	U.S. Agency for International Development
ZEF	Zentrum für Entwicklungsforschung

CHAPTER 1

Introduction

1 Introduction

1.1 Food security, plant diseases and technical changes in smallholder agriculture in the Central Highlands

The agricultural sector is the backbone of the Kenyan national economy directly contributing 24% of Gross Domestic Product (GDP) and 65% of the export earnings. In addition, the sector provides livelihoods and food security to over 80% of the Kenyan population (Republic of Kenya 2008). Various food crops are grown in the country, with Maize (*Zea mays L.*) as the most important staple food in the country (Republic of Kenya 2013). In particular bananas and potatoes are major sources of carbohydrates, starch and minerals (Republic of Kenya 2013, Mbogoh *et al.* 2003, Nguthi 2007, Kimani 2010).

In the Central Highlands (the area of study) maize, beans, Irish potatoes, bananas, rice, wheat, coffee (*Coffea spp*.), macadamia (*Macadamia spp. ternifolia*), and tea (*Camellia sinesis L.)* are the major crops grown. A large portion of the area is devoted to traditional cash crops such as coffee and tea (27%) and horticultural crops such as bananas, and potatoes (19%) (Place *et al*. 2006, Republic of Kenya 2013). In terms of crop production, maize is followed by Irish potatoes *(Solamum Tuberosum L*.), beans (*Phaseolus*), and bananas (*Musa spp*.) (Figure 1.1).

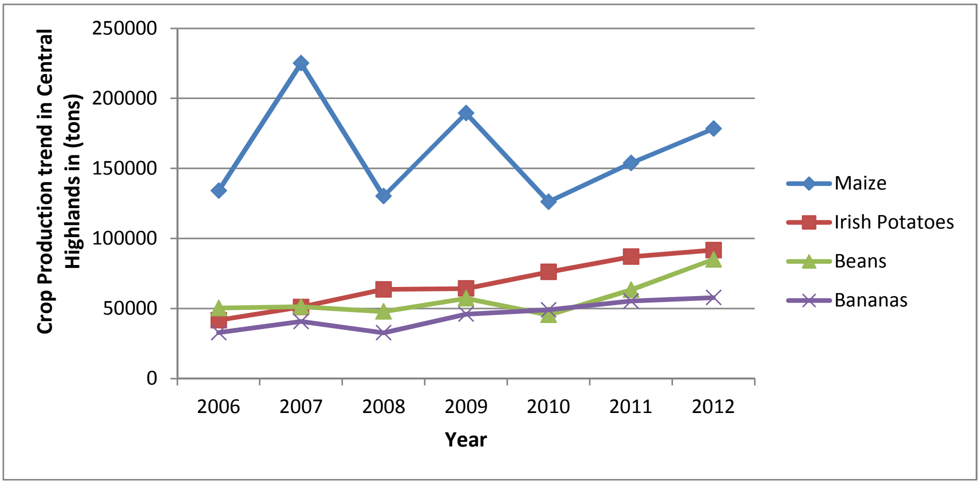

Figure 1.1: Crop production in the Central Highlands

Source: Economic review of agriculture, Ministry of agriculture, Nairobi, Kenya.

In the area, maize is the main cereal crop providing much of the needed carbohydrates while beans are the most significant pulse crops providing plant proteins, particularly for the rural poor**.** Irish potatoes are ranked as the second most important food crops after maize (Guyton *et al*. 1994, Muthoni *et al.* 2010). Banana (*Musa* spp.) is an important starchy crop (Wambugu *et al*. 2006) as well as an important source of carbohydrate, proteins, minerals and vitamins, and thus plays a major role in national food security. Additionally, banana is the main food for weaning babies (Mbogoh *et al.* 2003), and an important source of cash income (Wambugu and Kiome 2001, Njuguna *et al.* 2008, Kimani 2010). Both crops play a major role in national and local food security, nutrition, poverty alleviation, income generation, and provide employment in the production, processing, and marketing subsectors. The crops also have a cultural significance as they are cooked during important occasions such as wedding ceremonies (Mbogoh *et al*. 2003, Kabira *et al.* 2007, Muthoni *et al.* 2010).

Yields of these economically and culturally significant crops have been affected by pests and diseases (Wambugu and Kiome 2001, Qaim 1999, Muthoni *et al.* 2010, Lung'aho 2007). The national banana average yield had fallen to 10 tons per hectare, less than a third of its potential (Wambugu and Kiome 2001, Qaim 2009, Nguthi 2007), while potato yields fell to 7 tons per hectare in 2008, compared to 22.5 tons per hectare in 1920 (Kaguongo *et al.* 2008). The situation threatened food security and the incomes of small-scale farmers, who make up nearly 80% of the 40 million Kenyans and account for over 90% of food production (Republic of Kenya 2009).

Shortage of resistant varieties and clean planting materials is one of the causes for the spread of pests and diseases in bananas and potatoes (Table 1.1), often transmitted via infected planting materials. For instance, farmers reproduced bananas by replanting untreated suckers from their respective plantations (Wambugu and Kiome 2001, Nguthi 2007): 94% of seed potatoes are sourced from farmers' ordinary seed system, 5% from clean preselected seeds, and only 1% from certified seeds (Kaguongo *et al*. 2008, Potato Task Force 2009). Public research institutes, in particular the Kenya Agricultural Research Institute (KARI), launched programmes to develop, multiply and disseminate clean and disease resistant varieties such as the Cavendish bananas as well as Asante and Tigoni potatoes. The use of tissue culture (TC) techniques sought to ensure availability of clean planting material and thus alleviate poverty and hunger (Wambugu and Kiome 2001, Kaguongo *et al*. 2008).

Table 1:1: The main pests and diseases transmitted through planting materials affecting banana and Irish potato production in Kenya

Pests	**Diseases**
Bananas	
Weevils *Cosmopolites sordidus*	*Fusarium* wilt (Panama disease). *Fusarium oxysporum f. sp. Cubense*
Nematodes *Radopholus similes* *Pratylenchus goodeyi*	Cigar-end rot *Verticillum theobromae* *Trachysphaera fructigena*
	Banana wilt. *Xanthomonas campestris* pv *musacearum*
	Basal end rots
	Bunchy top virus
	Banana streak virus
Irish potatoes	
Potato tuber moth (PTM)	Bacterial wilt *Rolstonia solanacearum*
Nematodes	Late blight *Phytophthora infestans*
	Potato leaf roll virus (PLRV)

Source: Key informant interviews.

1.2 Collaboration and partnering in the process of technical change

This thesis unravels the process of induced technical change, which was developed based on the strategy adopted by KARI. The research zooms in on the introduction of disease resistant banana varieties in the Central Highlands (Chapter 2, 3 and 4). The examination of a similar but less successful, strategy to introduce disease resistant potatoes varieties (Chapter 5) highlights the importance of crop-specific and material conditions – in particular land distribution – for explaining the outcomes of collaboration and partnering in technical change.

To facilitate the process of technical change, the research institutes and laboratories of KARI partnered with the private sector and connected to associated farmers. KARI supported the acquisition of TC techniques and facilitated an evolving process of interactions between these public–private collaborations and farmer groups. This emerging context of collaboration and partnering shaped the conditions for varieties selection, multiplication, and dissemination (Dubois *et al*. 2007, Wambugu and Kiome 2001, Potato Task Force 2009).

The case study of technical change in bananas, central to this thesis, relates to a more general interest in the institutional conditions for selecting, manufacturing and distributing technical solutions for complicated and persistent problems, such as plant diseases, in small-scale agriculture (discussed in Section 1.3). This section first introduces the context of the case study of a process of technical change in banana production in the Central Highlands.

1.2.1 Technical change in banana production in the Central Highlands

In 1995, many banana plants in Maragua division of Muranga County wilted and finally dried up. Desperate farmers organised a protest at the Ministry of Agriculture‘s (MoA) office in Maragua, asking for a public interest in their situation and accusing the government for lack of technical advice (key informants interviews, 2011). The protesting farmers caught the attention of national journalists who brought attention to the problem on radio, television as well as print media. Photographs of dried banana crop became a common occurrence, with captions of desperate farmers scolding the failure of the MoA to provide assistance. This attracted the attention of KARI and other partners. In response to the challenge, KARI sampled the diseased plants for laboratory analysis. The results showed that the plants were infected with *Fusarium* wilt (Panama disease).

Fusarium wilt is a fungal disease caused by *Fusarium oxysporum* f. sp. *Cubense,* a soil-borne fungus that can persist for over 30 years (Kung'u and Jeffries 2001, Kidane and Laing 2008, Nguthi 2008). The disease has had a devastating effect on banana production in Kenya (Kidane and Laing 2008, Wambugu *et al.* 2008, Muyanga 2009, Njuguna *et al.* 2010). The disease was first observed in the country in 1952 but it did not cause much damage until the mid-1990s when it started infecting susceptible traditional varieties such as Gros Michel (AAA genome), Apple banana (AB genome), and *Muraru* (AA genome) (Kung'u and Jeffries 2001, Nguthi 2002). Between 1993 and 1995, the disease had spread at alarming rates resulting in the country’s average banana yields falling to as low as 200,000 tons, a figure less than an eighth of its current production (see Figure 1.2).

Offering farmers the opportunity to access clean planting material as well as resistant banana varieties was a central element in the public response strategy. Cavendish varieties resistant to *Fusarium* wilt and tissue culture (TC) techniques for micro-propagation of disease-free planting materials were identified as the best interventions (Mbogoh *et al*. 2003, Kimani 2010, Kiome and Wambugu 2001). Cavendish varieties were imported from South Africa and planted in participatory on-farm trials at various locations in the Central Highlands.

The preferred varieties were micro-propagated through TC techniques in public and private laboratories, and later disseminated to farmers.

The task of securing clean planting materials and Cavendish resistant varieties was not a task for a single actor. KARI, the national public research organisation, began to explore ways to involve other partners in this endeavour. The partnering process started immediately after KARI scientists confirmed that the problem was indeed caused by *Fusarium* wilt. Consequently, KARI approached the International Service for the Acquisition of Agri-biotech Applications (ISAAA) to pool resources. After the initial talks, KARI and ISAAA agreed to work together and gradually connected to local, national, and international public research organisations, government agencies as well as farmer groups involved in the banana sector (Dubois *et al.* 2006, Wambugu *et al.* 2006, Wambugu 2001).

The partnership strategy was adopted because the response to *Fusarium* wilt was a complex intervention requiring a combination of multiple resources such as knowledge, skills, funds, space, vehicles and equipment from various partners in research and development (R&D) (Hall 2006, Spielman *et al.* 2010, Bitzer *et al.* 2013). The initial phase of the partnership formation led to a focus on banana varieties in the Cavendish group, known to be resistant to race 1 of the *Fusarium* wilt (Wambugu *et al*. 2006, Wambugu 2001) and the acquisition of TC techniques used for producing clean planting materials of these varieties (Wambugu *et al*. 2006, Kahangi *et al*. 2008, Lule *et al*. 2011). The partnership wrote proposals and received funding from the Rockefeller Foundation (RF), World Bank, and International Development Research Centre (IDRC). The actions of the partnership encouraged investments in the acquisition of *in-vitro* stage three Cavendish plantlets (i.e. rooted plants in culture vessels that are suitable for long distance transportation) from South Africa. In addition, it facilitated access to biotechnological[1] knowledge and tools through the brokering of ISAAA. This organisational set-up enabled the multiplication and distribution of new, resistant banana varieties.

The partners succeeded in introducing technical change from the mid-1990s onwards: a change from traditional banana varieties susceptible to *Fusarium* wilt such as *Muraru* (AA genome*)*, Gros Michel (AAA genome), and *Kiganda* (EA-AAA genome) to Cavendish

[1] According to the 1992 Convention on Biological Diversity (CBD) biotechnology is defined as ‘any technological application that uses biological systems, living organisms or derivatives thereof, to make or modify products or processes for specific use’ (UN Convention on Biological Diversity, Art. 2). Biotechnology covers diverse applications including genome mapping, tissue culture, immunological techniques, molecular genetics, genetic transformation and recombinant DNA techniques in all facets of production.

varieties resistant to *Fusarium* wilt. The most preferred Cavendish varieties were Grand Naine (AAA genome), William hybrid (AAA genome), Giant Cavendish (AAA genome), and to a lesser extent Chinese Cavendish (AAA genome) (Wambugu and Kiome 2001, KARI Thika 2002).

The increases in production (Figure 1.2) and sales volume (Figure 1.3) [2] indicate that access to clean planting material of resistant varieties made a difference and suggests that an increasing number of farmers opted to use the new and more productive banana varieties, particularly since 2000. In the first phase of diffusing tissue cultured Cavendish varieties (1995–2000), only a select group of farmers appeared to be willing (see Chapter 2). Other farmers mentioned that they first associated the plantlets with witchcraft, because they could not believe that such small flower like transplants could be able to produce bananas, but after they started bearing banana fruits they were convinced beyond doubts and progressively started adopting the tissue-cultured Cavendish varieties resulting in gradual spread and increased production.

The two sections below further contextualise this process of technical change. Section 1.3 sketches the development of agricultural research and Section 1.4 presents the policy framework. This is a step towards the problem central to this research, namely how do processes of collaboration and partnering evolve and connect in the context of technical change (Section 1.5 and 1.6).

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[2] Key informant interviews revealed that about 20% of bananas produced are consumed at the household level, while 80% are sold.

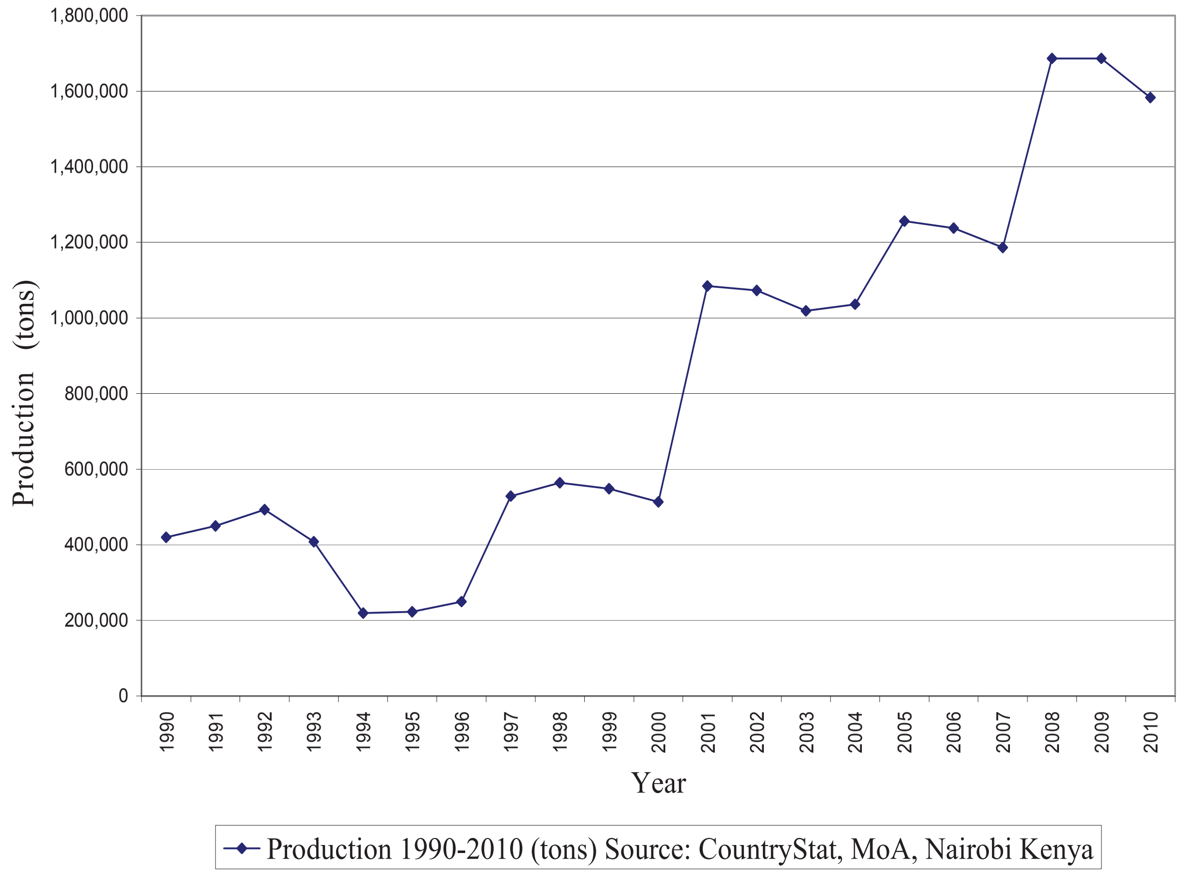
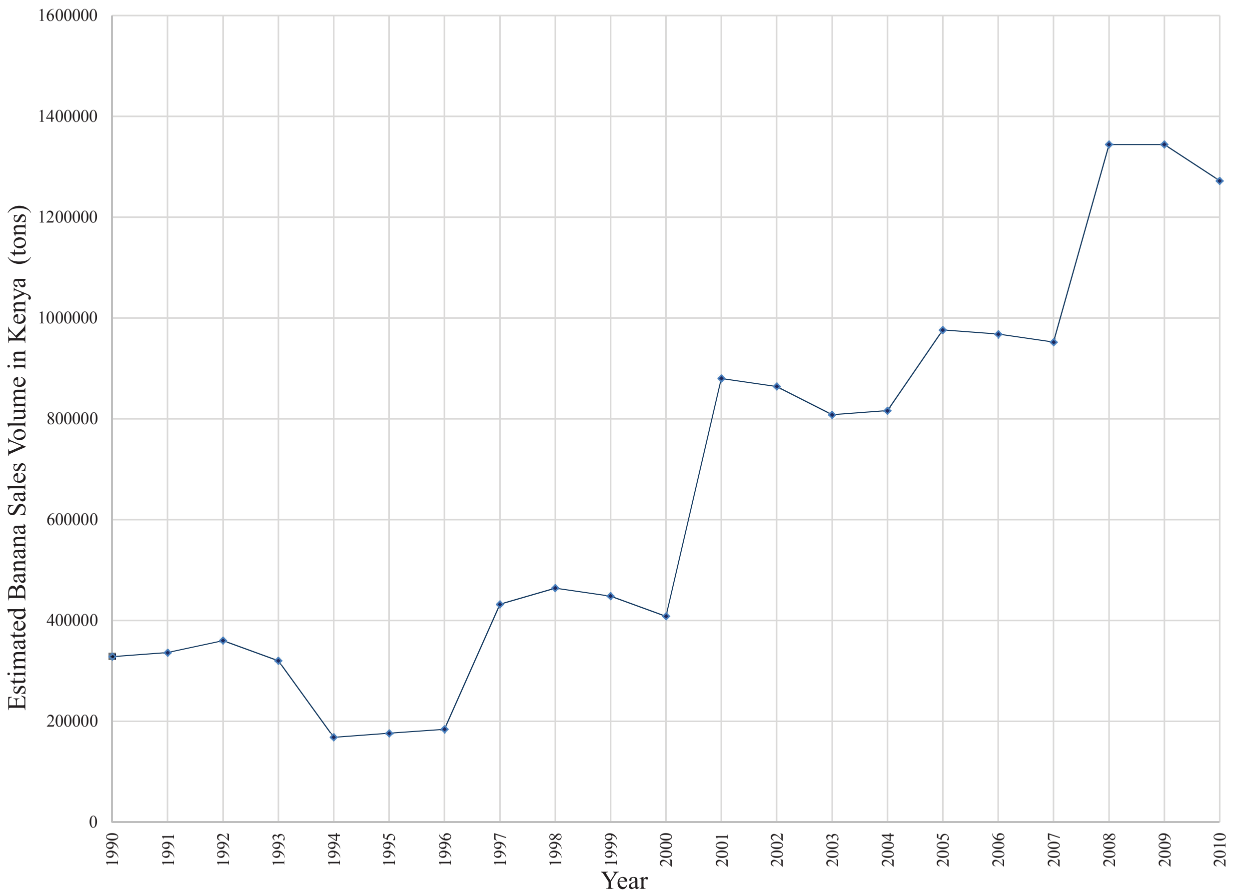


Figure 1.2: Banana production trend in Kenya (1990 – 2010)



Source:CountryStat, Ministry of Agriculture, Nairobi Kenya

Figure 1.3: Estimated banana sales volume in Kenya (1990 - 2010).

1.3 Developments in public agricultural research in Kenya

Agricultural research in Kenya was initiated during the colonial era. During this period, scientific and technological activities were undertaken to exploit natural resources for the benefit of the white settler community. Early developments in agricultural research were mainly to introduce cash crops such as coffee (*Coffea spp*.), tea (*Camellia sinesis L.*), pyrethrum (*Chrysanthemum cinerariaefolium*), cotton *(Gossypium spp*.), and sisal (*Agave Sisalama*). Research focused on improving crop and livestock production, and preventing crop and livestock diseases and pests. Later, independent commodity research institutions were established to address the research needs of specific agricultural commodities.

Since the late 1970s and early 1980s, the public agricultural research system embarked on an incremental process of institutional reform in order to become more responsive and flexible, considered essential for contributing to national development goals. In this regard, the government reorganised the public agricultural research system under the provisions of the Science and Technology Act of 1977 (amended in 1979). The emphasis was on integrating the various national agricultural research units and services, rationalising research infrastructure and designing programmes for the new research system. Alongside the evolution of research institutions, academic institutions were established to provide agricultural education and undertake research. This sets the scene for approaches to agricultural development wherein partnerships of public research institutes, in particular KARI, with both farmers' groups and the private sector have gained a more prominent role.

1.3.1 Farming systems approaches to agricultural research

The traditional approach to agricultural research was mainly supply driven. Researchers set the agenda without consulting clients and other stakeholders. The farming systems approach (FSA) evolved from a concern that this top-down approach to agricultural research and development was not making an impact on small-scale agriculture. The farming systems concept was taken on board by the Ministry of Agriculture's scientific research division in 1975.

Through the inputs by economists of the International Maize and Wheat Improvement Centre (CIMMYT), the FSA concept was amended and re-launched with the name of On-farm Research with a Farming Systems Perspective OFR/FSP. In 1991 the OFR/FSP was reviewed leading to the approach adopting the name Farming Systems Approach to Research, Extension and Training (FSA-RET) (Kamau, 2007). Shifting to the FSA-RET was, however, a scientific decision and did not involve any policy documentation. While FSA-RET transformed the way research was conducted, its participatory nature was limited to incorporating farmers and did not include other research institutions, which continued to operate independently. FSA-RET assumed that small-scale farmers were intelligent and could answer questions and discuss their farming issues with researchers. This implied that researchers did not need to carry out costly and time consuming extractive research to address the farming constraints. These insights led to the development of rapid appraisal methods such as Participatory Rural Appraisal (PRA), Participatory Learning and Action Research (PLAR) and Participatory Technology Development (PTD) (Kamau 2007, Matata and Wandera 1998). Other approaches that have been used include the Farmer Field Schools (FFS) and Agricultural Knowledge and Information System (AKIS). In these approaches emphasis remained at the farm level addressing production-oriented issues, with little attention directed at research on the agricultural product value chain.

1.3.2 Integrated agricultural research for development

The continuous discussion of the effectiveness of agricultural research encouraged rural development practitioners to look for and experiment with new and alternative ways of doing research. This created a demand for developing capacity for the formation, planning, operation and management of teams and partnerships. The Forum for Agricultural Research in Africa labelled this as Integrated Agricultural Research for Development (IAR4D). In response to this need, multidisciplinary teams of scientists from various Kenyan organisations (e.g., Kenyatta University, Jomo Kenyatta University of Agriculture and Technology, Egerton University, KARI, Ministry of Agriculture, Ministry of Livestock and Fisheries Development, and Kenya Federation of Agricultural Producers) received trainings at the International Centre for Development Oriented Research in Agriculture (ICRA) in the Netherlands, culminating in the launch of the IAR4D concept in KARI in 2006.

IAR4D is a generic approach that includes other paradigms such as farmer participatory research, integrated natural resource management and sustainable livelihoods. IAR4D is a process-oriented approach that recognises collective action by involving a broad range of stakeholders and multiple knowledge sources (including indigenous knowledge) to address complex development challenges. IAR4D sets out a process and progressive procedures and accompanying tools for planning how to resolve complex problems and how to implement rural development activities that respond to the needs of beneficiaries and stakeholders, and contribute to broad development objectives using multi-dimensional participatory and system approaches.

1.3.3 Agricultural value chain approach

In addition to IAR4D, agricultural research institutes in Kenya gradually adopted an interest in the agricultural product value chain approach. Expanded opportunities in domestic, regional and global markets stimulated the Kenyan agricultural research system to support their clients to compete in these markets and facilitate coordination along the agricultural product value chain. In this approach, agricultural research institutes contribute to knowledge, technologies, practices, and services required to participate in value chains by meeting the conditions to produce and deliver a product or service.

Community-based organisations, client organisations and trade associations began to play a role in improving coordination among stakeholders in a value chain and in communicating the needs of the industry to the government. Associations and organisations helped to organise production, negotiate contracts, improve market information systems, promote products, coordinate research, enforce quality standards, and pool risks. Research increasingly focused on finding and creating opportunities for small-scale farmers to participate in these arrangements and capture the benefits of new markets.

1.3.4 Public–private partnerships

The increased interest in private sector development and value chain approaches also created an interest in building linkages between the private and public sector, in particular for leveraging resources and combining individual capacities. Public–private partnerships (PPP) entered the Kenyan agricultural research system. This has taken various forms including increased investment in agriculture R&D, increased involvement of farmers, farmer groups, private entrepreneurs and public organisations (Pardey and Beintema 2001, Pray 2002, Wambugu 2001, Wambugu and Kiome 2001).

In Kenya, a substantial share of partnerships in agriculture are organised around the use of new biotechnologies and the introduction of improved plant varieties (Table 1.2). These partnerships include international organisations, public organisations, private organisations, bilateral and multilateral donors, philanthropic foundations, non-governmental organisations (NGOs), and community-based organisation (CBOs). Such partnerships have received support in both policy and academic circles (Hall 2006, Spielman and von Grebmer 2006b, Spielman *et al.* 2010, Bitzer *et al.* 2013). The process of technical change central to this thesis emerged in this organisational setting, which was supported by the agricultural policies discussed next.

Table 1:2: Public–private partnerships involving KARI in crop biotechnology in Kenya

Project	**Facilitator**	**Partners**
Banana tissue culture for mass propagation of clean planting materials	ISAAA	KARI, Rockefeller Foundation, the World Bank, farmer groups, Genetic Technology Limited, International Service for the Acquisition of Agri-biotech Applications (ISAAA), Du Roi laboratories, Agro-Genetic Technologies (AGT), John Innes Centre, African Technology Policy Studies (ATPS) network, Catholic Diocese, International Development Research Centre (IDRC), Wangu Investments, Beam Business Options, Jomo Kenyatta University of Agriculture and Technology (JKUAT), Institute of Tropical and Sub-Tropical Crops (ITSC), Ministry of Agriculture (MOA), Kenyatta University (KU), KEPHIS.
The development of drought-tolerant and pest/insect-resistant maize varieties	Biotechnology Trust Africa (BTA)	KARI, BTA, Dutch Ministry of International Cooperation (DGIS), CMMYT, farmers, University of Missouri-Columbia, Brookhaven.
Citrus fruit tissue culture for mass propagation of clean planting materials	BTA	KARI, University of Nairobi (UoN), BTA, DGIS.
Irish potato tissue culture for mass propagation of clean planting materials	CIP	KARI, GTZ, KEPHIS, MoA, USAID, International Potato Centre (CIP), farmers, farmer groups.
Sweet potato tissue culture for mass propagation of clean planting materials	BTA	KARI, BTA, DGIS, CIP, International Institute for Tropical Agriculture (IITA).
Cassava tissue culture for mass propagation clean planting materials.	BTA	KARI, BTA, DGIS, CIP, IITA.
Evaluation and promotion of *Bacillus thuringiensis* (*Bt*) toxin–based biopesticides	BTA	KARI, UoN, BTA, DGIS, Kenyan Industrial Research and Development Institute (KIRD), Int. Centre of Insect Physiology and Ecology (ICIPE), Int. Crops Research Institute for the Semi-Arid Tropics (ICRISAT).
Macadamia Tissue Culture for mass propagation of clean planting materials	BTA	KARI, BTA, DGIS, Japan International Cooperation Agency (JICA), the World Bank.
Virus-resistant sweet potato	ISAAA	KARI, Monsanto, CIP, ISAAA.
Maize streak-virus resistance of maize lines from Kenya and eastern and southern Africa	ISAAA	KARI, Rockefeller Foundation, John Innes Centre (UK), University of Cape Town (South Africa), ICIPE, Novartis Seeds.
Transgenic cassava project	ISAAA.	KARI, Moi University, USAID, Danforth Centre.
Insect-resistant maize for Africa (IRMA).		KARI, CYMMT, Syngenta Foundation, MoA, private seed companies, farmers.
Water efficient maize for Africa (WEMA)		KARI, AATF, CMMYT, Bill and Melinda Gates Foundation, Howard G. Buffet Foundation, farmers, MoA.
Virus-resistant sweet potato	ISAAA	KARI, Monsanto, CIP, MoA, farmers.
East coast fever (ECF)	DFID	KARI, ILRI, MoLFD, DFID, farmers.

Source: Ayele *et al*. 2006 and own data.

1.4 Agricultural policies supporting PPPs in Kenya

Cross-sector collaboration and partnering have become a key component of agricultural research in Kenya, in particular in the field of crop biotechnology. Various agricultural policies introduced legal and regulatory frameworks to support, facilitate and promote the formation of agriculture biotechnology partnerships in Kenya.

1.4.1 The Strategy for Revitalising Agriculture (SRA) 2004–2014

This policy document was composed and approved by the Ministries of Agriculture, Livestock and Fisheries Development, Cooperative Development and Marketing. The SRA identified partnerships between public and private sectors as channels for refurbishing the agricultural sector by creating synergies and increasing cost effectiveness in agricultural research and development. According to the document partnerships are important because they encourage investment, competitiveness, and improve market access (Republic of Kenya 2004b).

However, SRA's perception of the role of partnerships is very limited. Partnerships are essentially considered in terms of improving the allocation of resources and addressing market failures. Although the SRA recognises the private sector as a valuable stakeholder in agriculture, its involvement is limited to taking up business functions that have been streamlined and is primarily seen in terms of commercialisation. In its list of stakeholders in agriculture, the SRA does not mention international organisations, bilateral and multilateral donors, philanthropic foundations, NGOs, and CBOs.

The emerging biotechnology partnerships (see Table 1.2) demonstrate that the majority of funding for agriculture biotechnology partnerships is from traditional development partners, bilateral and multilateral donors, private not-for-profit foundations and multinational companies. It is surprising that none of these are mentioned in the SRA. Agriculture biotechnology partnerships in Kenya are mostly North–South partnerships. The private sector is typically a multinational company while the public sector almost always consists of KARI and may involve Northern research institutes such as universities.

1.4.2 The Ministry of Agriculture Strategic Plan (MASP) 2006–2010

The strategy of the Ministry of Agriculture also emphasises the need for partnerships between the public and private sectors and suggests a profound appreciation of the importance of partnerships beyond just addressing market failures. Although agriculture research is viewed as a public good, it is considered to include the private sector, so that it too can contribute to agricultural research and development in the country. Furthermore, the strategy advocates for the adoption of a value chain approach that incorporate actors from both the private and public sectors (Republic of Kenya 2006a).

1.4.3 The National Biotechnology Development Policy (NBDP) 2006 onwards

This policy became operational in 2006. Prior, Kenya had been conducting biotechnology research on crops such as transgenic maize, sweet potato, cassava and cotton. This research involved partnerships, which worked in a policy and legal vacuum, except for the 1998 biosafety regulations and guidelines drafted by the National Council for Science and Technology (Science Africa 2011, Wambugu 2001). The need for a national policy to outline directions for research and monitor biosafety of biotechnology R&D led to the drafting of the Biosafety Bill in 2005. This was debated in Parliament and later signed into law by the president in 2006, thus Kenya joined Burkina Faso, Egypt, and South Africa as African countries that permit genetically modified farming. The policy recognises the constraints to food security and suggests that these challenges require appropriate scientific technologies, such as biotechnology (Republic of Kenya 2006b).

The policy supports public and private partnerships in agricultural research and development. It aims to forge collaboration among public and private sectors, NGOs, international development agencies, donors, and other actors for the advancement of biotechnology locally, regionally, and globally in order to ensure food security. The acquisition of TC techniques is part of this overall strategy, and their use in both public (KARI and universities -managed) and private laboratories has increased gradually. To demonstrate the political will, the then acting president, Mwai Kibaki, launched the first biosafety green house at the biotechnology centre at KARI National Research Laboratories (NARL) in Nairobi, and the ultra-modern Biosciences for Eastern and Central Africa (BecA) hub at the International Livestock Research Institute (ILRI) in Nairobi (Kenya Daily Nation Newspaper of June 13, 2006, Science Africa 2011).

1.5 Theoretical context: partnerships in a development context

1.5.1 Partnerships and development

Since the failure of the green revolution to deliver promising R&D outputs in sub-Saharan Africa, a range of multi-actor approaches have been devised to overcome its weaknesses. These include various participatory approaches (Almekinders 2011, Pircher *et al.* 2012, Francis 2013); innovation platforms (Kilelu *et al.* 2013, Kouévi 2013); innovation systems

(Hall *et al.* 2003, Hall and Clark 2010); collective action (Davis *et al*. 2004, Place *et al*. 2004, Fischer and Qaim 2012, Markelova *et al*. 2009) and partnerships (Spielman and von Grebmer 2006b, Spielman *et al.* 2010, Bitzer *et al.* 2013). These approaches underscore the importance of multi-actor interactions and forms of partnering in the R&D process, and try to assess why and how partnerships achieve the intended outcomes (Hall 2006, Spielman and von Grebmer 2006b, Spielman *et al.* 2010) and/or generate intermediate processes of institutional change Vellema *et al.* 2013).

In policy and practice, the envisioned potential of partnerships to ensure food security is strongly linked to the pooling of resources among the various partners in the R&D process as a condition for opening up new technical possibilities or by encouraging new marketing arrangements (Hall 2006, Hartwich and Tola 2007, Spielman *et al.* 2010, Dubois *et al.* 2006). However, realising this potential is far from easy. The challenges confronting partnerships are manifold and includes: different incentives structures for partners to combine their resources and capacities, varying mandates and objectives, intellectual property rights (IPR), and aid dependency (Byerlee and Echeverrı´a 2002, Hartwich *et al.* 2003, Spielman and Grebmer 2004, Ayele *et al.* 2006).

The development-oriented literature on partnerships reveals several common features and assumptions that underpin their rationale:

(i) Partnerships are assumed to work towards the achievement of some mutual objective, i.e. all actors working together seek to meet common objectives (Rosenau 2000, Hall 2006);

(ii) All parties in a partnership are assumed to be involved in planning, operationalising, implementing and executing the mutual objective (Spielman *et al*. 2009, Hagedoorn *et al*. 2000). This does not imply that there is no division of labour although traditional roles are increasingly blurred; all parties should ideally have equal decision-making power;

(iii) A partnership implies ongoing interaction though which parties combine their forces to accomplish a shared objective (Mitchell-Weaver and Manning 1991: 5);

(iv) The use of resources from all the partners is another feature of partnerships. This does not refer to just financial resources but includes knowledge, infrastructural, and research based resources (Link 2006, Hall 2006);

(v) The impetus for the formation and implementation of a partnership comes from the partners.

1.5.2 Theoretical perspectives on partnerships

The literature on partnerships can broadly be categorised into three perspectives: (i) those that examine partnerships on the basis of economic incentives or benefits; (ii) those that look specifically at the organisational and institutional dimensions; and (iii) those that relate partnerships and multi-stakeholder collaboration to an innovative system approach.

First, the economic perspective stems from the classical division of goods into public and private goods and the ensuing market failure. Partnerships are analysed through the lens of efficiency in resource allocation in the face of scarce financial and human resources. The argument is tied to the division of labour with the contention that the government is best suited to provide collective or public goods that are non-excludable, while the private sector is better at providing goods that are excludable and non-collective (Olson 2009, Pray and Umali-Deininger 1998). But goods, and particularly those that are the subject of agricultural partnerships, rarely fall neatly within the pure public and private categories (Spielman and von Grebmer 2006, Spielman *et al*. 2010, Hartwich and Tola 2007). Although there are arguments that those goods displaying both public and private property characteristics (hybrid or mixed) form the main focus of partnerships (Van der Meer 2002) and that partnerships make the economy work more efficiently by broadening the sphere of activity directed by market forces (Mitchell-Weaver and Manning 1991), partnerships are much more than 'gap fillers' premised on market failure (Pray and Umali-Deininger 1998). It is therefore no longer helpful to refer to the simplistic division of labour between public and private domains as it is increasingly blurred. The resource allocation argument underlying neoclassical economics is therefore less useful as it does not advance our understanding of the actual performance of partnerships, particularly in the context of agricultural R&D (Pray and Umali-Deininger 1998, Spielman and von Grebmer 2006).

Second, the institutional economics literature views partnerships as governance strategies designed to minimise transactions costs, or the costs associated with forming and sustaining relationships, such as writing and enforcing contracts, bargaining over terms and conditions, coordinating and enforcing relationship between actors engaged in the production of goods or services (Williamson 1975, 1979, Hagedoorn *et al*. 2000). The magnitude of these transaction costs is determined by the frequency with which actor entities interact, the uncertainty of these transactions, the limit on actors rational behaviour, and the specificity of assets used in the interactions (Rangan *et al.* 2003). In this view partnerships reduce transaction costs and improve the potential for realisation of economic opportunity. This literature sheds lights on the reasons for forming partnerships under specific conditions.

Third, the innovation system perspective views partnerships not only as the product of institutional reforms but as organisational architectures specifically dealing with the unique problems and technology needs of the poor in the development context. Partnerships from this perspective are important social institutions that respond to development challenges (Clark 2000). They are social technologies (Chataway *et al.* 2011) that not only respond to the unique complex challenges associated with development but also shape the way in which these challenges are addressed. In this way, they have the potential to significantly influence how food security and other development related challenges are conceptualised and addressed. Partnerships are part of the multi-actor integrated solutions required by the wide scope and complex nature of today's problems (Brinkerhoff and Brinkerhoff 2004, Hall 2006).

The literature on partnerships tends to emphasise the rationale for partnerships: Why do actors agree to collaborate and share resources? In the case of banana planting materials this is linked to the acquisition of TC techniques and access to improved banana varieties. This thesis enriches the research on partnership by investigating practices taking place after the initial formation of a partnership. It aims to explain how partnering at different levels configures an evolving processes of technical change. The thesis traces processes and maps distributed task performances to understand how and why partnerships are able to generate technical change. It documents the use of skills, techniques, tools and know-how necessary for solving concrete and often unanticipated problems in an evolving process of technical change.

Accordingly, the thesis emphasises the capacity of partnerships to connect distributed competencies and to configure a chain of social-technical practices across multiple levels. Likewise, it opens a discussion on whether the observed increase in production and sold volumes can be attributed to the newly acquired planting materials and TC techniques, or whether the partnerships triggered a sequence of evolving socio-technical interactions, which produced a 'chain of technical change. This shifts attention from an exclusive interest in the organisational design of partnerships working on technical change to the social-technical practices of selecting recipes, solving unanticipated problems, correcting errors, and coordinating actions that incrementally form the process of technical change.

1.6 Orientation, objectives and research questions

1.6.1 Orientation of the research

The empirical research presented in the thesis focuses on the introduction and multiplication of new banana varieties based on the preliminary fieldwork and screening of all cases of agricultural R&D partnerships in Kenya. Banana is one of the crops that have received increased research attention over the last two decades in Kenya. Previously the crop was grown on subsistence basis but increasingly gained commercial importance over the years. Qaim (1999) attributes this change to a growing demand from urban populations and the declining incomes from coffee, the former main cash crop. The collapse of the coffee industry in the late 1980s resulted in a sharp decrease in coffee prices and fluctuating production (Wambugu and Kiome 2001, Qaim 1999, Dubois *et al.* 2006). Farmers who depended on coffee as their main source of income had to search for alternatives crops, and bananas were an attractive alternative. Bananas can be consumed at home and also sold at premium prices. However, the promising perspectives for banana productions eroded as a result of pests and diseases, which encouraged KARI to search for adequate responses by partnering with other public and private actors and to connecting with farmer groups.

Why did the introduction of improved banana varieties in the Central Highlands work? Did this technical change at the level of small-scale farmers directly result from a partnership at national level arranging a combination of financial and other resources to acquire multiplication tools and resistant varieties, as argued by Hall (2006), Hartwich and Tola (2007), and Spielman *et al.* (2010)? Or did it involve a variety of collaboration processes at different levels and time periods, involving power relations, tensions, divergent views, decision-making processes as well as coordinated uses of skills, techniques, tools, know-how and team's governance in the performance of distributed tasks over time and at different stages?

Various studies present the pooling of resources of partners at national level as an ideal partnership model to enhance food security and increase incomes (Njuguna *et al*. 2010, Wambugu and Kiome 2001, Mbogoh *et al.* 2003, Njuguna *et al.* 2010, Dubious 2006). This thesis considers the acquisition of TC techniques and resistant Cavendish banana varieties through PPPs as only the starting point for processes of collaboration and partnering at different stages and subsequent stages of the process of technical change. The interest of this thesis is to document processes of collaboration and socio-technical practices that occur after the acquisition of TC techniques for multiplication and transfer of planting materials. The aim is to demonstrate that technical change is not limited to traits of novel technical opportunities enabled or acquired by partnerships.

Three empirical chapters in the thesis (Chapter 2, 3 and 4) present descriptive accounts of the processes of variety selection, multiplication and dissemination of new banana varieties among small-scale farmers in Kenya. These descriptions reveal that different actors had to collaborate to achieve progress and address the problems associated with the process of technical change. The detailed investigations unmask subtle and sometimes hidden socio-technical and political processes related to the politics of variety selection (Chapter 2); distributed cognition and coordination of multiple tasks inside a TC laboratory (Chapter 3); and the governance and performance of a farmers group managing a TC banana nursery and the dissemination of the new Cavendish varieties (Chapter 4). On the basis of these detailed descriptions of socio-technical processes underlying the gradual spread of alternative banana varieties, as well as the case study of the failed introduction and multiplication of alternative potato varieties, this thesis enhances our understanding of why and how organisationally layered partnerships succeed (or do not succeed) in fostering technical change among small-scale farmers.

The case of tissue cultured banana varieties is contrasted with the case of the multiplication and dissemination of improved tissue cultured Irish potato varieties through a farmers group (Chapter 5), which highlights the relevance of including material conditions, i.e. land and nature of the crop-disease interaction, for explaining the performance of partnerships. In the Irish potato case, KARI partnered with international organisations, public organisations, private organisations, bilateral and multilateral donors as well as farmer groups in the introduction and dissemination of tissue-cultured disease resistant Tigoni and Asante varieties. The initiation process was similar to the banana case; however, the potato intervention was less effective in promoting technical change. I will make the argument that the poorer performance was due to contextual exogenous factors, in particular the distribution and scarcity of land. Not enough land was made available to guarantee adequate crop rotation, and as a result the disease infestation persisted and the partnerships failed to deliver clean planting materials to farmers.

1.6.2 Objective of the thesis

The objective of this thesis is to examine how different actors partner or collaborate at different stages of the configured chain of technical change and succeed, or not, to manage the process of selecting, multiplying and disseminating improved planting materials under changeable and sometimes unanticipated social and material conditions.

The thesis aims to develop a perspective on partnering in a process of technical change that looks beyond augmentation of resources in a joint project of technical change. This study of practices, coordination and collaboration that occur after the initial set-up of a partnership contributes to a more detailed and embedded description of how technical change and related development outcomes are brought about. Getting partnerships to work entails the daily management of many socio-technical issues at different stages of the ‘chain of technical change’. The thesis intends to fuse together several elements – the micro-politics of selecting banana varieties, the governance of skilful teamwork in a tissue culture lab, and the rules emerging in a task-oriented small group collectively managing a plantlets nursery – into an analysis of the performance potential of PPPs.

The empirical focus is on the practices of teams/groups in the period between the moments partnerships are formed and the time when their effects are observed. The boundaries of the examined ‘chain of technical change’ are drawn at the stage where selection and specification of the technical formula (i.e. TC techniques and Cavendish resistance varieties) takes place and the stage where the technical solutions are disseminated, in sufficient volumes, to end users (i.e. the group managing a tissue-cultured banana nursery or the groups multiplying Irish seed potato). The thesis neither assesses the direct effects on smallholder farmers nor investigates their reasons to adopt the improved planting material.

1.6.3 Research questions

The general research question is formulated as follows: How did partnerships contribute to a shift from the use of traditional plant varieties that are susceptible to diseases to adoption of improved varieties that are resistant to diseases in the Central Highlands?

This main research question is broken down into the following sub-questions:

a) How did a multidisciplinary team of scientists and farmers select preferred Cavendish varieties that were resistant to *Fusarium* wilt?
b) How did specialists and technicians working in a TC laboratory coordinate tasks and receive feedback on selected Cavendish varieties?
c) How did the farmer groups remain viable and collectively managed the technical and managerial processes of acquiring TC plantlets from the laboratory, managing them in the nursery, and disseminating them to the wider community?

The research also compares the material conditions and nature of the crop-disease interaction in banana with the case of seed potato, which was introduced in a similar partnership set-up, operationalised as the following sub-question:

d) How does the history of land tenure in the Central Highlands affect the capacity of partnerships among small-scale farmer groups, research institutes, and other partners to multiply and deliver tissue-cultured seed potato?

1.7 Research design

1.7.1 A technographic approach to researching technical change

The study employed a technographic lens to analyse the practices that constitute the chain of technical change at different stages and different sites. Technography is an interdisciplinary methodology for the study of technology in daily social situations (Kien 2008). Jansen and Vellema (2011) regard technography as the ethnography of technology, which systematically describes the use and performance of techniques, actors and organisations to achieve practical ends. The method entails detailed description of humans, tools and machine interactions and focuses on use – rather than the design – of skills, techniques and knowledge (Richards 2000, Jansen and Vellema 2011). The central element of a technographic approach according to Sigaut (1994) and Richards (2000) is for the researcher to see beyond the technology itself by considering the problems that the technological applications are supposed to solve and understanding the underlying mechanisms.

Technography aims to understand how the various components of the socio-technical process combine in situated action. Jansen and Vellema (2011) propose three dimensions for a systematic description of a process of making: (a) the making, which involves detailed examination of the use of skills, tools, techniques, and knowledge in achieving a practical end; (b) the distributed cognition, which involves coordination of the distributed tasks and various types of knowledge in smaller groups; and (c) the use of rules related to specialisation and professional association in directing actual performance.

I use these three dimensions in describing the practices constituting different stages of the chain of technical change in the Kenyan banana sector (Table 1.3). First, I reconstructed the process of variety selection, wherein a team of researchers interacted with a select group of farmers, which reveals how different skills and know-how combine and how interactions between these groups, with different governance structures and political dynamics, shaped a process of closure, leading to a preference for certain Cavendish banana varieties. I documented how the various partners, disciplines and the knowledge bases interacted in and contributed to the process of variety selection.

Second, I examined the process of micro-propagation of selected Cavendish varieties in the laboratory using TC techniques. This involved the coordinated use of skills, techniques, tools and machines for interacting with the material elements of tissue culture: plantlets, macronutrients, diseases, soils, growth hormones etc. Adherence to rules and protocols was an important aspect studied in the daily work practices of technicians and labourers in the laboratory and greenhouse.

Third, I investigated how the nursing and commercialisation of micro-propagated banana plantlets was managed by a farmer group, vertically linked to the agricultural research system and locally embedded in the farming communities. This specific group was able to increase the distribution of new banana varieties. A similar organisational set-up linking farmer groups to the research infrastructure was studied in the case of seed potato. Both case studies provided evidence that it is not the PPPs per se that make the difference, but rather that technical change results from social and material configuration that function well under specific conditions.

Table 1:3: Emphasis of technographic dimensions at different stages of the chain of technical change

Stage of the chain of technical change → ↓ Dimension of technography	Stage 1 Banana variety selection by a multidisciplinary team of scientists and selected farmers	Stage 2 Laboratory micro-multiplication using TC techniques	Stage 3 Tissue-cultured banana nursery management dissemination, and commercialisation
Skills, techniques, technical know-how, tools, and machines	√	√√√	√√
Team work, distributed cognition	√	√√	√√√
Rules and routines associated with specialisation and profession	√√√	√√√	√

1.7.2 Case study design

The thesis uses case studies to examine the various practices constituting the process of technical change: the interactions of researchers and farmers, the performance of a laboratory, and the functioning of farmer groups as multipliers and disseminators. The case studies were done at different sites and in combination look at the different stages of how the selected partnership generated technical change.

The rationale behind the case study design is that it permits to examine a contemporary phenomenon in depth and in its real-life context, especially valuable when the boundaries between the phenomenon, i.e. partnerships inducing technical change, and context, i.e. political processes and material conditions at different levels, are not clearly evident (Yin 2008, De Vaus 2001). Case studies are intended to provide details of daily practices similar to the ethnographer Clifford Geertz's (1973) notion of 'thick description', allowing for a thorough analysis of complex phenomena, such as the performance of layered partnerships, in their social and material context (Yin 2003). The design also emphasises an understanding of the entire case, recognising the temporal and spatial dimensions of an evolving process, and stresses the importance of looking at embedded parts as units of analysis (De Vaus 2001, Gerring 2004).

The distinctive feature of the research design is that it involves a strategic selection of multiple case studies, which are informed by distinct theoretical insights (De Vaus 2001, Yin 2003, Silverman 2010). Strategic selection means that we know something about the characteristics of the case before data collection commences. The empirical chapters reporting on specific stages and practices in the overall process of technical change in the banana sector relate to literature on the politics of selection and participation in agricultural R&D (Chapter 2), the performance of skilful and embodied tasks in small task-oriented groups (Chapter 3), and the dynamics of collective action (Chapters 4 and 5). By combining case studies of distinct and sequential organisational actions, the focus is on understanding and interpreting the whole phenomenon, which is shaped over time and at different sites.

In addition to the comprehensive analysis of technical change in the banana sector, a case study of four farmer groups working on the multiplication and dissemination of Irish seed potato was added to explore whether the findings of the banana case can be replicated. The Irish potato case has a lot of similarities with the banana case: (a) both crops are important for food and cash generation; (b) in both cases crop yields had declined due to diseases (bananas were infected by *Fusarium* wilt, while Irish potatoes were infected by *bacterial* wilt); (c) both cases sought to mitigate the problem through TC techniques for multiplication of planting materials and disease resistant varieties; (d) both used partnerships comprised of actors from international organisations, public organisations, private organisations, bilateral and multilateral donors for sharing of resources and synergy creation; (e) both used farmer groups as channels for technology dissemination; and (f) both were based in the Central Highlands.

1.7.3 Limitations of the case study design

The single case study design has been subject to a number of criticisms, most importantly related to external validity, researcher subjectivity and methodological rigour. External validity assesses whether the study's findings can be generalised beyond the immediate context of the study. It is ensured through the use of theory in single case studies and replication logic in multiple case studies (De Vaus 2001, Yin 2003). Multiple cases are better when dealing with 'generalisation', but as King *et al*. (1994: 212) write 'in all social science research and all prediction, it is important that we be as explicit as possible about the degree of uncertainty that accompanies out prediction'.

I investigated specific partnerships, and the generalisation of the findings is not guaranteed because of the dynamic contextual environments specific to Kenya. For instance, the banana case shows farmer groups that not only succeeded in performing well in the tasks of tissue-cultured banana plantlets acquisition, management and dissemination but also went beyond bananas expanding to other economic activities. However, a similar organisational set-up did not lead to the same dynamics and outcomes in the Irish potato groups. The Irish potato groups failed in their tasks of quality seed multiplication and dissemination due to inadequate access to land, which resulted in insufficient crop rotation and disease outbreaks. This implies that the Irish potato case did not match our prediction based on the preliminary insights derived from studying the partnership concept in banana (De Vaus 2001, Yin 2003, King *et al.* 1994). Nevertheless, the combination of case studies of stages of technical change in the banana case reveal multiple mechanisms that, in combination, may explain technical change in banana as an emergent outcome. The contrasting case study of potato then highlights the importance of the interaction between group formation and the material conditions.

The threat of researcher subjectivity is linked to the use of qualitative methods (Verschuren 2003). The presence of a researcher can alter the dynamic of the case being studied. I attempted to overcome this limitation by combining participant observation and interviewing with secondary sources, such as written reports, journals and archival documents. As argued by Berg and Lune (2010) pure objectivity is not a meaningful concept if the goal is to measure intangibles. In this research they include processes, events, team's social organisations, conflicts of interest, power relations, tensions, decision-making processes, and divergent opinions. It is for these reasons that Flyvbjerg (2006) suggests that the case study contains no greater bias toward verification than other methods of inquiry.

The case study design has also been criticised for lacking methodological rigour (Maoz 2002). Yin (2009) sees the absence of systematic procedures in case study research as being the greatest concern due to lack of methodological guidelines, but this critique seems somewhat unfair as many contemporary case study practitioners have increasingly sought to develop their methodological techniques and epistemological underpinnings (Bennett and Elman 2010). This thesis employs the systematisation offered by technography (Jansen and Vellema 2011) to produce descriptive accounts of distributed socio-technical practices and collaborative processes that lead to technical change.

1.8 General methods of data collection

Data collection methods included participant observation, key informant interviews, focus groups interviews and secondary sources.

1.8.1 Participant observations

Participant observation is a special type of observation in which the researcher is not merely a passive observer but an active participant in day-to-day activities (Yin 2008). I collected data by participating in the daily life of the actors in the laboratory and the two farmer groups. I engaged in extensive conversations that revealed the participants' interpretation of the pertinent situations and events (Silverman 2010). The data for these observations were recorded using a camera and taking detailed notes.

1.8.2 Key informant interviews

Key informant interviews are in-depth interviews of a purposively selected (non-random) group of experts who are very knowledgeable on the issues under investigation (De Vaus 2001, Yin 2003). Interviewing many key informants has the advantage of providing candid and in-depth corroborative data from multiple sources. Moreover, the interviews help build a fuller picture of the phenomenon being studied than would have been possible with the quantitative methods of data collection. Data for all the interviews were documented by writing detailed notes and by digital recording. The recorded interviews were stored in a computer and later replayed during analysis.

1.8.3 *Focus group interviews*

In focus group interviews participants are asked about their perceptions, opinions, beliefs and attitudes towards an issue under investigation. It is a flexible and open format, where participants are free to talk with other group members. The strength of the method relies on allowing the participants to discuss among them, thus providing insights into the issue under investigation. Various focus interviews were conducted with groups of 6 to 12 selected participants. Data for all the interviews were documented by writing detailed notes and by audio recording. The recorded interviews were stored in the computer and later replayed during analysis.

1.8.4 *Secondary data*

Data were also collected through secondary sources, especially written reports from various organisations, for example, national and international NGOs, the Ministry of Agriculture, KARI, Kenya federation of agricultural producers (KENFAP) and local universities. Other sources included newspapers and archival documents.

1.9 Specific methods of data collection according to stages in the chain of technical change

1.9.1 *Stage 1: Banana variety selection by a multidisciplinary team of scientists and farmers*

This stage examines how a multidisciplinary team of scientists and a group of farmers with specific social and political positions interacted in the selection of the resistant banana varieties from the Cavendish group that is resistant to *Fusarium* wilt (Race 1). The study documents three sequential activities comprising a Participatory Rural Appraisal (PRA), market survey and on-farm participatory variety selection. Data were collected by reconstructing the past through respondents recall memory (De Vaus 2001) and using multiple sources.

Key informant interviews were conducted with 20 scientists from different disciplines and institutions and 11 farmers who hosted the on-farm trials. The farmers and scientists were purposively selected because they participated in all three activities or were part of the implementation team. Books, journals, project reports, newspapers and archival documents provided additional data.

Eight focus group interviews were conducting with at least eight participants per group: the on-farm trial host farmers and about seven common interest group (CIG) farmers who participated in the on-farm trial variety evaluation and selection. The focus group interviews were held at each on-farm trial site, in order to gather additional data on the interviewees' views, knowledge, experiences and the conditions at the time. These group interviews provided depth and complexity that is not accessible through other methods.

Participant observation allowed lengthy and focused first hand observation to confirm crop's physical characteristics and that the banana varieties grown were indeed those that were selected as the most preferred. Participant observation enabled better understanding of *emic* notions (i.e. informants) shaping actual selection rather than relying on *etics* and what was reported in various evaluation and selection reports (Silverman 2010).

1.9.2 Stage 2: Micro-propagation of banana varieties with TC techniques

The case study was conducted between 2011 and 2012 at KARI Thika TC laboratory and greenhouses, located in Muranga County, and examined how the selected varieties were engineered in the laboratory using TC techniques. Documenting the daily work activities revealed adherence to rules, distributed cognition and coordination of distributed tasks. During this period of fieldwork, I stayed in KARI Thika TC banana laboratory, which provided me with complete access to observing the daily activities of technicians and scientists in their everyday laboratory environment.

Moreover, detailed observations were made on embodied performative behaviour (Ingold 1993), i.e. how laboratory employees with specialised tasks interacted with tools, machines, banana suckers, plant nutrients, chemicals, plantlets and protocols during the performance of the various tasks such as sucker uprooting, media preparation, culture initiation, sub-culturing, and transplanting in the green house. I participated in a variety of activities, such as media preparation, in order to experience the social and scientific contexts wherein the laboratory employees operated (Silverman 2010).

Observations were made on regulated conditions in the greenhouse and laboratory growth room such as temperature and relative humidity through reading of thermometers and hydrometers respectively. Additionally, the teams' conversations and body language, while not explicitly 'scientific', were also observed as an important indicator for the laboratory's socio-technical encounters. Attending and participating in these *in situ* routine, daily socio-technical activities helped me understand how the context shaped the decisions taken in the 'engine room of biotechnology' (cf. Yin 2008).

Participant observation was used to analyse how feedback from farmers on selected varieties was received and responded to by the specialists in the laboratory. Also, I attended forums such as technicians' monthly meetings and KARI Thika staff meetings where feedback from farmers was discussed by specialists and later incorporated in the engineering process. During this time, everyone knew that I was a researcher and spent a great deal of time listening, interviewing, participating, observing, engaging in dialogue, and taking notes on the nitty-gritty of the process. I participated in informal daily conversations, joined the daily work in the laboratory, greenhouses, offices and farmers' fields, and attended staff meetings.

Key informant interviews were carried out with 10 members of the scientific team, 7 of the support team and 10 farmers. The interviews were guided conversations rather than structured questions (Yin 2008) and were based mostly on issues that needed further clarification. I purposively selected the informants because they were either part of the TC banana team or were well informed. In addition, I consulted secondary data sources, including books, journals, project technical reports, protocols, manuals and other archival documents.

1.9.3 Stage 3: Collective banana plantlets nursery management, commercialisation, and dissemination

This research was conducted at Witikio self-help group (SHG) between 2011 and 2012. The group was selected as an example of collective action at the stage of commercialisation and dissemination. The group was well-connected to the networks linked to R&D and TC laboratories at national level. I documented how the group organised and sustained its collective responsibility of managing the nursery and what rules and governance mechanisms emerged in this social-technical practice. In addition, the case study traced the processes on how the performance of collective tasks by the group related to its horizontal embedding in local communities and its vertical network connections to public and private actors.

The study integrated three different qualitative techniques: (a) participant observations, (b) key informant interviews, and (c) group interviews. Participant observations were made on the evolution of group's collective task performance and governance, division and coordination of tasks and other economic activities. I also observed the specific elements of each tasks, for example, fetching clean soil from the forest, putting soil into polybags, making planting holes, transplanting, watering and dissemination of the tissue-cultured plantlets. Observations were also made on how the group related to its social environment via horizontal and vertical network relationships with actor configurations in the banana chain.

Key informant interviews were conducted with 18 professionals linked to the group: scientists, administrators, wholesale traders, input supplies, bank managers, donors, and farmer representatives from local, national, and international organisations. These informants participated in activities such as technical trainings or they provided resources such as funds and technology. The actions and events identified in the guided key informant interviews were triangulated with secondary sources (e.g., books, project reports, journals and archival documents).

Three focus group interviews were conducted with group members, ranging between 6 and 12 participants. The interviewees included (a) female members, (b) male members, and (c) executive committee members. In all these interviews, the group's chairman moderated the discussions while the researcher took notes. Group interviews were conducted to obtain more detailed information about certain events and verify data.

1.9.4 The counter case: collective multiplication and dissemination of improved potato varieties

This case study was conducted between January and August 2011 at KARI Tigoni and Lari location where the four sub-groups of the Lari SHG are based. The research combined key informant interviews and focus group interviews. This was complemented with secondary sources such as research reports on seed potato multiplication, newspapers articles, media reports on KARI Tigoni land deals and debates around it, archival documents and literature on land acquisition in Kenya.

Key informants interviews were conducted with 25 professionals, including scientists, lawyers, administrators and farmers. The scientists group included an agronomist, agricultural economist, seed manager, breeder, molecular biologist, food scientist and a seed inspector. Interviews were done with former managers, lawyers and decision-makers at different institutes: KARI, MoA, ISAAA, CIP, GTZ, KEPHIS and KENFAP. The interviews built on available information on land claims in the areas of seed multiplication and intended to obtain candid and in-depth data from a wide range of informants. The informants were selected because they participated in the multiplication of quality seed potato activities or were well informed about decision-making in KARI. At the level of production and farmer groups, the research had a specific interest in how the management of socio-technical risks was related to the combination of land distribution, crop rotation, seed replenishment and disease pressures. These risks clearly affected the performance both at KARI Tigoni and the four farmer sub-groups. The interviews were conducted while making observations at the seed multiplication farms, often while I participated in a variety of farming activities.

Five focus group interviews were conducted with teams of 6 to 12 participants. One group interview was conducted with a multidisciplinary team of specialists from KARI Tigoni. In this interview, the seed manager moderated the discussions while the researcher took notes. Four more group interviews were conducted with each farmer sub-group. The sub-groups' chairmen moderated the discussions while the researcher took notes. The theme of the interviews covered socio-technical aspects of seed multiplication, cooperation and gaining access to land by the group.

1.10 Data analysis

I started the analysis by mapping the sequence of events through cross-checking my written notes with the audio records. The written field notes were expanded and analysed soon after the interviews (Silverman 2006). The preliminary time paths were triangulated with secondary sources and integrated in the text. Data analysis was based on composing time series and chronological analysis of events as proposed by De Vaus (2001) and (Yin 2008) to track the 'story' in which occurrence of *Fusarium* wilt disease in bananas triggered the formation of partnerships. This has the advantage of offering a methodologically rigorous analysis of evidence on processes, sequences and conjunctures of events within a case, which opens a discussion on the plausible causal mechanisms contributing to the overall outcome of the chain of technical change (Bennett and Checkel 2012).

Through a retrogressive reconstruction of chronological history of events, Chapter 2 analyses how *Fusarium w*ilt occurred and how it triggered the formation of partnerships. In these partnerships, sequential activities contributed to the selection of Cavendish varieties resistant to *Fusarium* wilt. Data were collected retrospectively by use of interviews and analysed. Chapter 3 analyses the performance of a team of specialists and technicians in a specific laboratory. The chapter uses a limited number of instructive events to map the interactions between these specialists and buyers of the new banana varieties. Chapter 4 traces the events that resulted in the formation of Witikio SHG and analyses the viability and expansion of the group. Chapter 5 maps the events that contributed to the inadequate access to land for multiplication of disease free Irish seed potato at KARI Tigoni and Lari location. It starts with the arrival of British settlers before the Second World War and zooms in on the process underlying the distribution of land after Kenya gained its independence from Britain in 1963 and identifies how this affected partnerships between research and farmer groups in quality seed potato multiplication.

1.11 Study area

The study areas are situated in the Central Highlands (see Table 1.4 and Figure 1.4). Agriculture is the mainstay of the economy in the Central Highlands. Most farmers practice small-scale farming, growing perennial and annual crops. Tea, coffee, bananas and Irish potatoes are the main cash crops. Crops such as maize, beans, kale, carrots and spinach are mainly grown for home consumption, with the surplus being sold. Sheep and goats are also kept for both cash and home consumption. The area is inhabited by the *bantu* speaking Kikuyus and Merus, who are mainly Christians.

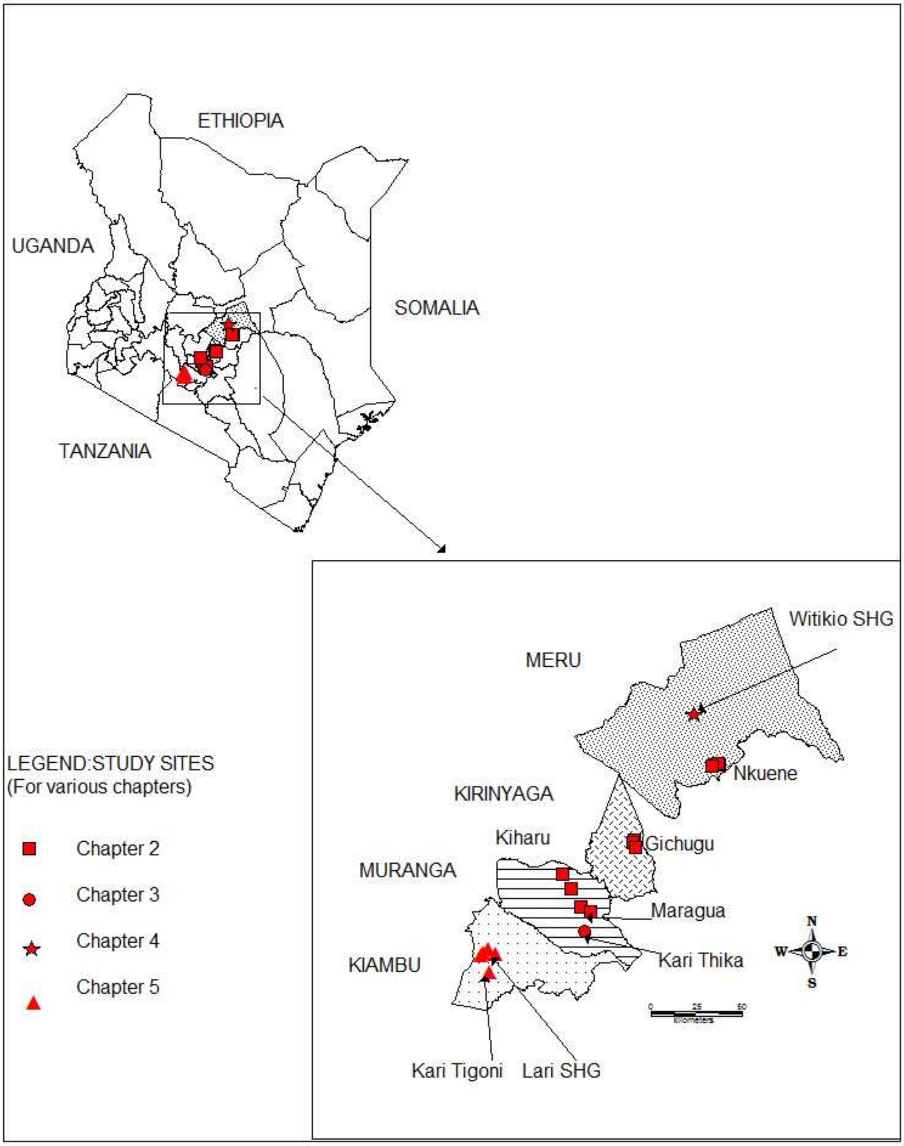
Altitudes are between 985 and 2,000 meters above sea level. Rainfall ranges from 1,000 to 1,600 mm per annum and is bimodal in distribution, with the long rains occurring in March to June and the short rains in October to December. Meru, however, has long rains from October to December and short rains between March and June. Soils at the Muranga and Meru sites are Eutric Nitosols with Nito-chronic Cambisols, Chromic Acrisols and Luvisols, while those in Kirinyaga sites are Humic Nitosols. The topography ranges from mountain foothill plateaus and high elevations to rolling structural landforms, while agro-ecological zones range from upper medium zone 2 (UMZ 2) to lower medium zone 3 (LMZ 3), with vegetation cover that includes rainforest savannah interspersed with trees (Jaetzold 2010).

The processes of selecting banana varieties were researched at eight different locations in the Central Highlands (Chapter 2). The case study of the laboratory was at one site (Chapter 3). Likewise, the case study of the group managing a banana nursery was located in one area (Chapter 4). The groups involved in multiplication of seed potato worked in four closely clustered villages (Chapter 5).

Table 1.4: Locations of the study sites

Chapter	2 Variety selection - banana	3 TC lab - banana	4 Nursery - banana	5 Multiplication sites – seed potato
Latitude	0^{o} 06´ 09˝S & 0^{o} 49´ 53˝S	1^{o} 09´ 9˝S	00º 08´ 44˝ N	1^{o} 9´ 5˝S & 1o 13´ 33˝S
Longitude	37^{o} 54´ 21˝E & 37^{o} 45´ 51˝E	37^{o} 04´ 38˝E	37 º 40´ 31˝ E	36^{o} 41´ 8˝E & 36^{o} 33´ 22˝E
Site name	Maragua, Kiharu, Gichugu, and Nkuene	KARI Thika laboratory	Witikio SHG	KARI Tigoni and four sub-groups of Lari SHG
County	Muranga, Kirinyaga, and Meru	Muranga	Meru	Kiambu

Figure 1.4: Map of Kenya showing the study sites



1.12 Thesis outline

This thesis consists of 6 chapters. The current chapter 1 introduces the research problem and design. It is followed by four empirical chapters (2 to 5), while the last chapter (6) presents the general discussions and conclusions. How collaboration and partnering processes generate technical change is the main theme that runs throughout the chapters.

Chapter 2 focuses on the initial stage of technical change and shows how a multidisciplinary team of scientists from various organisations and farmer organisations partnered and integrated their knowledge bases in the performance of three activities to select preferred Cavendish varieties that were resistant to *Fusarium* wilt. The selection process reveals the blending of micro-politics in the form of decision-making processes in research and the social and political embedding of the selected farmer representatives that hosted the on-farm trials. The convergence of knowledge within the partnership was an important condition for the selection of Cavendish varieties resistant to *Fusarium* wilt.

Chapter 3 focuses on the intermediate stage of technical change and examines how a task-oriented, small group of specialists and technicians coordinates their actions and connect their work to users of the micro-propagated banana varieties outside the boundaries of the laboratory. The findings indicate that feedback from farmers resulted in correction of errors and modification of the technological product, which contributed to effective technology engineering. However, the use of fixed protocols made it difficult to shape a new portfolio of demanded varieties that were not in tandem with the set procedures.

Chapter 4 looks at the downstream portion of the chain of technical change: the multiplication, dissemination and commercialisation of the new banana varieties. It researches the performance of a farmer group, which succeeded to sustain a viable form of collective action for acquiring quality plantlets from the laboratory, managing them in their nursery and disseminating them. The findings relate the governance structure and modalities of managing conflicts to the performance and contents of specific tasks necessary to jointly manage a nursery and sell the plantlets. The emerging small task group stayed intact and forged horizontal network relationships with friends, neighbours, relatives, and churches through which the group disseminated the TC banana plantlets. In addition, the group sustained vertical network relationships to stay connected to national and international organisations that provided various resources such as funds, technology, technical know-how and market opportunities.

Chapter 5 shifts the attention to the importance of materiality. The case study of farmer groups multiplying and bulking seed potato reveals the difficulties to deliver reliable and consistent volumes of seed potato. The farmer groups performed in a context of land scarcity, which resulted in lack of rotation and disease infestations which damaged the seeds. Both case studies emphasise the embedding in social and material circumstances as an important precondition for technical change.

Chapter 6 synthesises the findings and argues that the combination of partnering process at different stages in the chain of technical change has the potential to solve the constraints of crop diseases in Kenya. It is insufficient to rely only on formal PPPs, which are functional for sharing resources at the initial stage of technical change. The invention or acquisition of novel techniques may trigger a process of technical change, but the capacity of the subsequent partnerships, teams and groups to handle errors, feedback and constraints in specific social and material conditions will ultimately make the difference. Hence, it is the combination of the use of skills, tools, techniques and know-how in daily practices and the evolving organisational set-up that makes partnerships effective in addressing persistent crop disease problems in small-scale farming.

CHAPTER 2

Convergence of knowledge and politics in the selection of banana varieties

2 Convergence of knowledge and politics in the selection of banana varieties

2.1 Introduction

Top-down approaches to technology development that ushered in the green revolution have been criticised for producing technologies that were not adapted to the circumstances of small-scale farmers in many parts of sub-Saharan Africa (Chambers 1997, Richards *et al.* 2001, Pircher *et al.* 2012, Kiptot and Franzel 2014). Critics of this linear model of technical change argue that scientists failed to engage farmers in the technology development process (Chambers 1990, 1997, Scoones and Thompson 1994). As a strategy of overcoming this criticism, approaches such as participatory rural appraisal (PRA) and participatory variety selection (PVS) were introduced. These participatory approaches sought to integrate farmer knowledge with scientific knowledge, thus contributing to improved adoption of the results generated in crop R&D processes (Cornwall and Jewkes 1995, Ashby 2009, Almekinders 2011, Pircher *et al.* 2012).

PRA and PVS approaches give both scientists and farmers the role of researcher, as they share, analyse and debate their knowledge (Merrill-Sands and Collion 1994, Lacy 1996, Chambers 1997, Almekinders 2011). Farmers' co-researcher roles include diagnosing problems, setting overall goals, taking charge of on-farm trials, and determining specific priorities in the R&D process (Biggs 1989, Reijntjes *et al*. 1992, Ashby 2009). PVS is a qualitative evaluation of trial treatments that designs explicit criteria for selecting one variety over another (Reijntjes *et al.* 1992, Bertuso *et al.* 2005, Francis 2013). Many of the studies that use a PVS approach examine the farmers' preferred choice and the reasons behind the selection (Zannou *et al.* 2004, Almekinders 2011, Asfaw *et al.* 2013). This thesis aims to go deeper into the detailed and precise nature of the socio-technical interactions within the selection process.

The objective of this case study is to examine how a multidisciplinary team of scientists and farmers came to opt for the Cavendish banana varieties, by documenting interactions between researchers and a select group of farmers in three sequential processes related to a PRA, a market survey and PVS. In examining the combination of these processes, the study acknowledges that participatory approaches are important strategies for facilitating the process through sharing of resources and combining multiple knowledge bases (Chambers 1997, Cornwall and Jewkes 1995, Biggs 1989). However, the case study went beyond these two aspects and looked at the micro-politics of power relations, decision-making processes and conflicts of interest that hindered the process to some extent.

2.2 Theoretical context: participation and agricultural development

Participatory variety selection has been practiced for a long time by both private and public scientists as part of their evaluation and validation trials (Almekinders and Elings 2001). Debates on PVS maintain that it is useful in quickly explaining the farmers' preference criteria (Reijntjes *et al*. 1992, Morris and Bellon 2004). Participatory selection is also useful for understanding which varieties are suitable for which agro-ecological zones (AEZ), taking into account varying climatic conditions and the varieties' susceptibility to diseases and pests (Barker 1979). Moreover, PVS is known to reduce the time gap between variety testing and their adoption as well as to improve the selection of varieties in order to meet farmer and consumer market demands (Ashby 1996, Witcombe 1999). Participatory variety selection approach can also lead to the replacement of traditional varieties if only the new improved varieties are taken up and grown by farmers (Vroom 2009).

In addition, farmers' knowledge adds an important element to scientific research (Richards *et al*. 2009, Gyawali *et al*. 2002, Kornegay *et al.* 1996, Bertuso *et al.* 2005). One of the main benefits of PVS is that it provides a means of assessing subjective traits. In food crops these traits include culinary attributes such as taste, flavour, colour, appearance, texture, ease of cooking, and other characteristics that determine its suitability for human consumption. These traits are difficult to measure quantitatively because they are a function of human perceptions (Morris and Bellon 2004). The approach is also known to empower rural communities (Almekinders 2001). PVS allows rural farmers to maintain germplasm that enables them to participate in the development of new varieties that suit their needs (Almekinders 2001, 2011). PVS can empower groups that traditionally have been left out of the development process (McGuire, Manicad, and Sperling 1999).

On the other hand, PVS has its disadvantages. Unlike traditional approaches to crop improvement, where scientists do most of the work, farmers participating in PVS must invest extensive resources such as time, knowledge, land, labour and other provisions. The resources farmers invest increase in proportion to their degree of participation (Morris and Bellon 2004). This requirement could pose a problem for poor farmers, who have few resources to contribute and therefore may be unwilling or unable to participate.

The purpose of this case study is to investigate the actual process of selection (rather than narrowly focusing on farmer preferences), with the convergence of knowledge bases and the micro-politics of selection as the central two points.

2.3 Results: the interaction between scientists and farmers in the selection process

The process of variety selection was triggered by the event presented in the introduction, the infection and mass-expiration of local banana trees due to *Fusarium* wilt disease (Section 1.2.1). In response, KARI partnered with the International Service for Acquisition of Agri-biotech Applications (ISAAA) and established a multidisciplinary team of scientists, which shaped the process of variety selection through three sequential activities: a PRA, a market survey, and a PVS. These three activities were performed through integration of various knowledge bases and involved political process enabling decision-making and closure, which will be presented in the result section below.

Banana varieties have different attributes such as yields, taste, colour as well as disease and pest resistance (Kikulwe 2010, Dowiya *et al.* 2009, Ayinde e*t al.* 2008, Barekye *et al*. 2013, Akankwasa *et al.* 2013). For instance, the East African highlands are the home to more than 80 cultivated varieties of locally evolved bananas (suitable for cooking, brewing and desert use), with Uganda as the leading producer and consumer (Gold *et al*. 2002a, Kikulwe 2010, Ssali e*t al.* 2008). Scientists recognised the value of recording farmer selection criteria for bananas as a way of meeting farmer and consumer demands and preferences (Gold *et al.* 2002b, Ssebuliba *et al.* 2005), and within this framework initiated a PVS process.

2.3.1 Convergence of knowledge

Participatory Rural Appraisal

The PRA was conducted in a partnership of a multidisciplinary team of scientists from various organisations and farmers, located in the Gakoigo, Gathiga, Kigaa, and Gatituri sites (Annex 1). The objectives were (a) to diagnose and identify main banana diseases, pests, and other production constraints; and (b) to identify and rank the most preferred traditional banana varieties in the region and document their traits (Nguthi 2002). It was coordinated by the agronomist in the team and involved two phases that included planning and implementation. During planning, consultative meetings were organised in the study sites, attended by a multidisciplinary team of scientists, farmers and representatives of relevant government ministries at different administrative levels. In these meetings, participants discussed the objectives of the PRA and the modalities of conducting the exercise.

This phase was followed by the implementation phase, during which consultative meetings were organised for members that participated in the planning meetings. In this meeting, participants were divided into three groups and assigned different banana issues to diagnose.

Group one was facilitated by the agricultural economist while the sociologist acted as the secretary and took notes. The group's tasks were to identify various banana varieties, document their attributes and rank them in order of preference. All varieties in the region were listed and subsequently ranked in order of priority using a pairwise matrix. The criteria for ranking included the following attributes: yields, size, price, taste, flavour and susceptibility to *Fusarium* wilt. After tallying the points in the matrix, Gros Michel emerged as the most susceptible variety to *Fusarium* wilt and the most preferred across sites as shown in (Table 2.1). Other popular varieties were *Muraru* (AA genome) and *Kiganda* (EA-AAA genome).

Table 2:1: Ranking of traditional varieties according to PRA site

	Site			
Banana variety	Gakoigo (Maragua)	Gathiga (Kirinyaga)	Kigaa (Runyeenjes Embu)	Gatituri (Central Embu)
Kampala – Gros Michel (AAA genome)	1	1	1	1
Muraru (AA genome)	2	3	2	2
Kiganda – Uganda green (EA-AAA genome)	3	2	4	3
Gatumia – Dwarf Cavendish (AAA genome)	7	4	5	5
Wangae – Apple banana (AB genome)	4	5	7	6
Mugithi (EA-AAA genome)	5	6	3	7
Mutahato (EA-AAA genome	6	-	6	4
Uganda red (EA-AAA genome)	8	7	8	-
Golden beauty (AAA genome)	-	6	-	-

Source: Nguthi *et al.* 2002

Group two was facilitated by the agronomists with the post-harvest scientist taking notes. The group's tasks were to identify banana agronomic practices. The results of the consultative discussions indicated that all farmers used suckers from their gardens, neighbours or friends as planting materials and that this fuelled the spread of *Fusarium* wilt. Also, most farmers planted bananas unsystematically with no specific spacing and made little use of manure.

Additionally, some farmers did not practice regular pruning. These poor agronomic practices contributed to low yields.

Group three was facilitated by the entomologist while the pathologist took notes. The group generated data on the magnitude and pressure of diseases and pests. It emerged that *Fusarium* wilt was the most economically important disease followed by Black sigatoka, Yellow sigatoka, and cigar end rot respectively. Pests included weevils, nematodes and caterpillars. Although farmers used indigenous techniques such as application of wood ash and neem to control pests and weevils (see Annex 3), there were no such techniques for controlling *Fusarium* wilt.

Market survey

The market survey was conducted by a multidisciplinary team of agricultural economists, agronomists, post-harvest scientists and sociologists. The objectives of the survey were (a) to understand banana consumer tastes and preferences; (b) to identify the most popular varieties in the region and their attributes; and (c) to identify banana marketing constraints (Munene *et al.* 1999, Ndubi *et al.* 2000). To accomplish these objectives, the team administered a structured questionnaire to 100 respondents comprising of sellers, buyers and consumers in various markets (roadside open-air markets, supermarkets, municipal council retail markets and wholesale markets) in Muranga, Kirinyaga, Embu and Meru counties. The data were analysed by the scientists who participated in the activity. The agricultural economists analysed data on the most preferred varieties in order of priority with reference to price and consumer tastes and preferences. The post-harvest scientists examined shelf life, ripening qualities, texture, colour and ease of storage.

The results showed that Gros Michel, strongly susceptible to *Fusarium* wilt, was the most marketable variety, and preferred by 52% of traders and consumers (Munene *et al.* 1999). The finding was in agreement with the PRA results (Nguthi *et al. 2002*). Gros Michel’s strong marketability was due to numerous positive attributes such as taste, flavour, size, texture, long shelf life and colour. *Muraru* and *Kiganda* followed as the most positively rated varieties.

Having identified Gros Michel as the preferred variety and *Fusarium* wilt as the main constraint, the multidisciplinary team’s third task was to search for substitutes that have similar desirable traits and are resistant to the disease. The aim was to provide varieties that were acceptable to clients while at the same time fitting well with farmers’ socio-economic and agro-ecological environments. Literature review indicated that Cavendish varieties grown in the Caribbean and South Africa were resistant to *Fusarium* wilt (Wambugu and Kiome

2001, Kidane and Laing 2008). Consultatively, the team agreed to import tissue-cultured Cavendish varieties and use of TC techniques from South Africa. These varieties were planted in on-station trials and participatory on-farm trials.

Participatory on-farm trials

For the participatory on-farm trials the host farmers provided land and performed all activities such as weeding and irrigation of the plants. These farmers were selected in a participatory manner by other local farmers and actors such as the MoA extension staff, and researchers during the PRA activity. The selection was based on three criteria: (a) adequate land to host the trial; (b) ample labour for all crop operations; and (c) a cooperative attitude that would allow other farmers to visit the trial in the process of variety selection. The selected farmers came from Kiharu and Maragua divisions in Muranga County, and Gichugu and Nkuene divisions in Kirinyaga and Meru counties respectively (see Annex 1). The counties and divisions selected were among the major banana growing areas affected by *Fusarium* wilt.

After the selection of the on-farm trial host farmers, the multidisciplinary team's next task was to import Cavendish varieties. Consequently, the first batch of tissue-cultured Cavendish plantlets arrived from South Africa in March 1996, and was planted in the already selected on-farm trial sites. The objectives of on-farm trials were (a) to evaluate various Cavendish varieties under farmer-researcher managed conditions, in order as to select the most preferred varieties for further multiplication; (b) to demonstrate agronomic practices of tissue-cultured Cavendish varieties, and (c) to demonstrate varieties resistant to *Fusarium* wilt. Each on-farm trial plot was planted with at least three of the tissue-cultured Cavendish varieties.

The multidisciplinary team and host farmers played complementary roles in these trials in relation to trial design, crop husbandry and provision of inputs, which catalysed the process. For example, host farmers provided land, manure, and labour for all activities, including land preparation, making planting holes, watering, mulching, weeding, pruning, desuckering, debudding and security of the plot. The project provided fertilizers, tissue-cultured plantlets, transport, offices, computers and storage facilities, while the agronomist designed the trials.

Accordingly all trials used a randomised complete block design (RCBD), which was replicated four times. Host farmers, the multidisciplinary team of researchers and extension officers jointly planted the crop. Each plant was planted in holes 60 cm by 60 cm by 60 cm, and spaced at 3 m by 1.5 m between and within rows respectively. Each plant received 5 kg of farmyard manure, 200 g of Diammonium phosphate (DAP), 60 g of Furadan for control of nematodes and other soil borne insect pests. Top dressing was done with Calcium Ammonium

Nitrate (CAN) at a rate of 200 g/plant per year. The varieties included Giant Cavendish, Dwarf Cavendish, Chinese Cavendish, William hybrid, Grand naine, Valery, Gold finger and Paz. These varieties were chosen because they represented a broad range of attributes (e.g., tolerant to pests and diseases, high yielding, early maturing, good taste, and flavour) and satisfied the criteria identified by the farmers during the PRA.

The on-farm trials were monitored and evaluated by the multidisciplinary team of scientists and the selected group of farmers during the growth of the crop, using the following jointly developed criteria: planting date, growth rate, time of flowering, diseases and pests tolerance, frequency of watering, yields, taste, diameter of the stem (girth), number of off-types, bunch weight, number of fingers per hand, number of hands, date of harvesting, and resistance to pests and diseases. The scientists visited the on-farm plots regularly and recorded the crop's progress. Host farmers and other members of their common interest group (CIG) also visited the plots to make independent observations and record data. Researchers always cross-checked their records with the host farmers.

These regular monitoring and evaluation visits provided windows of opportunities where the scientists interacted and integrated their technical knowledge with the farmers' knowledge. For instance, farmers acquired knowledge from the agronomist on agronomic aspects like hole size, spacing, weeding, watering, desuckering, sucker selection, pruning, and mulching. However, the application of inorganic fertilizers remained precarious because the farmers' knowledge was irreconcilable with the agronomist's technical knowledge. For example in the Mukangu SHG, farmers opposed the notion of inorganic fertilizer application on the grounds that it made their bananas 'soaky' and thus unfit for consumption. This was in contrast with the agronomist's argument that inorganic fertilizers increased yields. Besides, even though all farmers agreed with the agronomist that irrigation resulted in high yields, especially for giant Cavendish, in practice some of them did not irrigate as required because of inadequate labour, resulting in lower than expected yields.

The agricultural economist shared technical knowledge with farmers on business skills such as record keeping and collective marketing. Yet our discussion with farmers revealed that even though all farmers appreciated the notion of collective marketing, some, especially those who did not have off-farm income, sold their bananas to traders at farm gate prices to get money for daily needs.

The post-harvest scientist integrated technical knowledge with the farmers' knowledge on issues such as de-handing, disinfection, ripening, packaging and transportation with the aim of improving banana shelf life so as to attract better prices and reduce post-harvest losses. The food scientist exchanged technical knowledge with farmers on banana utilisation, while the entomologist and pathologist exchanged knowledge on major diseases and pests, symptoms and control techniques (see Annex 3).

Participatory Variety Selection

When the crop was ready for harvest, a day was set for PVS using criteria that were consultatively developed by farmers and scientists. Prior to this day, announcements were made in market places, local schools and churches so as to attract as many participants as possible. On the agreed day, the programme began with the national banana coordinator explaining to the participants the process that was followed in the course of the on-farm trial. After the explanation, participants were divided into groups comprising farmers and scientists. Each group selected a chairman and a secretary from its members. Facilitated by the chairman, participants of each group observed the various varieties and scored them based on the collectively chosen attributes criteria such as yields, price, tolerance to *Fusarium* wilt and other diseases, pests, labour requirements, tolerance to falling, texture, shelf life, and colour (see Annex 2).

Also culinary attributes such as taste, flavour and ease of cooking were evaluated by an untrained panel consisting of farmers and scientists who cooked and tasted various banana dishes. The dishes included *mukimo*,[3] boiled bananas, crisps and cakes. Participants discussed, shared experiences, integrated knowledge and made agreements by consensus before approving what mark to score on each attribute per variety. Disagreements on what mark to score on each attribute per variety sometimes aroused. This was because there were no clear cut differences among the varieties in relation to taste, flavour, texture and colour. Such disagreements aroused because what was the best ‘bet’ for farmer A was not necessarily the best for farmer B. These tensions were resolved through voting by show of hands.

When the groups finished the evaluation and selection, they gathered in a central place where all group rankings were aggregated (on a five point Likert scale: 5 = very good, 4 = good, 3 = fair, 2 = poor and 1 = very poor). The results of aggregated points revealed that Grand naine was consistently the highest yielding cultivar in terms of bunch weight and size. This attribute made it the most preferred variety in all sites except in two sites in Kirinyaga. Moreover, Grand naine was resistant to *Fusarium* wilt and a favourite of many farmers due to

[3] A dish made of mashed bananas, potatoes, maize, beans and pumpkin leaves.

its inherent traits such as its moderate height that prevented it from falling during stormy weathers. Grand naine also required little water hence less labour for bucket irrigation. Additionally Grand naine had long slender fingers, sweet taste, hard texture, and a long shelf life, allowing it to fetch premium prices at the market. All these attributes combined to make Grand naine the most preferred variety by the majority of farmers and consumers (see Annex 2).

The majority of farmers observed that Giant Cavendish had good attributes similar to those of Grand naine (e.g., resistant to *Fusarium* wilt, high yielding with long slender fingers, good taste, and long shelf life). It also had a height that did not require poles for its support. However, the cultivar's yields were lower than those of Grand naine in most sites except in Kirinyaga. Additionally, all farmers argued that Giant Cavendish was labour intensive since it required a lot of water, and most of the farmers could not meet its water requirement through bucket irrigation. The inadequate intake of water resulted in yields that were lower than its expected potential. At the Kirinyaga sites, which enjoyed generous rainfall (1,400 to 1,600 mm per annum), Giant Cavendish out yielded Grand naine and ranked first. This implied that Giant Cavendish performed well in high rainfall areas, and yield performance results was site specific. It was uncertain whether similar results could be realised in areas with other agro-ecological conditions.

Farmers argued that William hybrid closely resembled Giant Cavendish and Grand naine in resistance to *Fusarium* wilt, finger size, taste and shelf life. However, the variety had lower yields than either Grand naine or Giant Cavendish as indicated in (Annex 2) due to its genetic makeup that was characterised by widely spaced hands.

Generally, Chinese Cavendish was not preferred by farmers, even though it was resistant to *Fusarium* wilt. According to farmers, the cultivar was low yielding, had small sized bunches and short fingers that did not attract consumers (Annex 2). Moreover, the variety had a high abortion rate and many mutants, earning it a second-to-last rank among the tested Cavendish varieties.

Dwarf Cavendish was ranked the poorest among the Cavendish varieties because, while resistant to *Fusarium* wilt, it had the smallest fingers and lowest yields which made it unattractive to consumers. Besides, the variety was susceptible to *cigar end rot*. This made it unattractive for most farmers, leading to low adoption.

Farmers in sites where Valery was planted argued that it was marketable because it had a big bunch weight, big hands, long slender fingers, good texture and long shelf life with favourable yellow rink. Besides, the variety was resistant to *Fusarium* wilt. However, the variety was significantly taller than others. This height made it susceptible to falling, and if not supported could be severely damaged by winds causing substantial yield losses. Fetching poles for the cultivar's support was labour intensive. These attributes discouraged farmers from adopting the variety.

Farmers observed that Paz too had good attributes similar to Grand naine, Giant Cavendish, and William hybrid in that it had good taste and resistant to pests and diseases. In addition it was a multi-purpose variety as it is good for desserts and cooking. However, its lower yields than Grand naine, Giant Cavendish and William hybrid made it less attractive.

2.3.2 The politics of selection

As observed in Section 2.3.1., the integration of a scientific knowledge base with farmers' knowledge facilitated the process of selecting preferred Cavendish varieties through three sequential activities. The activities were performed by two partners: (a) an interdisciplinary team of scientists from various organisations; and (b) a select group of farmers who hosted the on-farm trials. These partners affected the selection process through pooling of resources, such as funds, knowledge, germplasm, intellectual property rights, land, labour and other inputs. However, the set-up also affected the selection process through political mechanisms – in both the research organisations and the local farmer communities. These dynamics are examined below to explore how they catalysed or potentially undermined the selection process.

Partnering, politics and teamwork in research

The partnership context was initiated by KARI scientists upon the realisation that they could not solve the constraint of *Fusarium* wilt on their own. A key mobilising strategy was the identification and involvement of relevant actors from the banana value chain in the project. The partnership strategy received a boost when ISAAA joined the project and brokered the import of Cavendish germplasm from South Africa. Additionally, ISAAA linked the project to more relevant partners at local and international levels who offered vital resources. In this partnership, KARI hosted the project and used its human resource capacity to conduct on-station cultivar evaluations and agronomic studies for imported varieties. Moreover, KARI and Jomo Kenyatta University of Agriculture and Technology (JKUAT) developed TC protocols while the Ministry of Agriculture (MoA) offered extension services. DuRoi laboratories, a private South African company with long experience in banana TC techniques, supplied the initial TC planting materials.

Once these materials arrived in Kenya, they were received and hardened at Genetic Technologies limited (GTL), a local private company with expertise in TC techniques, before they were dispatched to on-station and on-farm trials. Donors such as the Rockefeller Foundation (RF), World Bank, and International Development Research Centre (IDRC) offered funds to facilitate the activities. The Centre for Development Research (Zentrum für Entwicklungsforschung – ZEF), University of Bonn, Germany carried out an ex-ante impact assessment study. The Institute of Tropical and Sub-tropical Crops (ITSC), a public institution in South Africa with long experience with TC banana technology, offered technical backstopping. John Innes centre in the United Kingdom (UK) conducted virus diagnostics. Beam Business Options Ltd, a private company with expertise in design and management of rural financial services, provided microcredit to groups of farmers on a revolving fund basis. Kenya Agricultural Commodity Exchange (KACE) acted as a banana market outlet, and a selected group of host farmers offered land and labour for on-farm trials. The various partners brought complementary and necessary resources in the partnership, which facilitated the introduction of new banana varieties.

Several private companies and NGOs that participated in the partnership were set up by scientists who were part of the multidisciplinary team. Interviews showed that a director of one of the key public institutions owned shares in one of the private companies. He was also supported by several NGOs and maintained good relations with donors. Using his position, he influenced the collective decisions of the multidisciplinary team, potentially in the interest of personal gain. For instance, when the project received funds from the World Bank for the development of a public laboratory, he did not support the idea because he reckoned that the private company where he owned shares would lose market share resulting in reduced profits. Consequently, he rejected the idea and those who opposed him were sanctioned through transfers, as explained by one of the affected scientists:

> This director's argument was not very much in favour of developing the public TC laboratory. Rather, he argued in favour of using a private laboratory. When I opposed him, he got annoyed and influenced my transfer. (Interview, February 2012)

A lecturer from one of the universities had this to say:

> As a representative of my organisation, I understood the politics. This director was for sure corrupt yet very strong and influential. He influenced decisions to be made in favour of the private company where he owned shares at the

> expense of the public organisation where he worked. His selfish motives frustrated me – because things were not done according to what we had planned. When I could not withstand the frustration any longer I became inactive and gradually withdrew from the project. (Interview, June, 2010)

As observed, politics related to tensions, divergent views, conflicts of interests, and competition between public and private organisations hindered the participatory processes to some extent. Some partners and members of the multidisciplinary team of scientists stopped participating in the project due to frustrations and conflicts with senior scientists with other interests.

Politics and embedding in farming communities

Another context that catalysed the process of variety selection was that of a select group of on-farm trial host farmers. These eleven farmers were intentionally selected during the PRA activity as those who have sufficient resources and were socially and politically well connected (see Table 2.2). For instance, they were affiliated to local churches and local political parties, implying that they were active in local decision-making processes. They also obtained leadership qualities as managers of many development projects in the community. They were considered lead farmers and the majority had previously hosted other on-farm trials. Therefore, they had the skills and experiences to engage freely and confidently with scientists in discussions. Also, they were knowledgeable, literate, socially well integrated and open to new ideas. They were also cooperative and friendly, and allowed their plots to be visited by other farmers and scientists for evaluating the planted varieties. Moreover, they had both sufficient land to host on-farm trials and labour to do the weeding and irrigation. The select group of farmers was, therefore, in the position to co-create the selection process.

Table 2.2: Characteristics of host farmers within the community

Farmer	**Religion**	**Political position within the community**	**Involvement with other common interest groups (CIG)**	**Professional affiliation**	**Farming history**
1	ACK	A chief campaigner and sister in-law of one of the country's most powerful politicians and a onetime presidential candidate.	She was the chairlady of the church mothers' union and Mukangu SHG. Besides, she was involved in charitable activities such as donating food and cash to orphanages.	Farmer and business lady.	She started farming in 1971 and gradually became one of the most reputable farmers in the area. She had hosted many on-farm trials.
2	ACK	He was a former councillor who was elected twice from 1997 to 2007 to represent Ichagaki ward.	He held leadership positions in more than five groups: chairman of new Nginda dairy cooperative society; chairman of men church fellowship; chairman of Maragua horticulture SHG and Secretary of Muranga County Banana Growers Association.	Politician, farmer, development worker, teacher, and opinion leader.	He started farming in 1996 when he left his teaching job to join politics. He had hosted many on-farm trials.
3	Catholic	Highly regarded in the community	She was the treasurer of Maragua horticulture SHG, member of Kianjiruini and Uguithania SHGs as well as a member of Maragua banana growers association.	Farmer and business lady.	A keen farmer who started farming in 1971. She had hosted many on-farm trials.
4	Catholic	Highly regarded in the community	Member of Wanjo community SHG and Maragua horticultural sales and marketing association.	Farmer and businessman.	He started agribusiness and farming in 1986. He had hosted many on-farm trials.
5	ACK	Socially and politically well integrated. Additionally he was a political activist and opinion leader.	Chairman of Maragua horticultural farmers SHG.	Farmer, politician and retired civil servant.	He started farming after his retirement in 1996. Since then, he had hosted many on-farm trials.
6	ACK	Socially well integrated in the community as a leader and development worker.	Secretary of Muireri Kiai SHG and Mumako irrigation water project.	Farmer and development worker.	He started farming in 1980. He had hosted many on-farm trials.

Farmer	Religion	Political position within the community	Involvement with other common interest groups (CIG)	Professional affiliation	Farming history
7	ACK	Socially well integrated in the community as a leader and development worker.	She was the chairlady of many SHGs including: Goodwill, Urumwe, Wendani, Kiamungi, and the green belt movement. She was also chairlady of Ngiriambu primary school board of governors.	Farmer and development worker.	She started farming in 1981. She had hosted many on-farm trials.
8	EAPC	Socially well integrated in the community. A model farmer and local leader with the title of senior leader.	Chairman of the following SHGs: Mitunguu banana growers, Kauroni Kamwiga, Mitunguu dairy goats, and Mitunguu soya beans.	Farmer, development worker, and opinion leader.	He has a passion for farming. In 1967, he resigned from a civil service job to practice farming. He is an early adopter and ready to embrace new technologies. He had hosted many on-farm trials.
9	ACK	Socially well integrated in the community, a leader, and a development worker.	Secretary of Mitunguu banana growers SHG.	Farmer, public health officer, development worker, and trainer.	She started farming in 1995. She had hosted many on farm trials.
10	PCA.	Socially well integrated in the community.	Member of Mitunguu banana growers SHG and Mitunguu soya bean SHG.	Farmer and business lady.	She had a long history of good farming practices spanning over 50 years and had hosted many on-farm trials in her farm.
11	ACK	A former sub-chief who wields a lot of power in local politics.	A member of Mitunguu banana growers SHG and Mungumo SHG.	Farmer and businessman.	He started farming in 1971. He had hosted many on-farm trials.

Source: Interviews with farmers in collaboration with the scientific team

2.4 Discussion

Most studies of participatory approaches focus on the outcomes, for example, in terms of varieties selected and the match with farmer preferences. The case study in this chapter focuses on the selection process, during which other traits, such as high yielding, market prices or taste, were part of the participatory evaluation of planted varieties. The findings confirm studies by Ayinde *et al.* (2008), Gold *et al*. (2002a), and Dowiya *et al.* (2009), which demonstrated that farmers selected bananas, which had big fingers, sweet taste, and were marketable. Also, they preferred varieties that were not labour intensive for irrigation and propping against stormy winds, a finding also confirmed by Ssali *et al.* (2008). Furthermore, similar to findings from Shabd *et al.* (2008), dwarf Cavendish was ranked the lowest due to its low yields and susceptibility to *cigar end rot*. However, the selection process was strongly driven by the wish to introduce new varieties resistant to *Fusarium* wilt, which implied replacement of existing varieties that were, for example, highly appreciated in the local markets. These varieties played an important role in the daily diets and cultural culinary dishes in the local communities.

This case study shifted the attention from the farmer's rationale to three processes underlying selection. First, the convergence of the knowledge exchanged by scientists and farmers, which shaped the selection process, leading to a shift from traditional banana varieties like Gros Michel, to the selection and adoption of a few preferred Cavendish varieties namely Grand naine, Giant Cavendish, and William hybrid. Even though the main constraint was *Fusarium* wilt, it was not only the pathologist's knowledge that guided the selection criteria and process but a combination of many knowledge bases. This finding is in line with other PVS studies (Bertuso *et al.* 2005, Richards *et al.* 2009, Zannou *et al*. 2004, Misiko *et al.* 2008, Almekinders 2011).

Second, in addition to the convergence of knowledge, the selection process was shaped by the micro-politics of inclusion in rural communities as well as in research. A select group of farmers, who provided land and hosted the participatory on-farm trials, played an important role in the selection process. In addition to being resourceful, most of these farmers were affiliated to various churches as well as local politics, and thus had the capacity to be proactive in larger decision-making processes. They had the knowledge and skills to interact and negotiate with other actors in the banana chain. Their involvement may have generated some level of procedural justification that encouraged both researchers and farmers to accept the outcome of the selection process (Richards *et al*. 2009, Misiko 2008, Morris and Bellon

2004). The link between researchers and a select group of farmer established the conditions for taking a decision despite the uncertainties still associated with the new Cavendish varieties.

The third process is the observed competition among researchers and tensions between private and public partners. This was despite the partnership concept promising consultative decision-making processes where all partners had a level playing ground (Cadbury 1993, Byerlee and Fischer 2002, Hall and Yoganand 2004). The behaviour of influential and politically connected scientists caused tensions and annoyed some partners who subsequently withdrew from the project, thus depriving the project of the diversity of capacities and world views. For instance, one of the scientists who withdrew from the project was a biotechnologist whose task was to continuously fine-tune the protocols in order to cater for any new portfolio of varieties. His departure undermined the capacity of the partnership to select new varieties and as a consequence the technicians continued micro-propagating only the varieties that were initially selected and for which rigid protocols were in place. This, finding reflects the studies of Spielman and Grebmer (2004) and Hall (2006), which show how the partners' differing objectives and working styles shape the capacity of partnerships to respond to user demands. Powerful scientists, some with an interest in privatised TC laboratories, dominated collaborative meetings and influenced decision-making processes. These processes complicated building connections between the private and public organisation involved in micro-propagation and the public domain working with farmer groups for multiplication and dissemination. These findings echo other studies, such as Kilelu *et al.* (2013) and Kouévi (2013), which found several factors that hindered collaborative platforms in meeting their objectives, for example, tensions, divergent views, and domination of board meetings by few members.

This study challenges the assumption that all partners in collaborative ventures wield more or less equal power and are equally engaged in decision-making. This perspective fails to recognise the impact of micro-politics shaping technical practices and procedures. In partnerships in agricultural biotechnology in Kenya (and other developing countries), inequalities in power relations do exist. National public sector partners, seen as the guardians of national sustainability and food security goals, and also donors who fund the projects have particularly strong positions (Ayele *et al.* 2006, Smith 2004). McQuaid (2000: 23) argues that the biggest power generally rests with those who control the resources, in this case access to Cavendish varieties and TC techniques.

CHAPTER 3

The making of TC bananas in the laboratory: team work, distributed cognition and user feedback

3 The making of TC bananas in the laboratory: team work, distributed cognition and user feedback

3.1 Introduction

The previous chapter examined how in the case of introducing new banana varieties the participatory approaches have gained prominence and shaped researcher collaboration with farmers in the R&D process (Ashby 2009, Ashby and Sperling 1995, Almekinders 2011, Asfaw *et al.* 2012, Pircher *et al.* 2012). The focus in these processes is on selecting the right varieties to ensure that developed technologies are adapted to farmers' diverse production systems (Chambers 1994a, 1994b, 1997, Cornwall and Jewkes 1995). This is in addition to ensuring that technologies meet the needs of farmers (Merrill-Sands and Collion 1994, Lacy 1996, Richards 2000, 2010) and fit the diverse agro-climatic systems and realities (Almekinders and Elings 2001, Misiko *et al.* 2008, Almekinders 2011). These participatory approaches constructed the first stage of the chain of technical change central to this thesis. The previous chapter demonstrated how, in the first stage, the micro-politics of selection result in the choice of particular Cavendish banana varieties as foundation of the process of technical change.

While PVS has received a lot of attention (Reijntjes *et al.* 1992a, Zannou *et al.* 2004, Misiko *et al.* 2008, Asfaw *et al.* 2012), less is known about how, after the initial stage of technical change, the selected varieties are made in the laboratory and to what extent feedback from farmers can still be accommodated by the specialists in the R&D organisations. Ideally, participatory approaches are supposed to address all stages of the chain of technical change, from variety selection to micro-propagation in the laboratory and in farmers' fields. This chapter describes the production of banana plantlets in a specialised laboratory. It explores to what extent and in what way the skilful micro-propagation of planting materials through tissue culture (TC) technology by specialised technicians, the accompanying protocols, managerial procedures, rules, and organisational designs of a laboratory enabled or constrained an adequate response to farmers' needs. This chapter goes beyond the usual sphere of influence of participatory approaches and examines how after the phase of variety selection, feedback is received and handled in the R&D organisations, and how the desired varieties are produced in the laboratory.

The rest of the chapter first briefly introduces the theoretical context. Next, the result section presents the institutional context under which TC techniques and Cavendish banana varieties were selected and subsequently introduced in the laboratory. This is followed by a description of the organisational set-up and the technical practices in the laboratory, which maps how the laboratory is linked to other actors in the banana chain and how the technicians and workers coordinate their activities. The section shows how the selected varieties were produced in a context of distributed tasks and capacities, highlighting the importance of adhering to rules and protocols. The next section shows how feedback from farmers reached the laboratory specialists and the extent to which this feedback was incorporated in the laboratory. The chapter ends with a discussion about how the performance of skilful tasks in a setting of distributed cognitions shapes the interaction with technology users outside the boundaries of the laboratory.

3.2 Theoretical context: skills and distributed cognition

The research borrows from various studies in technology engineering on the actual use of tools, machines, skills and know-how in the process of making (Jansen and Vellema 2011, Sigaut 1994, Dant 2005). The study investigates the making of banana plantlets in the laboratory with a particular interest in performance, improvisation and repair in situated action (Barber 2007, Suchman 1987), uncovering how specialists and teams interact with tools, machines, and among themselves in the laboratory (Latour and Woolgar 1986). The use of protocols and manuals related to the profession shapes the daily activities of the technicians (Bowker and Leigh Star 2000, Gibbon and Ponte 2008), but cannot fully explain how specialist workers use skills and know-how to deal with the material and managerial realities of working in the laboratory (Jaarsma *et al.* 2011, Debele 2014).

In addition to the interest in skilful and situated performance, the making of clean planting materials is conceptualised as team work involving task-oriented actions by specialists and technicians. The daily realities and problem-solving practices in the laboratory are analysed from the perspective of distributed cognition (Hutchins 1995, 2006, Hutchins and Lintern 1995), which shifts attention to coordination processes for the different tasks. From this perspective, capacity to perform emerges in a team through the practice of continuous problem solving and the correction of errors (Jansen and Vellema 2011). This intervention is only lightly regulated by rules, although the laboratory introduced various manuals, protocols and communications to organise the performance of distinct tasks. However, as Hutchins (1995) shows in relation to the process of harbour and anchor navigation in the US Navy, the rule book is present and is referred to, but it is rarely visible in daily routines. This implies that for understanding the functioning of the laboratory rules do matter, but the formal guidelines and protocols are not the full story. Cognitive processes can be distributed among tools, machines and materiality (physically distributed) or among persons (socially distributed). In the use of TC techniques for banana plantlets, rules and artefacts are distributed across the laboratory as distributional codes reflecting practice as much as theory.

Situated performance of skilful tasks and distributed cognition are used to describe this second stage of the chain of technical change, an organisational setting wherein specialists respond to farmers' demands and feedback. Accordingly, the objective of this case study is to examine how feedback on selected varieties was received by specialists and responded to as well as to examine the skilful nature of micro-propagating quality planting materials using TC techniques. In this way, the study takes a fresh look at participatory approaches, because it documents the possibility to re-engineer, repair or modify the technological package of the selected varieties at a later stage. In so doing, the study adds knowledge to the study of participatory approaches by revealing the limitations of incorporating farmers' feedback into the engineering of banana plantlets at later stages of the process of technical change.

3.3 Results: case study of a tissue culture laboratory

3.3.1 Institutional context and business models of the TC laboratories

The laboratory started its activities when in the early 1990s Kenya banana production drastically declined due to infestation of diseases such as *Fusarium wilt* (Panama disease) *oxysporum* f. sp. *Cubense* (FOC) and pests such as weevils (*Cosmopolites sordidus*) in addition to nematodes (e.g. *Radopholus similis*) (Kung'u and Jeffries 2001, Qaim 1999, Wambugu and Kiome 2001). In this context, KARI and ISAAA formed a partnership for introducing Cavendish varieties resistant to *Fusarium* wilt and TC techniques to micro-propagates disease-free planting materials (Mbogoh *et al.* 2003, Kimani 2010).

Before the KARI–ISAAA partnership started only the public Jomo Kenyatta University of Science and Technology (JKUAT), located in Kiambu County, applied TC techniques for banana plantlets. In fact, JKUAT started tissue culturing bananas in 1991 when they developed the first protocol. Demand for clean planting materials provoked KARI Thika, a public organisation located in Muranga County, to start a TC banana laboratory in 1996. Kenyatta University (KU), another public university located in Kiambu County, followed soon and started applying TC techniques in a pilot project.

Intensified demands for tissue cultured banana plantlets prompted local private laboratories to get involved. For example, Genetic Technologies International Limited (GTIL), established in Nairobi in 1994 to work on sugarcane and pineapples, started applying TC techniques on bananas in 1996 (at the same time as KARI Thika). Another private laboratory, Mimea International Company Limited, was founded in Nairobi in 2005 with the objective of micro-propagating bananas through tissue culture. As the benefits of the tissue cultured materials became apparent and adoption of the technology increased, there were plenty of business opportunities for the TC banana laboratories.

To meet local demand, it became necessary to import TC banana planting materials from international private laboratories. These included DuRoi in South Africa and Rahan in Israel. Actually DuRoi laboratory provided the initial planting materials to KARI Thika and GTIL. Furthermore, DuRoi has continued to supply *in-vitro* stage three plantlets (i.e. rooted plants in culture vessels that are suitable for long distance transportation) to Aberdare Technologies limited (ATL), a privately owned company specialising in banana plantlets nursery management. ATL also imports TC plantlets from Rahan, a private company in Israel. Once the imported materials arrive they are quality checked by Kenya Plant Health Inspectorate Services (KEPHIS). Involvement of the private sector was encouraged in order to create a self-sustaining system.

Both private and public laboratories augmented their strengths and resources such as knowledge and infrastructural facilities to ensure that the plantlets produced are disseminated widely. This augmentation of resources was well exemplified in the early stages of the project when KARI and other partners identified DuRoi laboratory to provide the first batch of TC banana plantlets and GTIL to handle the materials once they arrived. Furthermore, the private laboratories relied on the public sector researchers to develop or introduce new varieties that they use as raw materials. The private laboratories also used protocols developed by the public laboratories. In addition private laboratories used the findings of market research conducted by public sector researchers to determine which varieties to give priority. Once the private laboratories were sure of the demanded varieties, they used their infrastructural capacity and long experience in TC techniques to micro-propagate large amounts of plantlets for farmers. All the laboratories worked closely with KEPHIS scientists to ensure quality through regular monitoring.

KARI, JKUAT and GTIL laboratories operated their own greenhouse nurseries near the laboratory facility from where they wean plantlets, harden them and subsequently sell ready-to-plant products. Apart from these nearby nurseries, the laboratories are linked to farmer groups and individual entrepreneurial nurseries located at strategic sites. These farmer groups and individual entrepreneurs bought TC plantlets from the laboratories and acted as (a) sales and distribution hubs, connecting the laboratories with farmers; (b) training centres for farmers and farmer groups; (c) channels for feedback and response exchanges; (d) strategies for reducing transportation cost of the ready-to-plant materials; and (e) opportunities for viable business enterprises. Other actors linked to the laboratory that act as distribution channels for the TC plantlets included farmer organisations (e.g. KENFAP), public institutions (e.g. MoA), church based organisations (e.g. Catholic diocese), NGOs (e.g. World vision), and community-based organisations (e.g. Wangu Investment). All these interconnected actors and activities transformed the making of TC bananas into a viable commercial enterprise (Figure 3.1).

From a business point of view the production of tissue-cultured materials is very lucrative for the private laboratories, with profit margins reaching up to 100% (AHBFI 2008). Public laboratories such as KARI Thika and JKUAT's were also involved in commercial production of tissue-cultured bananas, although they sell their plantlets at a slightly subsidised price in comparison to the private laboratories. The profits generated from the KARI Thika laboratory were later fed back into the laboratory to sustain the micro-propagation process by replenishing chemicals and stock solutions (such as micronutrients, macronutrients, vitamins, hormones, iron, anti-oxidants, sucrose, gelling agents). Additional funding to run the TC banana laboratory came from the government of Kenya and donors.

Although micro-propagation of tissue cultured materials was a viable business for the laboratories, the plantlets require more appropriate handling and management practices to optimise their benefits. Consequently, this additional effort and the cost of tissue-cultured plantlets generated an extra cost for the farmer. These extra cost and efforts deterred very poor farmers from using tissue cultured plantlets. These poor farmers therefore continued to source their planting materials from their own gardens or their neighbours. In this way the traditional method of using suckers as sources of planting materials competed with tissue cultured plantlets, with the latter estimated at only 7% coverage of total banana acreage (AHBFI 2008).

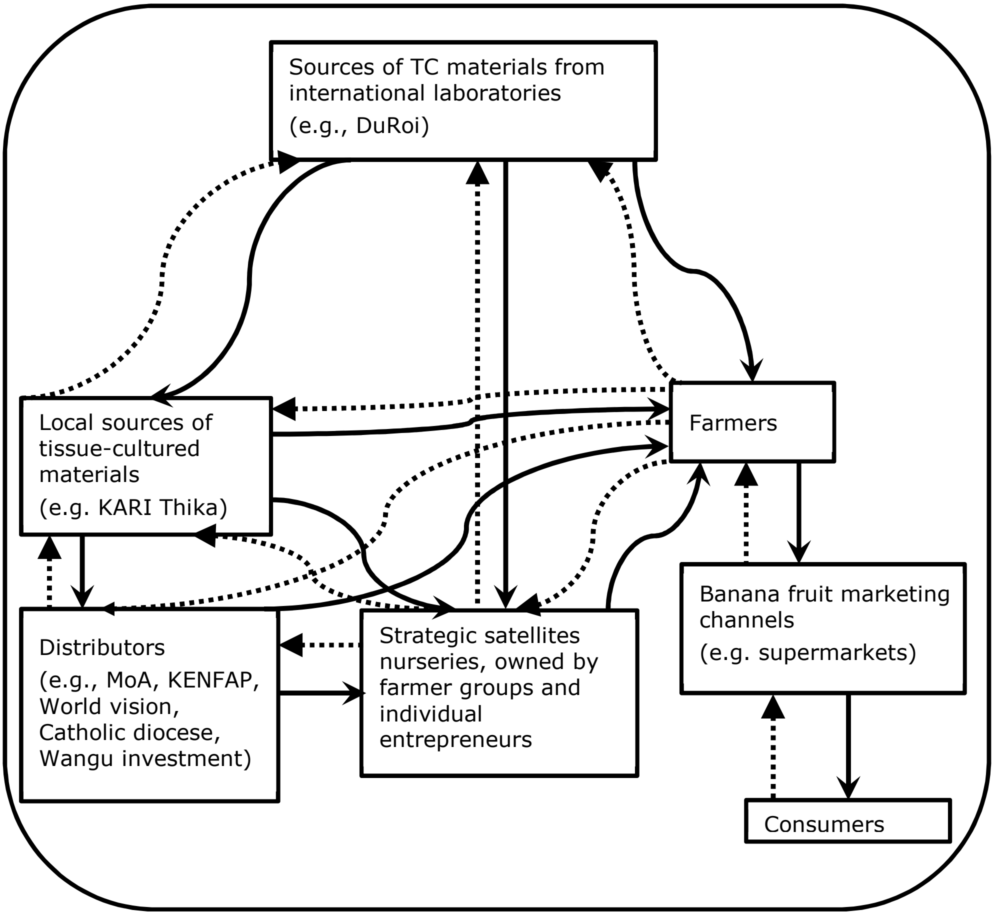


Figure 3.1: Economic business model of production and distribution of TC plantlets

Legend:

The continuous line denotes expenditure for the actor touched by the arrow end ⟶

The dotted line denotes revenue/sales for the actor touched by the arrow end ⋯⋯▸

3.3.2 The organisational set-up of the banana TC laboratory

The banana TC laboratory was a unit embedded in KARI Thika National Horticulture Research Centre. The centre has a national mandate to design and execute in collaboration with other KARI centres and partners a horticultural research programmes for vegetables, fruits, beans, flowers, macadamia nuts, crop protection, post-harvest, and socio-economics (KARI 2003). The programmes were executed by a team of scientists supported by technical and administration staff. The TC banana laboratory is under the fruit sub-programme. The TC activities were performed by a multidisciplinary team of scientists (e.g., an agronomist, pathologist, economist, sociologist, post-harvest scientist, soil scientist, biotechnologist, extension liaison scientist), technicians and casual labourers. The laboratory also employed a financial and administrative team, comprising of the centre director, an accountant, supplies and transport officer as well as other actors such as farmers (see Figure 3.2).

These specialists, technicians and other actors had distributed tasks and interacted iteratively in the layered organisational set-up to complete various actions: to give guidance, money, and other provisions, offer knowledge and advise, introduce new varieties, request information and give feedback while focussing on the task at hand. For instance, the agronomist introduces preferred varieties in the mother block that the laboratory uses as raw materials. The accountant provides the required funds for purchasing laboratory chemicals and other necessities. The supplies officer purchases all laboratory provisions. The labourers uproot the suckers in the mother block. The team of technicians handles micro-propagation following the procedure of culture initiation, sub-culturing, and rooting using TC techniques.

The chief technician was the liaison between technicians and the various specialists, and coordinated all tasks in the laboratory and carried out daily inspections of the cultures in the growth room. The labourers maintained the green houses by watering, weeding and rogueing out the undesired plantlets as well as uprooting suckers needed for micro-propagation in the laboratory. The extension liaison specialist linked the laboratory to individual or grouped farmers through direct marketing or by conducting seminars in the farming communities, participating in exhibitions (e.g., agricultural shows and field days), and distributing information.

The distribution of roles and knowledge among individuals shows that the team of technicians performing the actual task of micro-propagation does not work in isolation but is entrenched in an organisational set-up connecting their daily practices to specialists and other technicians with available tools and materials (see Figure 3.2).

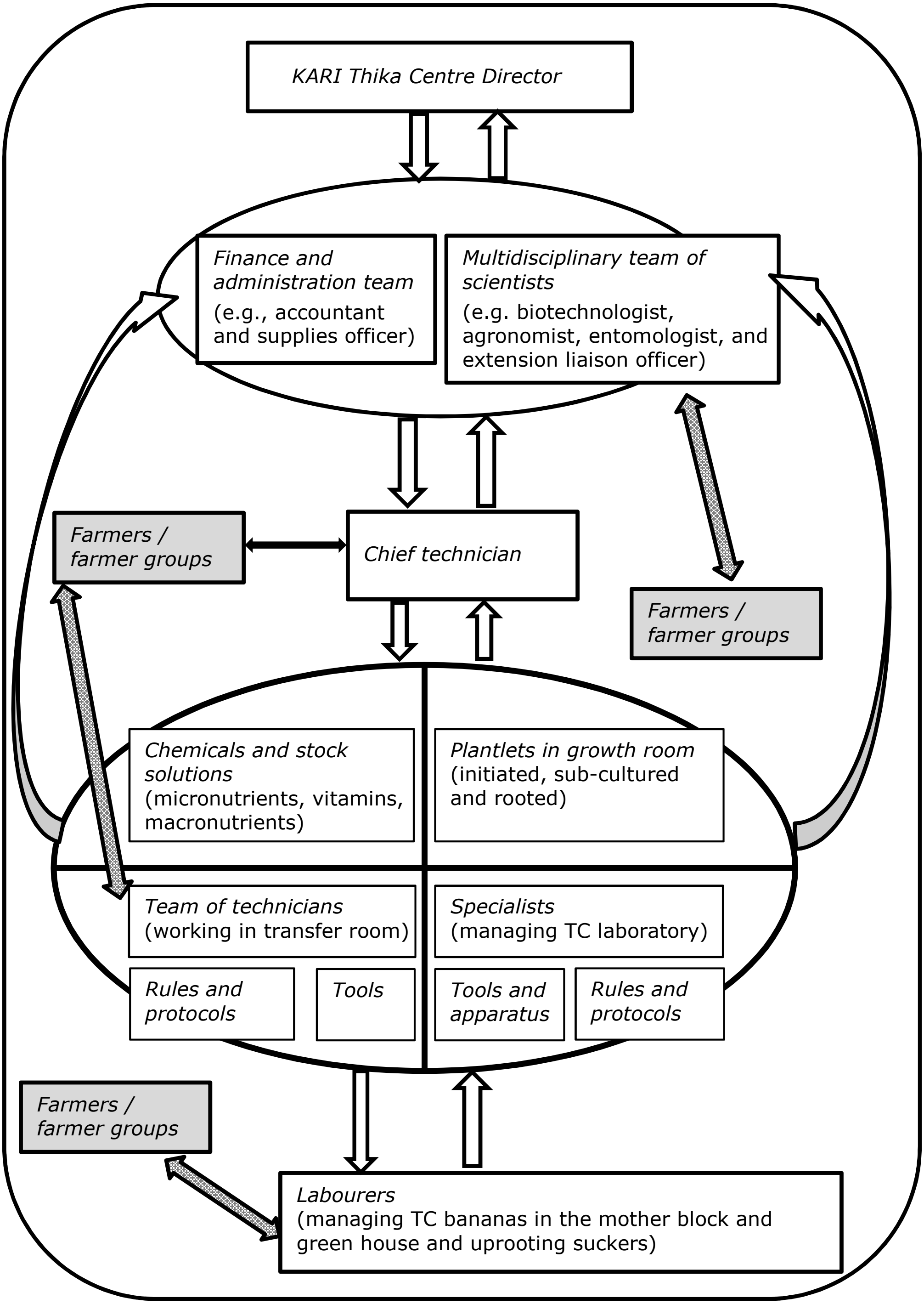


Figure 3.2: Visualisation of the distribution of human activities and tools in the banana TC laboratory, and three processes of interaction with farmers (dotted arrows)

3.3.3 Making banana plantlets in a setting of distributed cognition

The performance of a combination of skilful and delicate tasks in the laboratory was fundamental for the micro-propagation of the selected banana varieties using TC techniques. This second stage of the chain of technical change involved the work of different technicians and labourers performing their daily tasks concurrently at different sites in the laboratory and greenhouse. The work integrated technical elements (techniques, knowledge, skills, tools and machines) with the social and organisational dimensions of coordination of the cognitively distributed tasks). These two dimensions are examined in this section.

Distributed cognition

The production of quality planting materials involved the skilful and daily performance of linked activities: selection and uprooting of the mother suckers, media preparation, culture initiation, sub-culturing, rooting and hardening of plantlets in the greenhouse. Parts of the activities were performed by a team of specialists with various complementary skills, knowledge and techniques. The team of specialists collaborated with laboratory technicians and labourers all performing various interdependent components of the process. The different teams also had distinct interactions with users outside the laboratory (Figure 3.2). Below, performance is presented as a composite whole of interdependent tasks executed by multiple team members. The case study has a specific interest in understanding how these cognitively distributed tasks were coordinated.

The first task of selection and uprooting was performed by a labourer. The nature of this task is demonstrated in the following conversation between the researcher and the labourer, heard during the researcher's usual observations of the mother plot:

> **Researcher**: What do you consider when deciding which sucker to uproot?
>
> **Labourer**: I select suckers based on the following agronomic traits that are of vital importance: (a) trueness to type, (b) vigour and rate of growth, (c) plant height, and (d) girth of the pseudostem.
>
> **Researcher**: Why is trueness to type important during selection of the mother sucker?
>
> **Labourer:** The only reason I can remember is to minimise somaclonal variations.

After sucker selection, the researcher observed how the labourer uprooted it. These observations reveal that the interaction between a person (labourer) and materials (suckers) was largely shaped by the tools used. Using a spade and experience, the labourer carefully removed the suckers from the corn making sure that the meristem, the innermost growing point of the plant, was intact. The outer leaf bases, roots and corn tissues of the suckers were trimmed with a sharp knife, avoiding cutting the meristem. Afterwards the explant was washed with running tap water to remove soil and handed over to technician number two [4] inside the laboratory for initiation.

Culture initiation was said to be the most difficult task examined in this chapter. The task was performed by technician number two, six and seven inside the transfer room using laminar flow hood machines and tools. To perform the task, the technicians used pairs of forceps to pick tissue blocks from bowls and placed them on glass planes. When the tissue blocks were on the glass planes, the technicians exercised a lot of patience to carefully hold the tissue blocks with pairs of forceps. Then using surgical blades, the technicians steadily and systematically removed the ensheathed leaves making sure that the meristems were intact.

Performance of this task required the hands, eyes and mind to work together while interacting with a range of material objects that included explants, ensheathing leaves, pairs of forceps, surgical blades and other tools. All the tools in the transfer room that the technicians interacted with were artefacts designed or intended for special use. These interactions of people, plant tissues, tools and machines left blocks of tissues (5 mm x 8 mm) containing shoot-tips and basal corn shoot-tips enclosing the meristems that were directly placed on the surface of fresh multiplication medium in magenta jars, closed with double aluminium foils.

This task required a lot of concentration as it entailed meticulous precisions in order not to interfere with the meristemic tissues. The technicians worked in the operating room for a maximum of three hours. After the operations, the freshly prepared propagules were transferred and incubated in windowless growth rooms with carefully regulated biophysical environmental conditions: air conditioner controlled temperature (28 ± 2^{o}C) and relative humidity (60–70%), photoperiod of 16 hours and 8 hours dark supplied by gro-lux fluorescent tubes. After a few days in the multiplication media, the explants swelled and a mass of shoots grew that were further multiplied.

[4] Each technician was assigned an index number, in order to track their performance in the laboratory. The numbering system made it easy to identify the technician with the highest culture death rates, and assisted the coordinator of laboratory activities in taking remedial actions.

Culture initiation was followed by multiplication or sub-culturing, which was performed by technician number one and four. They used the same aseptic protocols, tools, machines, attires and media as in culture initiation, but the skills and techniques were less demanding, as demonstrated by this conversation between the researcher and the technician:

> **Researcher:** Since I started working in this laboratory, I have never seen you initiating the explants.
>
> **Technician number four**. You know systematically cutting the ensheathed corns of the explant tissue block without touching the meristem tissues requires a lot of concentration, patience, skills and techniques. I have tried to perform this task on many occasions but my tissue cultures failed to shoot because of interfering with the meristemic tissues. Technician index number two, six, and seven are excellent in the task. Therefore as you have observed we perform tasks here according to our skills and talents as not every Tom, Dick, and Harry can perform the initiation task since it is the most difficult.

To perform the task of sub-culturing, the technicians carefully removed the propagules (plantlets) in magenta jars from the growth room and placed them on the glass plane using pairs of forceps. Subsequently, the newly formed shoots and bud clusters were shortened and subdivided longitudinally using surgical blades. This resulted in well splintered propagules that were re-cultured in magenta jars, labelled accordingly and placed in the growth room. This process induced tiny propagules, each consisting of a single bud/shoot, to form new meristems (a highly proliferative shoot/bud mass and a very rapid rate of propagation).

The rooting of plantlets commenced after sub-culturing for a maximum of six times. This task was performed by technician number one and four, who sub-cultured only the best shoots with a thick pseudostem that had 2-3 leaves. These shoots were carefully placed on the surface of fresh rooting medium in magenta jars using the tip of the forceps after which the mouths were covered with double aluminium foils, labelled and placed in the growth room. After 4 to 14 days, white cord roots appeared. Once these roots appeared, the shoots were left for about 6 to 10 weeks on the rooting medium. By the end of week 10, the leaves started touching the top surface of magenta jars. At this stage, the plantlets were removed from the laboratory and transplanted in the greenhouse by a labourer under the supervision of technician number four. Meanwhile, technician number three performed the task of media preparation and took stock of inventories in the laboratory. When the technician detected that the inputs like macronutrients, micronutrients, vitamins, anti-oxidants, hormones, and other chemicals were about to be depleted, he started the process of replenishing them.

To ensure quality, the head of laboratory services, who was the chief technician, inspected all the cultures in the growth room on a daily basis, assisted by technician number three and seven. Besides, the head of laboratory services chaired all laboratory monthly meetings and coordinated all the cognitively distributed tasks in the laboratory, in the mother block, and in the greenhouse. He was also the link person between the team of technicians in the laboratory and other specialists in the R&D institution such as the director, accountant and the team of scientists (Figure 3.2).

Adherence to rules and protocols

The engineering and production of clean planting materials using TC techniques, as portrayed above, entailed dynamic interactions between the activities of various professionals and the biology of plants. This section investigates the use of rules and protocols to coordinate, correct, and manage these interactions between the organisational and material dimensions of work in the laboratory.

Adherence to aseptic rules was imperative in the process of shaping quality planting materials through TC techniques. Failure to adhere to these rules and to follow the protocols poses a contamination risk and potential death of the plantlets. For instance protocols for media preparation were constant for all varieties. Interviews with technicians and scientists revealed that the protocols developed in the initial stages of the project required continuous fine-tuning. However lack of a biotechnologist to continually adjust the protocols constrained the laboratory from micro-propagating any demanded portfolio of new alternative varieties. Observations revealed that the aseptic rules and protocols were rigid and left little room for finding new responses to unanticipated and situated problems.

Furthermore, rules dictated the technician’s dress and practices. For instance, all micro-propagation tasks including culture initiation, multiplication, and rooting were supposed to be performed inside the transfer room using laminar flow hood machines.[5] The technicians should wear white laboratory coats, caps, surgical face masks, and hand gloves while carrying

[5] This machine is used to prevent contamination of biological samples. Air is drawn through a HEPA filter and blown out in a very smooth, laminar flow towards the user. The cabinet is usually made of stainless steel with no gaps or joints where spores might collect.

out the various tasks. Before performing any task inside the laminar flow hood machines, the technicians are required to thoroughly wash their hands with 10% sodium hypochlorite solution, paying special attention to fingernails and any other part of the forearms that extend into the operating chambers. All sterilised tools and tissue materials not touched by hands are supposed to be placed as far back into the operating bench as conveniently possible. During manipulations, dissecting forceps and surgical blades should be dipped regularly in absolute ethanol, and then flamed in a methanol lamp and cooled in plates before reuse. Sub-culturing was limited to six times, to avoid the problem of somaclonal variation due to mutation and was to be repeated after every four weeks.

However, detailed observations of the technicians' daily practices revealed deviations from the ideal rules, and plantlets perished due to contamination. As a participant observer, I detected that most contaminations appeared in a series of vessels inoculated by technician number two. Technician number two would sometimes forget the nitty-gritty details mentioned in the laboratory procedures, for example, ignoring aseptic rules like flame sterilisation of dissection tools before use, repeatedly dipping tools in absolute ethanol before use, wearing gloves to cover the hands or caps to cover the skull hair. Some of the other technicians would sometimes fail to closely follow the rules, for example, not always wearing head caps when performing the operations. The failure to rigorously follow aseptic rules and procedures resulted in contaminations and the loss of plantlets.

At first, I could not understand why some technicians were not closely following the aseptic rules. Later I learned that besides the head of the laboratory services, who was the chief technician and coordinator of activities, only technician number three was a trained laboratory technician. Technician number six was trained as lab technician but was recently recruited on temporary basis. Technician number four and seven were trained technical assistants, while 'technician' number five and two were auxiliary staff recruited due to staff shortages. These two technicians did not receive any formal training and acquired their skills through hands-on training. My observations revealed that even though the poorly qualified technicians, like technician number two, had acquired good skills, they lacked the knowledge to understand the logic behind the septic rules, like wearing proper attire or repeatedly dipping tools in ethanol before use.

Subsequently, due to the role of aseptic rules in the micro-propagation process and the consequences of ignoring these rules, the head of laboratory services kept emphasising the importance of following them to the letter whenever he got an opportunity, as demonstrated in this meeting that I attended:

> Let me remind you of our team work philosophy. We should work as a team. Working as a team means correcting one another. For example, if so and so is not putting the right attire, or not following the aseptic protocols, do remind them. Tell them, ‘please dress appropriately. Put on the head skull cap, wear glove.’ ... This is because not following the aseptic protocols will bring in micro-organisms that will contaminate and kill the plantlets. Deaths of plantlets will, as you are all aware, affect negatively our team’s output and make the institute incur losses. From the records, it is clear that some of you caused more contaminations than others, but remember that this is teamwork and some of you are in a learning process. Therefore, I cannot blame a specific person for the loss. I also wish to remind you of the importance of precise weights and measurements. As you are aware, errors in measurement of the various weights will jeopardise our products.

To underline the importance of strict adherence to these rules, inspection of cultures in the growth room and quality surveillance to detect errors was a routine activity. During these inspections, contaminated cultures were removed from incubators, counted, discarded, and the index number of the operator was recorded. The discarded cultures were not permitted to accumulate in the laboratory since they produced spores that could contaminate the rest.

The reality in the laboratory reflected a setting wherein various tasks were distributed and were, to some extent, coordinated and governed by rules and managerial coordination. Teamwork among specialists with complementary knowledge, techniques and skills facilitated the production process. Hence, the production of TC banana plantlets appears to be a skilful task organised within the boundaries of the laboratory. This small group of specialised workers interacted with the end users, i.e. farmers and farmer groups, via the distribution of plantlets, but also via their responses to feedback provided, to be further explored in the section below.

3.3.4 Feedback and interaction between farmers and specialists in the laboratory

Direct sales of banana plantlets

The daily sale records at KARI Thika laboratory show that the most demanded tissue-cultured varieties in order of priority were Grand naine, William hybrid, Giant Cavendish, Chinese Cavendish and Chinese dwarf. Others included Ngombe, Solio, and Peripita. This record reflects the varieties that were chosen during PVS (see Chapter 2), with the exception of Ngombe, Solio, and Peripita.

Farmers bought and adopted the tissue cultured materials because they (a) are pest and disease free; (b) grow more vigorously, allowing for quicker, more abundant yields; (c) produce more uniform bunches, allowing for more efficient marketing; (d) can be produced in large quantities within short periods of time, permitting faster distribution of planting materials and new cultivars; and (e) the TC technique does not change the genetic makeup of the crop, preserving culinary attributes such as taste, flavour, colour, and ease of cooking (Wambugu 2001, Qaim 1999, Nguthi 2008).

The purchase requests for the TC plantlets arrived at the laboratory through direct inquiries, either by individual farmers or agricultural service providers, for example, KENFAP, MoA, NGOs, church-based organisations, and farmer groups. After farmers planted the materials, other kinds of feedback reached the laboratory through different channels. The following events are described below: (a) exchanges with extension officers, (b) farmers providing feedback, and (c) interactions during agricultural shows and field days.

Exchanges with extension officers

MoA extension officers provided an important feedback channel. To illustrate the communication path, I will describe the case of Mr Kibe's (not his real name) farm in Muranga County. The extension officer reported to KARI Thika that his bananas had ripening anomalies. Upon receiving this feedback, the KARI Thika Director responded by sending a multidisciplinary team of scientists comprised of an agronomist, soil scientist, and post-harvest specialist to investigate the problem. After observing the problem, the team had lengthy consultative discussions with the farmer, after which they all agreed to set up a post-harvest experiment to further examine the problem. To perform the experiment, the team harvested 180 bananas from different varieties at three-quarter maturity stage in the affected farm. The harvested bananas were transported to KARI Thika laboratory where the experiment was laid out in a completely randomized design (CRD) and replicated three times. The batch was divided in three crates, lined with polyethylene sheets. Sixty bananas were packed in each crate together with 10 randomly arranged passion fruits, a source of bioethylene which promotes ripening of bananas. The crates were covered with polyethylene sheets to minimise moisture loss. Afterwards, the crates were randomly placed in the ripening room. The ripening room was closed for 36 hours, after which the ripe bananas were removed from the crates and analysed. The results indicated a severe deficiency of potassium (K) in the fruits, which contributed to ripening anomalies. The scientists visited the farm and collected soil samples, which demonstrated potassium depletion of the soil.

In response, further research was carried out through on-farm trials, to ascertain the appropriate K fertilizer dosage. To conduct further research, the multidisciplinary team did a literature review. During this initial stage, it became apparent that banana farmers around Kibe's zone used a blanket dosage of recommended fertilizer comprising two *debes*[6] (40 kg) of decomposed manure and 200 g of di-ammonium phosphate (DAP) at planting, and thereafter two *debes* of manure mixed with 200 g of calcium ammonium nitrate (CAN) per stool every year (KARI Thika 2002). The FURP recommended a blanket zero potassium fertilizer application for the region (KARI FURP 1994, KARI Thika 2002). The recorded lack of potassium in the soil prompted the researchers to set up fertilizer application trials to ascertain the optimal dosage. Results showed that a dosage of between 150 kg/ha and 300 kg/ha, delivered as Muriate of potash, gave optimal yields (KARI Thika 2003). These results were shared with Mr Kibe. Interviews revealed that application of K fertilizer not only solved Mr Kibe's banana ripening problems but also dramatically increased yields.

Farmers providing feedback

Feedback from clients also reached the laboratory through farmers' visits to the centre. This was exemplified by Mr Kamau's (not his real name) visit after about a year of purchasing 880 TC banana plantlets. According to the interview with Mr Kamau, he bought several varieties, including Grand naine, Giant Cavendish and Chinese Cavendish. He planted the plantlets as a monocrop and used irrigation as recommended by the specialists. While the bananas were growing, the farmer searched for a market and secured a contract for supplying ripe bananas to Uchumi supermarket. When the bananas matured, they were harvested and placed in the ripening chamber following the instructions. During the ripening process, the rind turned cream yellow but the pulp texture did not soften. Instead the pulp became crispy and was not sweet to taste. The farmer still decided to take the bananas to the supermarket as was agreed in the contract; however, many consumers complained vocally about the poor quality (practically inedible) and the supermarket decided to terminate the contract.

When the farmer realised that he had lost the market outlet for his bananas, he went back to KARI Thika to give feedback and to seek advice about his banana crop. The feedback prompted the KARI Thika Director to set up a team of specialists, including a post-harvest scientist, pathologist, agronomist and a soil scientist, to investigate the problem. This team went to the plot and examined the crop, consulted with the farmer, and collected banana samples. The sample analysis showed high concentrations of Benzyladenine, a plant growth

[6] *Debe* is the Swahili word for tin.

hormone, which had a negative effect on the ripening process. Subsequently, the team of specialists concluded that the technicians had added more Benzyladenine than was required during media preparation. As a response, the farmer was advised not to ripen the first crop of his bananas but instead sell them when green for cooking. He was told that the second crop would be unaffected by the hormone. Indeed, the second crops' pulp texture and taste improved dramatically. The laboratory technicians were informed of the error and cautioned on the importance of precise weights and measurements for the various plant nutrients and hormones during media preparation.

Another example of farmer feedback was presented to me when collecting data in the field. An officer from KENFAP asked me to visit a farmer called Mwenda (not his real name) who had a banana that local residents had labelled 'wonder banana' because of its unique characteristics. When I visited the farm, there was a banana with unique bunch characteristics. I was not able to answer the questions of the farmers who had gathered to seek guidance and advice, but I promised to link them to the specialists. I called the Assistant Director in charge of horticulture at KARI headquarters and informed her of problem and the location. She sent a team of specialists that was already in the county to diagnose the problem. The following day, the team arrived at the scene and after making their observations responded by informing the farmer that the phenomenon was called mutation caused by somaclonal variation during sub-culturing in the laboratory. They advised the farmer to uproot the whole corm in case any other sucker from the same corm produced a similar bunch. On return to KARI Thika, this feedback was conveyed to the head of the laboratory services. Later, during a monthly meeting that the researcher attended, the issue of mutation was relayed to the technicians by the head of the laboratory services as demonstrated by this record.

> I wish to thank all of you for your performance during this month. The TC banana laboratory, however, did not meet the set targets because of various factors. First, feedback from the field indicates that some bananas sold in Meru County had somaclonal variations. Secondly, let me remind you to minimise somaclonal variations through limiting sub-culturing and multiplication to only six cycles with a maximum of 1,000 plantlets per primary explant.

The technicians and labourers took several steps to minimise somaclonal variations: (a) selecting superior and vigorous true-to-type mother plants for micro-propagation; (b) limiting sub-culturing to only six cycles with a maximum of 1,000 propagules per primary explant; and (c) screening of plantlets in the green house in order to detect and rogue out early variants and off-types. This correction of errors eventually led to fewer mutation incidents being reported.

Agricultural shows and field days

Agricultural shows are events where agricultural organisations, farmers and other actors exhibit technologies on crops, livestock, machinery, and other inputs for wider dissemination and marketing. Such events also provide an opportunity for farmers and other participants to exchange feedback on the technologies and products being exhibited with the experts who service the stands. I observed such an exchange between a farmer and a KARI scientist who exhibited TC bananas at the Nairobi agricultural show in September 2012:

> **Farmer:** Good afternoon 'mwalimu wa kilimo' [agricultural teacher].
>
> **Scientist:** Good afternoon. Welcome to our stand.
>
> **Farmer:** Thank you sir. I have a problem with my tissue cultured bananas.
>
> **Scientist:** Tell me the problem.
>
> **Farmer:** I bought tissue cultured bananas comprising of William hybrid, Grand naine, and Giant Cavendish from KARI Thika and planted them in my farm in Muranga. When the bananas began to flower the fingers became brown and silvery resulting in very low yields.
>
> **Scientist:** Were you shown how to plant and manage the TC banana plantlets?
>
> **Farmer:** Yes, the local extension officer demonstrated how to plant and manage the bananas.
>
> **Scientist:** Can you recall the spacing he gave you and the crop management practices.
>
> **Farmer:** He demonstrated how to dig a hole 60 cm by 60 cm by 60 cm with a spacing of 3 m by 1.5 m between and within rows respectively. He went ahead and showed me how to water, weed and desucker them.
>
> **Scientist:** Did you follow this management practice?
>
> **Farmer:** No.
>
> **Scientist:** Why?

Farmer: Mwalimu [teacher], you see I bought the bananas expensively at a price of KSH 120 [EUR 1.20] per plantlet. Besides my land is too small, therefore, I reduced the recommended spacing. I also did not desucker because I wanted more bananas in my plot in order to have enough for the family and for sale.

Scientist: That means you have a lot of bananas in one stool and they are densely populated.

Farmer: Yes.

Scientist: The fact that you planted the bananas close to each other combined with not de-suckering means that your bananas are densely populated. This high density offers a favourable environment for thrips, which attack banana bunches and make them brown and silvery leading to low yields. This situation therefore explains the cause of your problem.

Farmer: So what should I do to overcome the problem?

Scientist: My advice is – please go and de-sucker the bananas and if possible uproot some plants to reduce the density. And the next time you want to plant bananas, follow the recommended agronomic crop management practices.

Farmer: Thank you very much.

Similar exchanges between users and expert also occurred during field days. Field days are normally held when the crops are in the vegetative stage or when they are mature. Field days not only serve to create awareness about agricultural technologies but also provide a chance for farmers to evaluate a range of different technologies. In the process, farmers take the opportunity to ask questions and get answers from the specialists on the technologies being demonstrated. In another example, I observed a trader's visit to a field day in Kiambu County. He examined the bananas and other technologies on display, and during the question and answer session posed the following question to the experts:

Trader: My name is Tom. I'm a trader of ripe bananas. Usually I buy green bananas, ripen them and sell to customers. Of late, I have noted that my bananas are rotting at the proximal end while in the ripening chambers. This problem has incurred a lot of losses on my business and I do not know what to do.

Scientist: Thank you for the question. The rotting is usually caused by a fungus disease. This disease thrives in ripening chambers that have warm and high humidity. The fungus can be destroyed by disinfecting the ripening chamber.

The above illustrated how demands and feedback from farmers reached the laboratory and got incorporated into the interactions among and practices of specialists. The discussion below further examines the interactions in the production of banana plantlets in the laboratory and the interactions between the laboratory specialists and the end users.

3.4 Discussion

This chapter presented the case study of producing banana plantlets in a public laboratory. The work of a group of specialised scientists, technicians and labourers represents the second stage of technical change, taking place after the initial selection of banana varieties. This group of professionals used and coordinated their skills, knowledge, and techniques to produce the required banana varieties in the laboratory. The case study presents the work in the laboratory both as a skilful practice that constantly adapts to unanticipated errors and as a configuration of distributed capacities regulated by a fixed set of protocols and routines.

3.4.1 Skilful practices of producing TC plantlets

The study shows that creating channels for receiving farmers' feedback contributes to effective engineering as much as the capacities of the specialists in the laboratory. The case illustrated how incorporating farmer feedback resulted in the correction of errors. This is in addition to the corrections initiated through the daily surveillance by the chief technician, together with experienced technicians who have detailed knowledge and experience with the monitored tasks. When an error was reported, the team examined it and developed hypotheses (e.g., poor handling by a particular technician or whether defects originated from post-planting in the field). Additionally, errors were reduced by a hierarchical intervention emphasising the importance of following the recommended aseptic rules (Dodds and Roberts 1985, Vuylsteke 1998, George *et al.* 2008).

The study also suggests that incorporation of farmer feedback in the laboratory by specialists resulted in some modifications of the technological package. In line with Latour and Woolgar (1986), the modification process involved the scientific team interacting with tools and among themselves to create the data. In the case of Mr Kibe's farm with ripening anomalies, the laboratory analysis uncovered a potassium deficiency. Further analysis revealed inadequate potassium in the soil. This problem was corrected by a shift from a blanket zero potassium fertilizer application, as recommended by KARI FURP (1994), to flexible and variable area specific recommendations. Also other studies have confirmed the importance of context-specific recommendations (Okali *et al.* 1994b, Ashby and Sperling 1995, Snapp *et al.* 2003).

In my participant observations I recorded that during the performance of the various tasks in the laboratory, tools, solutions and chemicals were arranged in an orderly way by the technicians. The orderly arrangement of these apparatus on the operating bench and the embodied performance of the technicians are close to Dant's study (2005, 2006) of the way car mechanics arrange the interaction between properties of skills, techniques, and knowledge and the physical layout of tools, organisational set-up, and physical task environment. Most of the technicians' tasks were executed in parallel. For example, while technician number three was preparing the medium, technician index two, six, and seven were initiating the ex-plants, while technician number one and four were multiplying through sub-culturing and rooting. At the same time, the labourer was transplanting the plantlets in the green house. This is an example of simultaneous coordination of many tasks in the TC micro-propagation process, which transcends the boundaries of individual actors, a finding also shared by Hutchins and Lintern (1995).

3.4.2 Performance as a configuration of distributed capacities

Work in the laboratory process involved the performance of different specialised tasks. The specialists iteratively interacted below, above and horizontally in the layered organisational set-up. The interactions within the organisational boundaries enabled the workers to give guidance, obtain funds and other provisions, request information, share knowledge and respond to feedback. The assigned roles and knowledge among individuals in the team functioned in an exhaustive and mutually exclusive manner, so that the sum of the individuals' knowledge fulfilled the combined requirements, as argued by Hutchins and Lintern (1995). Therefore, the success of the process depended on the subtle organisation of practices and interactions among the staff, and the associated coordination and disciplining measures.

Task performance involved adherence to the set protocols underlying coordination of the cognitively distributed tasks (Hutchins 1995, Jansen and Vellema 2011). The structural relations between the practices of producing TC plantlets and the protocols in TC micro-propagation process associated with the specific selected banana varieties constrained the capacity of the laboratory to explore the value of alternative banana varieties. The technicians and specialists collaborating in the laboratory continued micro-propagating only the varieties that were initially selected using corresponding protocols tailored to these varieties. The laboratory showed a trajectory of routine procedures and fixed protocols, which enabled professionals to handle errors but did not allow much deviation from the originally selected varieties. The biotechnologist who had the capacity to fine-tune protocols and new varieties was transferred as a result of internal tensions. The study concludes that the making of quality planting materials in a laboratory setting, which includes constant correction of errors and incremental modifications, is fundamentally different in its orientation and progression from that of selecting and shaping a radically new portfolio of technological alternatives or varieties. A more flexible application of biotechnological know-how is needed to continuously fine tune the organisation of work in the laboratory and customer demands for alternative banana varieties.

CHAPTER 4

Governance and embedding of small task groups: a case study of acquisition, nursing and dissemination of TC bananas by Witikio SHG

4 Governance and embedding of small task groups: a case study of acquisition, nursing and dissemination of TC bananas by Witikio SHG

4.1 Introduction

The final stage in the chain of technical change is the element in the chain where tissue-cultured banana plantlets, produced in KARI or private laboratories (Chapter 3), are disseminated to farmer users. To facilitate dissemination, the partnership created channels through which groups of farmers acquired tissue-cultured banana plantlets, housed them in collectively managed nurseries and eventually distributed them to farmers in the surrounding communities. This approach relied on the involvement of privately organised groups, which augmented the constrained ability of the Kenyan government to provide adequate agricultural extension (Place *et al.* 2004, Davis *et al*. 2004, Fischer and Qaim 2012). The reorganisation of the public extension service was fuelled by the structural adjustment programmes in the late 1980s, creating conditions for new divisions of labour between the government, private sector, and other organisations or groups. New partnerships took over the provision of agricultural extension and other services such as credit, certified seeds, and market information, helping to reduce government expenditures (Rono 2002, Markelova and Mwangi 2010).

In this setting, farmer groups were the linchpin between public and private research organisations and the main end users. The assumed advantages of using groups include (a) high diffusion rate of agricultural technology and information, (b) better access to inputs, (c) better access to markets, (d) increased profits from market transactions, and (e) increased bargaining power (Bose *et al.* 2002, Markelova *et al*. 2009, Place *et al*. 2004).

This chapter focuses on the collective performance of tasks in Witikio SHG, a small farmer group located downstream the chain of technical change, as an entry point for explaining how groups are both governed and embedded in horizontal and vertical network ties.

4.2 Theoretical context: small groups and collective action

4.2.1 Group and member characteristics

The case study builds on the literature on collective action and social networks, which aims to explain why people collaborate and what accounts for successful group performance. In the agricultural sector, Barham and Chitemi (2009) analysed how groups' characteristics and assets facilitated the collective marketing of agricultural crops. Their findings showed that few farmer groups performed better in the collective marketing of cereals and legumes than of fruits and vegetables. Furthermore, Barrett (2008) used a household market participation model to analyse how physical attributes such as roads and institutional infrastructure (extension services and market information) affected the collective marketing of grains and cereals in eastern and southern Africa. The study showed that collective marketing of these crops in the two regions failed due to, among other reasons, lack of adequate policies supporting physical and institutional infrastructure.

Fischer and Qaim (2012) use transaction cost economics and organisational theories (Williamson 1985, Key *et al*. 2000) to compose a conceptual framework for determining farmers' attributes, such as education and land size, that explain determinants and impact of collective action in production of tissue-cultured bananas. Among their findings was that group members performed better than non-members in banana production. The study contributed to the literature on collective action in three ways. First, it provided insights into determinants of groups' membership. Second, it showed impacts of group membership on marketing and non-marketing outcomes. Third, it distinguished the impact of different modes of group participation (Fischer and Qaim 2012). Okello and Swinton (2007) also used the concept of transaction cost economics, relying on attributes such as family labour, non-family labour and farmer education to explain how green beans groups in Kenya successfully accessed European markets.

Böhringer *et al.* (2003) used social and human capital concepts to study how farmer groups managed tree nurseries in southern Africa. The study used regression analysis and concluded that group-operated nurseries produced significantly fewer tree seedlings than those operated by non-associated actors. In this case, group performance was affected by the additional effort to organise and coordinate the collectives, which hampered performance. Davis *et al.* (2004) also used regression models to study the dissemination of dairy goat technology in Kenya. The study found that group members were not willing to share dairy goat technology with others due to jealousy. Ouma and Abdulai (2009) studied why agro-pastoralists join collective action and based their research in the terms of social capital and economic rational choice theory (Olson and Olson 2009). The study found that poor households were more likely to join communal breeding activities than wealthy households. Hence, the economic position explains individual choices to pull resources in order to access improved bull technology through communal breeding. In this literature, social capital within the group is considered an asset that can positively impact on the outcome of collective action. Social capital refers to aspects of social structures, such as obligations, expectations, trust and information channels

(Portes 1998, Blau 2007, Coleman 1988), which facilitate cooperation among members. Like other forms of capital, social capital is a productive force, making certain achievements possible.

Agrawal and Groyal (2001) synthesised the works of several authors – Wade (1994), Ostrom (1990), Baland and Platteau (1996) to name a few – in an effort to show factors that contribute to successful groups. In their literature review, they found that medium-sized groups are more likely to be successful than either small or large groups. In contrast to these findings, Olson (1965) found that small groups are more likely to be successful because as the group becomes larger, some members become ‘free riders’ and provide only marginal contributions. Hardin (1982), however, observed ambiguities in Olson's argument and suggested that the relationship between group size and collective action is not that straightforward, because trade-offs exist between free riding and economies of scale. Another characteristic that can impact positively on a group’s success is the degree to which the members depend on the collective good (Dietz *et al*. 2003, Demsetz 1997). If members derive a lot of benefits from the collective good, then they will be more motivated and interested in ensuring that the group does not collapse.

4.2.2 Group rules and networks

Other literature demonstrates that success in collective action can be achieved when people agree to install and use institutions, i.e. sets of rules directing behaviour, to govern themselves. These rules contribute to successful task performance as they define norms, and arbitration behaviour of members with respect to collective performance (Schlager and Ostrom 1992). Monitoring is crucial for ensuring compliance; members have no commitment to follow the rules if internal monitoring mechanisms are lacking (Ostrom 1990). Group members can monitor each other’s activity or delegate the task to qualified members (Ostrom 1990, Wade 1988). The establishment of a forum for discussion is also known to provide members with an opportunity to express their grievances and come to a common understanding for the needed improvements (Varughese 1999). In order to limit opportunistic behaviour, sanctions can be applied to members that violate the rules (Ostrom 1990). Furthermore, higher education levels among group members can contribute to the group’s success in many ways. For instance, it increases the capacity of individuals to follow rules and regulations, and limits free riding (Lyne *et al.* 2008). It also raises the members’ capacity to negotiate and agree on the terms for sharing collective responsibilities (Lubell *et al.* 2007).

Social networks also play a major role in a group's success. The strength of the social ties affects the quality of resource flows. Strong ties are described as relationships among individuals in a social network that are emotionally connected (e.g., family, friends and neighbours). In contrast, weak ties are acquaintance relationships that act as bridges, connecting social groups to the society at large (Granovetter 2005, 1988, Pretty 2003). For instance, the connection of farmer groups with donors and international experts is an example of a weak tie.

4.2.3 A task-group relating to its environment through performance

The above studies of collective action adopt a strong focus on correlating fixed attributes of groups or individual members for explaining successes and failures of group-based activities. The case study of a small group presented in this chapter makes the collective performance part of an evolving process of technical change. Its technographic lens uses McFeat's (1974) notion of small task groups to describe how the execution of certain technical and managerial concepts shapes group structure and governance. In this sense, group features gradually fit the content of the task. In addition, McFeat argues that groups relate to their environment through the performance of tasks. This perspective on the collective management of a nursery has the potential to closely study the actual social and technical processes underlying the daily practices and the actions taken to create and sustain collective action. This chapter documents these processes through the case study of Witikio SHG, examining how the group gained on functionality – and consequentially also improved its viability – through performing tasks in the on-going process of technical change.

4.3 Results: the case study of Witikio SHG

This section first presents the setting of the group collectively managing the nursery. Then it describes performance, i.e. how the group manages the performance of collective tasks, and identifies the related modes of governance that emerged within the group. Next, it maps horizontal and vertical linkages of the task-oriented group with its environment.

4.3.1 The formation of the group

The formation of the Witikio SHG was initiated by KENFAP, a lobby organisation that advocates for farmers' interests. The formation of SHGs built on a history of communal work embedded in the region through the Kenyan slogan of *harambee*, a Swahili word that means working together to achieve a common objective. Group formation was a continuous process that dates back to 2006, when the chairman, who was KENFAP's national secretary, organised members from in his village into a group. In 2007, when membership reached 37, the group was officially registered with the Ministry of Gender, Sports, Culture, and Social Services (MoGSCSS). Its specific tasks were to acquire TC banana plantlets from R&D laboratories, manage them in the nursery, and disseminate them to other farmers in the region.

This particular SHG was formed against a background of two challenges: (a) inadequate provision of extension services, and (b) the devastation brought on by *Fusarium* wilt, nematodes and weevils (Wambugu and Kiome 2001). In this context, the introduction of new and clean banana varieties, partly through TC techniques, was seen as a good way to revive banana production. Farmer groups located at strategic locations, acted as plantlet dissemination hubs, connecting laboratories with farmers. These group nurseries were operated as business enterprises with profits shared equally among members.

Some groups (e.g. Witikio SHG) eventually evolved into viable enterprises with excellent performance in crop agronomic practices, commercialisation and dissemination. One plantlet was sold at KSH 120 (EUR 1.20) to non-members and at a subsidised price of KSH 80 (EUR 0.80) to group members. Post-sale, the group was supposed to train their customers[7] on plantlet agronomic and cultural crop management practices. The money from the sale of plantlets was put in the group's bank account and later used to buy more plantlets from the laboratories, with dividends shared equally among members. The group's successful performance was confirmed by increased volume of bananas produced and increased acreage under bananas in the region (see Figure 4.1 and 4.2). Since 2007, this group sold about 2,000 plantlets per year, thus proliferating tissue-cultured bananas to surrounding locations in Miriga Mieru east division, including Chungu, Munithu, Kiburine, Ntankira and Giaki.

[7] Customers included other farmers and entrepreneurs.

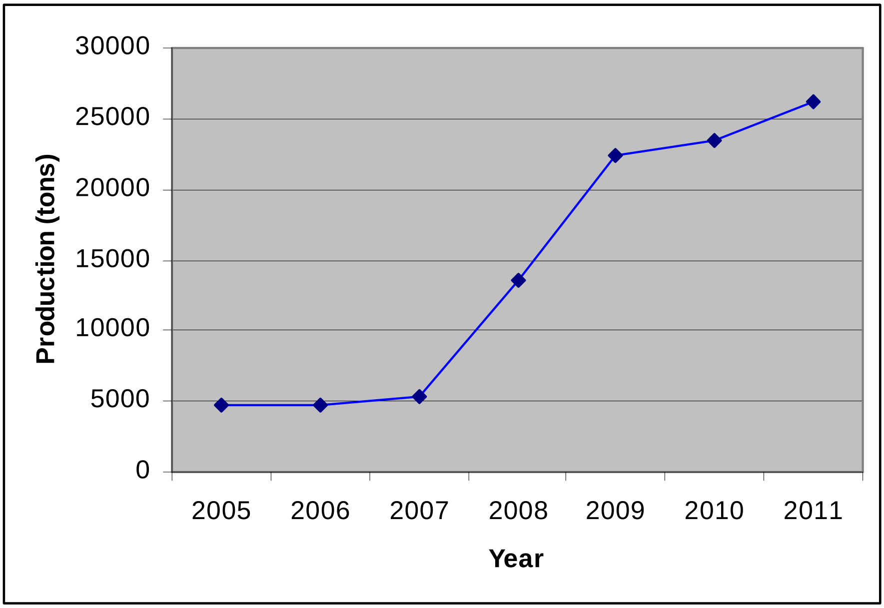


Figure 4.1: TC banana production (tons) in North Imenti district, Meru County (2005–2011)

Source: North Imenti district tissue-cultured banana data: MoA, Meru County.

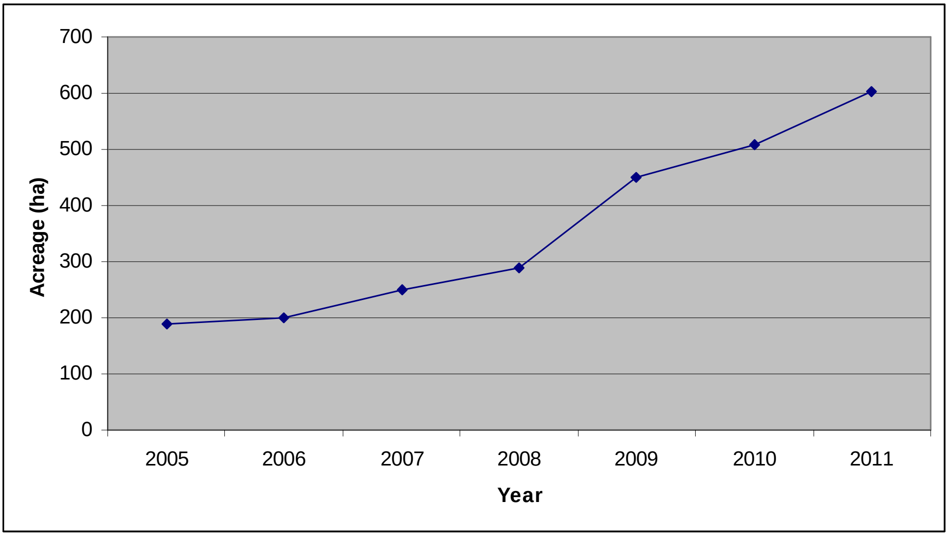


Figure 4.2: TC banana production (ha) in North Imenti district, Meru County (2005–2011).

Source: North Imenti district tissue-cultured banana data: MoA, Meru County**.**

To secure funds for these activities, the group established vertical networks with local, national, and international organisations, for example, with Agriterra, a Dutch agricultural agency founded by Dutch farmer organisations in the Netherlands. Using this network, the group wrote a proposal to Agriterra and received KSH 500,000 (EUR 5,000). This success motivated the group to write a second proposal. The second proposal was submitted to the local constituency development fund (CDF),[8] which was coordinated by the area's Member of Parliament (MP). The CDF proposal was awarded KSH 300,000 (EUR 3,000). To augment this amount, group members contributed KSH 50,000 (EUR 500) for a grand total of KSH 835,000 (EUR 8,350). This money provided the initial starting capital for the group to purchase construction materials and hire a technician to construct the tissue-cultured banana nursery shed net. Later, the group forged more vertical linkages with Jomo Kenyatta University of Agriculture and Technology (JKUAT) as a source of tissue-cultured banana plantlets. Using this network, in September 2007, the group ordered the first batch of 2,000 acclimatised tissue-cultured plantlets (approximately 10 cm tall) at a subsidised price of KSH 60 (EUR 0.60) each from JKUAT's laboratory. This order was made through KENFAP due to the existing vertical linkages. This was a good arrangement since KENFAP had an office with the necessary communication facilities, such as an email address and a fax number, for the group to correspond with other actors in the banana chain.

The remaining funds were used to purchase the TC banana nursery materials such as polybags and to pay for the nursery management activities. To gain the skills required for TC plantlet management, the group linked with other actors such as MoA and KARI, which offered technical trainings on handling, agronomic, and crop's cultural management practices (transplanting, potting, watering, soil management, spacing, disease and pest management). Additionally, the group connected with TechnoServe, an international NGO based in Washington D.C., and received training on business skills such as record keeping, cost benefit analysis as well as assistance on market linkages. To obtain clean soil, the group forged links with the Ministry of Natural Resource Management which allowed them to access clean soil from Nkunga forest in Meru County.

4.3.2 Collective performance of tasks

The group's specific tasks were performed through three interlinked processes: plantlets acquisition from the laboratory, management in the nursery, and dissemination in the region. These processes involved numerous sub-tasks that were performed in a division of labour

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[8] CDF is funded by the government of Kenya.

according to gender and abilities. The processes began by acquiring the tissue-cultured plantlets from the laboratory. This task was performed by the chairman who ordered the plantlets through KENFAP's office. Before arrival of plantlets, men fetched virgin soil from Nkunga forest. Wheelbarrows were used to load soil into the vehicle. Men were considered fit for this activity because they could deal with potentially challenging eventualities in the forest better than women. After the tissue-cultured plantlets and soil had been delivered in the vicinity of the nursery, a day was organised for collective transplantation of the plantlets.

During the transplanting, women performed the tasks of putting soil in polybags and making planting holes, as they were believed to be fast in these activities. Men transplanted plantlets into polybags, watered and transported them from the working area into the nursery shade net. Meanwhile, the chairman closely supervised and coordinated these tasks to ensure that the crop's agronomic rules and cultural management practices were followed to the letter. Such communal work aroused a lot of commitment and excitement resulting in completion of tasks within the specified time. At the end of the exercise, a duty list was drawn showing who will water the plantlets on what specific days. Plantlets were watered daily using buckets. Daily watering of plantlets was considered a sensitive activity and members were cautioned not to fail in their watering duties. In cases where members failed to water the plantlets, an employee of the chairman who hosted the nursery watered them. The penalty for failure to perform the duty of watering was KSH 200 (EUR 2). This money was given to the employee who watered the plantlets. These penalties were applied to all members without discrimination. Additionally, the chairman, who was very devoted to this project, visited the nursery every morning to monitor and ensure that the tasks were implemented well and that plantlets were in good condition.

Equipped with resources such as technical knowledge, technology, funds, and marketing opportunities, the group performed well in tissue-cultured banana activities and reaped good profit margins through the seasonal sales. At the time the group had no competitors in the region, and tissue-cultured bananas were in high demand due to their resistance to disease and pests. The profits generated from these sales motivated the group to expand its activities. Consequently, in 2010 the group wrote a proposal to the Small Holder Horticulture and Marketing Programme (SHOMAP)[9] and was funded with KSH 150,000 (EUR 1,500). This money was used to construct a greenhouse where the group started growing tomatoes and

[9] SHOMAP is a collaborative project between IFAD, MoA, and the Ministry of Local Government.

onions, in close collaboration with the MoA which offered technical advice. The profits were again fed back into the group's account, with dividend pay-outs given to members.

Furthermore, the group expanded into other economic activities, like various savings and credit scheme, merry-go-round micro-finance, welfare savings, and National Health Insurance Fund (NHIF). Witikio SHG's strong performance cannot be explained by one factor alone; it follows from a convergence of several processes, like the collective task performance discussed above, as well as group governance, strong horizontal embeddedness and vertical linkages, as outlined below.

4.3.3 Group governance

Gradually, the group gained an organisational structure anchored in the activities of the nursery, with an approved structure of communication and a chain of command. This section identifies governance mechanisms that created trust among members and reduced conflicts, resulting in a favourable environment for collective task performance and sustainability.

The group had a governance structure and conflict management processes in place. The apex of this structure was the executive committee comprising of the chairman, secretary, treasurer, and three members who acted as monitors. To forestall leadership struggles, elections for the executive committee and sub-committees were held every year. When voting for the chairman, one member proposed the name of a preferred candidate after which a second member endorsed. In this way, many names of preferred chairmen/chairladies were proposed and endorsed. This procedure was repeated for other posts such as that of the treasurer and the secretary. After names of the preferred candidates were proposed, all members were given small papers. In each of the papers, members wrote down their choice for the various posts. These papers were folded, gathered, and the votes counted transparently in the presence of all members. The winning candidates were announced and assigned responsibilities.

Each elected member of the executive committee had a responsibility and characteristics that contributed to group's success. For instance, the chairman, who had held the position since the founding of the group, was charismatic and dynamic, and had a master's degree in agricultural sciences along with extensive experiences in various leadership positions. He was chairman of the local church, advisor to the local area MP, former provincial director of agriculture (PDA), national secretary of KENFAP and chairman of many local development projects. The chairman knew the vision and objectives of the group and ensured that they were met. Besides, the chairman used his vast experience and acquaintances to facilitate establishment of network relationships at local, national and international levels.

At the international level he established networks with Agriterra and TechnoServe, while at the national level he established linkages with KARI, KENFAP, MoA, and JKUAT. Additionally, his in-depth knowledge in agricultural sciences allowed him to translate the group's needs into successfully funded proposals. He also used his technical knowledge to closely supervise and coordinate the various tasks in the nursery. Moreover, he mentored members in transmitting TC banana technical skills to customers, neighbours, friends and relatives who bought the plantlets. In this way, he combined his administrative and technical skills to ensure that the group was managed well and that activities were implemented according to plan.

The secretary recorded minutes of meetings, maintained the group's records in an orderly fashion, dealt with letters to and from the group, and read aloud minutes of meetings. The treasurer maintained and safeguarded the group's financial records and accounts. He also made payments and recorded members' contributions. Moreover, the treasurer reported financial matters to members, and collected fees and fines as decided by the group. In addition, he executed internal financial controls and responded to audit issues. The farming committee monitored and evaluated the group's TC banana nursery and other agricultural activities such as onion production in the greenhouse and banana production in individual farms to ensure that the prescribed agronomic and cultural management practices were followed.

In addition to this formal organisational set-up, the executive committee was responsible for managing or reducing conflicts with the help of three members who acted as monitors. Their identities were only known to the executive committee. To perform their tasks, the monitors mixed freely with other members and reported to the executive committee on members who did not follow the group's laws and code of ethics. For instance, monitors reported to the executive committee group members who spread unethical rumours and lies. After receiving the information, the executive committee summoned the culprits to a special meeting 'court' where the charges were read. If the alleged offenders agreed with charges, they were sanctioned in accordance with the group's rules. If the alleged offenders disagreed with the charges, more evidence was gathered. If the 'court' found grave transgressions beyond reasonable doubt, the offenders were ejected from the group and given back their contributions minus the interest earned. Thus, potential culprits were judged and sanctioned differently according to the nature of the crimes committed.

John's case is a case in point. John borrowed a loan of KSH 5,000 (EUR 50) from the group's saving and credit scheme. Paul, Tom, and Agnes acted as guarantors, and John posted his bicycle as collateral. John failed to repay the loan and also sold the bicycle that had served as collateral. John, however, told the financial committee that he had lent the bicycle to his brother. The monitors discovered that the bicycle was not with the brother but that John had sold it. In light of this evidence, John was summoned in 'court' where he agreed with the charges. Due to the nature of his crime, he was sanctioned by being expelled from the group. However, he was given back his shares, minus profits earned and also minus the KSH 5,000 (EUR 50). This way of policing and sanctioning deviant behaviour minimised internal tensions and managed conflicts, thereby contributing to the group's success and vitality.

Witikio SHG drafted a written constitution, comprised of rules and a code of ethics, which was established through a participatory process. Members proposed rules and ethical principles during group's meeting, which were written down and shared with all members for deliberation, before selecting those to include in the final draft through a secret ballot. While waiting to vote, members consulted each other and discussed the advantages and disadvantages of each rule or ethic. During the voting exercise, all the rules and ethics were written in small papers with a word 'yes' or 'no' beside them. The papers were given to members, who were instructed to tick the word either 'yes' or 'no'. Ticking a 'yes' meant that the member had endorsed the rule while a 'no' meant rejection of the rule. After all the members had completed the ticking exercise, the papers were folded and collected for public counting before all members. The rules and ethics that received more than 50% of the cast votes were approved and formed the group's constitution.

The constitution provided the legal framework for judging and sanctioning deviant behaviour. Moreover, the constitution strengthened group's governance by structuring the social interactions and relationships among group members as well as with other actor configurations in the tissue-cultured banana chain. Within the group's boundaries, rules related to group's activities such as attendance and punctuality in meetings, communal activities, and payment for various investment activities. Outside the group's boundaries, rules related to contracts with other actors in the banana chain. Transgressions were counteracted with sanctions. For instance, failure to attend a group meeting incurred a penalty of KSH 50 (EUR 0.50), while failure to attend a communal working day a penalty of KSH 200 (EUR 2). Outside the group, the constitution specified the actors' social arrangements and interactions. For instance, when the group entered into contracts with wholesale traders, it signed contract documents that were legally binding. The contracts specified the volume and quality of bananas to be delivered on specific days at Thuura market (2 km from the group's nursery). This constitution created a kind of culture that exerted some degree of pressure on all actors to adhere to the group's rules and code of ethics. The constitution, therefore, created an enabling environment for collective task performance and boosted social viability.

4.3.4 Embedding and network linkages of the group

Dissemination of tissue-cultured banana plantlets and information was facilitated through processes of horizontal embedding with friends, neighbours, relatives, and various churches. Vertical networks with actors such as MoA and KENFAP facilitated dissemination through channels such as field days, agricultural shows and farmer study tours. The section below shows how the group connected with surrounding communities and vertical networks.

Churches

Group members were affiliated with five different Christian churches (Methodist, Baptist, Pentecostal, Full Gospel, and Catholic), which acted as channels for tissue-cultured banana technology and information dissemination. The researcher participated and observed the dissemination processes through these various churches. The processes began with the chairman writing letters to the various churches seeking permission for group members to speak to the congregations about tissue-cultured bananas. After permission was granted, presenters went to the various churches carrying tissue-cultured banana plantlets and booklets describing banana agronomic and cultural management practices. The researcher recorded the speeches of all presenters using a digital recorder.

These speeches were replayed during analysis, and the following key message categories were identified: (a) advantages of tissue-cultured bananas over traditional suckers, (b) types of varieties available in the nurseries and price per plantlet, and (c) planting techniques. On the advantages of tissue-cultured bananas over traditional suckers, the messages stated that most farmers in the area reproduced bananas by replanting untreated suckers of the same cultivar, obtained from their own plantations or from other farmers' fields within or outside the village. This practice greatly contributed to the spread of pests and diseases and is the reason why farmers failed to control them. On the other hand, the tissue-cultured plantlets from Witikio SHG were free from pests and diseases. Second, the speeches informed the congregations that the group offered three varieties (Grand naine, William hybrid, and Giant Cavendish) on Fridays for KSH 120 (EUR 1.2) each, available at the group's nursery. The varieties were very marketable due to their size, shape, and good culinary attributes and texture. Third, the speeches dealt with agronomic techniques, such as planting distances, soil fertilisation and pest and disease management.

This process of marketing tissue-cultured banana plantlets through horizontal embedding within network of church members accelerated the dissemination process. Besides, group members transmitted the technology and information to their friends, relatives and neighbours through word of mouth.

Field days

Information about the use of tissue-cultured techniques for making banana plantlets was displayed at field days. I visited one of these field days, organised in conjunction with KENFAP and MoA on 25 May 2012 at the homestead of the farmer who hosted the group's banana nursery and banana plot. People from the group's horizontal relationship network (friends, relatives, and neighbours) came to see and learn about TC techniques, while representatives of the vertical relationship network (KARI, MOA, KENFAP, Equity bank, and Amiran) pitched up tents to display their goods and services. In this way, farmers, not only learnt about tissue-cultured bananas but also about fertilizers and pesticides.

At the entrance of each tent was a big poster showing the actor's objectives, and attending experts explained the goods and services. For example, Amiran Company displayed various farm inputs, while Equity Bank advertised the various loan schemes available to farmers and their interest rates. During viewing, farmers exchanged knowledge and information with these experts through questions and answer sessions. Afterwards farmers were given brochures, exhibits, and booklets for reference.

At the group's TC banana nursery, two members and one MoA staff demonstrated to the participants through practical sessions the process of TC banana nursery management from plantlet acquisition to transplanting, watering, and selling. At the group's banana plot, two members demonstrated to participants practically the process of the crop's agronomic and cultural management practices. This was in addition to practical demonstrations of value adding processes, such as baking banana cakes, making banana jam and crisps.

The field day did not only create awareness about the TC banana technological packages but also provided a forum for the various actors to interact. Later, all participants gathered at a central place where group members recited poems and acted drama pieces related to the topic of tissue-cultured bananas. The highlight of the event was the song and dance performance. They started dancing in praise of the TC banana technology and as the dance continued other participants joined the arena. Therefore, the field day did not only disseminate the technology through observation but also through songs, poems, and drama. At the end of the day, some participants bought TC plantlets while others bought value added products.

Agricultural show

The Meru County Agricultural Show was held from 30 May 2012 to 3 June 2012 and was organised by the Agricultural Society of Kenya (ASK). Witikio SHG participated by exhibiting tissue-cultured bananas and the value added products. Their stand was located in the middle of the show grounds and managed by three members. At the entrance of the stand, a poster showed the group's objectives and collaborating actors. Near the poster were three bunches of green bananas comprising Grand naine, William hybrid, and Giant Cavendish. Next to green bananas were 20 tissue-cultured banana plantlets. Adjacent to the plantlets was a well arranged table with clearly labelled value added banana products. These included ripe bananas, crisps, a cake, and mukimo.[10] As soon as a visitor entered, one member would utter the words 'welcome to the tissue-cultured banana stand'. Subsequently, the three members would talk in turns to guests about the TC bananas emphasising on their advantages over the conventional suckers. Usually, guests would ask questions, and the three members would answer them.

Farmer organised study tour to Witikio group

Due to the group's popularity, it has attracted a lot of visitors from Meru County and beyond – as far as Bugoma County in western Kenya. These visits were normally organised by farmer service providers like MoA. In some cases farmers took the initiative and pooled their finances to cater for transport, meals, and, if necessary, accommodation.

One day, KENFAP organised a study tour for Karia SHG to visit Witikio SHG. This process involved writing and responding to letters and defining the theme of the visit. On the actual day, Karia SHG members were picked by two Nissan *matatus*[11] at their nearest shopping centre. On arrival, the chairman of Witikio SHG briefed the visitors on the history of the group highlighting the activities, successes and constraints. Later, he led participants to the nursery where he took them through the entire process, from acquisition to dissemination. Afterwards, they proceeded to Witikio's banana plot where a hole of 60 cm by 60 cm by 60 cm had been dug. Near the hole were a bucket of water, a *jembe*,[12] 5 kg of farmyard manure,

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[10] A traditional dish made of a mashed mixture of bananas, potatoes, pigeon peas, and pumpkin leaves.

[11] Swahili word used for a public transport vehicle in Kenya.

[12] *Jembe* is a fork-shaped tool used for performing farm activities such as digging and weeding.

200 g of DAP, and 60 g of Morcup. The chairman used these materials to demonstrate and transmit skills and techniques of planting a tissue-cultured banana plantlet to the visitors.

After the demonstrations, there were a lot of questions on tissue-cultured bananas, which led to exchange of know-how and experiences between the two groups. Later in the afternoon, the guests were taken to observe Witikio's other farming activities. At the end of the day, Karia SHG members purchased the tissue-cultured banana plantlets, thus acting both as a market outlet and a dissemination channel for their area.

These processes of collective tasks performance, group's governance and dissemination became routinized practices over time, which resulted in the emergence of a viable group with a specific code of ethics and governance structure.

4.4 Discussion

The case study of the successful performance of the Witikio SHG raises the question why this group was able to stay intact for a longer period, to generate economic benefits, and to disseminate TC banana plantlets in the region so effectively. This chapter examines how and why groups remain viable and consistently perform tasks essential for the induced process of technical change. The case study of Witikio SHG suggests that this outcome was the result of several processes: collective performance of technical and managerial tasks shaping a group structure fit to the task, the emergence of governance mechanisms in a task-oriented group, and the capacity of the group to combine strong horizontal ties and weak vertical ties.

4.4.1 Collective performance and group governance

Part of Witikio's routine work was to transmit TC banana skills and techniques to their customers. Through this, the group reciprocated the technical training gesture it had received from experts such as KARI and MoA. This transmission of skills and techniques created high demand that created employment to group members through increased sales and income for group and individual members through the equally shared dividends. The dividend benefits motivated members to adhere to group's rules and code of ethics, for fear of losing this valuable income. These findings agree with Dietz, Ostrom and Stern (2003) and Demsetz (1997) who argued that the extent to which group members depended upon the collective goods enhanced their successful performance. Furthermore, the accumulated transmission of TC banana techniques and skills to other farmers increased adoption rates for the technology.

To facilitate collective task performance, the group developed a comprehensive governance process, including group-specific hierarchical structure and a variety of internal control and correction procedures. For instance, the group had a code of ethics and rules to regulate individual behaviour. Failure to adhere to these rules and ethics was sanctioned with fines, penalties and sometimes expulsion from the group. Additionally, three monitors were in charge of gathering information on deviant behaviour, and a ‘court’ was put in place to judge culprits. This social organisation with an approved process of governance based on rules, code of ethics, sanctions, and chain of command corrected deviant behaviour, managed conflicts and created a favourable environment for collective task performance. Furthermore, the provision of a court offered an opportunity for suspected culprits to present their side of the story. This finding echoes the work of Varughese (1999) who asserted that the provision of a forum for discussion provided group members with a chance to express their grievances and find common solutions for the welfare of collective action.

Although members were from the same village and spoke the same language, they did not have close kinship ties such as being brothers, sisters, cousins or nephews. This partly explains why sanctions and penalties were applied equally to all members without discrimination, strengthening group performance (as also observed by Mcfeat [1974], for certain tasks absence of kinship ties contributes to effective group performance).

These findings anchor well with a large body of literature that argues in favour of governance structures and institutional rules and ethics for effective group performance. Many authors – including Baland and Platteau (1996), Mcfeat (1974), Olson and Olson (2009) and Ostrom (1990) – have argued that the ability of group members to collectively establish and modify rules, norms, and obligations to govern themselves greatly enhances their performance. Other studies that examined birth and death rates of dairy goats among groups in Kenya and Tanzania also concluded that high levels of success were related to incentives and groups’ governance structure (De Haan 1999, De Haan *et al.* 1996). Narayan and Pritchett (1997) and Baland and Platteau (1996) also found that group performance was positively influenced by past ability to organise cooperatively.

Successful completion of collective tasks and organisational viability, as observed in Witikio SHG, can further be explained through the notion of group’s internal cohesion and strength. Communal work in the group reflected the *harambee*[13] slogan which is embedded in the socio-economic fabric of the Kenyan society (Kenyatta and Malinowski 1953). This *harambee* spirit also facilitated the process of successful collective task performance, an argument that is in agreement with Place *et al.* (2004), who arrived at similar findings with

[13] *Harambee* means ‘working together to achieve a common objective’ in Swahili.

groups disseminating agroforestry technology and information in Kenya. Social capital is another important concept (Coleman 1988). Some of the resource aspects of social capital include: obligations, expectations, reciprocity, and trust which facilitates cooperation among actors. Using this concept we argue that the reciprocity that emerged from mutual recognition of the obligation to perform collective tasks and the expectation to receive benefits facilitated cooperation among members, which in turn contributed to internal stability and the group's sustainability.

Similar findings on how social capital positively impacted on the outcomes of collective action are reported in rural South Africa by Haddad and Maluccio (2002), in rural Tanzania by Mushi (2000), for women in the slums of Nairobi by La Ferrara (2002), and for the poor in Bolivia, Burkina Faso, and Indonesia by Grootaert (2001). Additionally, the concept of bonding social capital as discussed by Putnam *et al.* (1994) suggests that the group's internal cooperation in collective task performance and viability resulted from close relationships that emerged in the practice of collectively managing the nursery – which also included making errors or handling tension. These findings agree with Pretty (2003) who argued that social bonds play a critical role in collective performance, citing bonding and bridging social capital as critical features for successful task performance.

4.4.2 Embedding and networking

Additionally, the group needed various resources (funds, technology, technical know-how) and market opportunities to perform its specific tasks. To access these resources, the group engaged in the processes of forging various vertical network relationships, through the chairman's acquaintance with national and international organisations. In addition to vertical networks, the group used her horizontal network embedding in communities – friends, relatives, neighbours and several churches in particular – as dissemination channels.

The case study documents how the group forged horizontal and vertical network relationships. The case study therefore supplements McFeat (1974) conceptualisation of collective task performance and how task-oriented groups relate to the environment with Granovetter's analysis of embeddedness and the strength of weak ties (Granovetter 1973, 1985, 2005). Building on this framework, Witikio's vertical network relationships at international and national level can be considered as weak ties, while the diversity of churches, friends, relatives and neighbours enabled maintaining a variety of strong horizontal ties. The group used weak ties to access vital economic resources such as funds, technology and technical know-how that were required in collective performance of specific tasks

(Granovetter 1973, 1985, 2005). The assumption is that relying exclusively on strong ties, such as friends and relatives, would be redundant, as these actors already knew each other and had the same resources. A further disadvantage of strong ties is linked to path-dependency arguments, i.e. a lock-in effect in favour of a particular technology or way of doing things (Granovetter 1973, North 1998). The group's successful track record hinged on its ability to take advantage of its strong ties that created dissemination opportunities and of its weak ties that enabled gaining access to resources.

A crucial question that remains, however, is whether the group could have been able to perform successfully and remain viable without the charismatic leadership, dynamism and dedication of their chairman. He played a catalytic role in various ways. First, his past experiences helped the group forge vertical network relationships, which provided access to various resources. Second, his knowledge was instrumental in writing proposals to unlock funds from various donors. Third, the chairman used his technical skills and extensive leadership experiences to coordinate and supervise all group's activities. This finding supports the argument that high levels of education among group members can contribute to group success (Lyne *et al*. 2008, Lubell *et al.* 2007). In this case, the chairman's managerial and networking capacities greatly enhanced the group's performance.

CHAPTER 5

Farmer groups navigating partnerships and land tenure in seed potato multiplication in the Central Highlands

5 Farmer groups navigating partnerships and land tenure in seed potato multiplication in the Central Highlands

5.1 Introduction

This chapter compares the findings of the tissue-cultured banana case from the previous chapters with the outcomes of the Irish potato case, another partnerships intervention to introduce technical change for responding to diseases in the Central Highlands. The Irish potato case resembles the banana case in various ways. Both crops are important for food security and cash generation. Both crops suffered a sharp decline in yields due to diseases. Bananas were infected by *Fusarium* wilt while Irish potatoes were infected by *bacterial* wilt. Both cases forged partnerships to avert the problem. This strategy relied on access to disease resistant varieties and the use of TC techniques for multiplication of planting materials. Both cases used farmer groups for organising multiplication of seed potato and as dissemination channels.

Although multiplication of clean seed potato is considered a public good (Olson 1965, 2009, Pray and Umali-Deininger 1998), the multiplication and dissemination of tissue-cultured seed potatoes included elements that fall in both public and private domains. In the private domain, technology firms brought proprietary TC techniques and other resources, such as fertilizers and chemicals, while the public domain provided services such as micro-propagation, inspection, multiplication and dissemination. KARI also initiated partnerships with international and national research organisations, public organisations, private organisations, bilateral and multilateral donors, and NGOs (Hall 2006, Hartwich and Tola 2007, Spielman *et al.* 2010). Access to improved planting material was accompanied by the introduction of tissue culture techniques for multiplication of clean planting materials.

To overcome the constraint of inadequate land for availability for seed potato production, and in addition to the formal partnerships at national level, KARI partnered with farmer groups. Farmer groups offered land for seed multiplication and provided labour for all the crop's activities such as planting, weeding, harvesting, marketing and dissemination. Despite their immense potential, partnerships failed to deliver a reliable volume of quality seed potato to the farmers as was envisioned.

This chapter will explore and analyse the exact causes of why these partnerships failed to perform. Let's start by revisiting the debate on the effectiveness of partnerships in meeting their objectives. Many contributors to this debate argue that there are few examples of successful agricultural partnerships that partially meet their objectives – and even fewer examples of complete success (Ayele *et al.* 2006, Hall 2006, Byerlee and Echeverría 2002). Most studies that examine the constraints to successful agricultural partnerships (also including the previous chapters) focus on factors endogenous to the partnerships, such as divergent views, power relations, different incentive structures, clashes with working styles, complex intellectual property rights (IPR) arrangements, and unsupportive institutional arrangements and cultures (Byerlee and Echeverría 2002, Spielman and von Grebmer 2006b, Hall 2006).

The case study presented in this chapter shifts attention from the performance and task-oriented analysis in the previous chapter to the inclusion of materiality. The capacity of the farmer groups to multiply and deliver a reliable volume of quality potato was heavily conditioned by the confluence land tenure, crop and plant diseases interactions, and the enabling and constraining conditions for crop rotation. The chapter demonstrates how the history of land tenure, access, distribution and ownership (Section 5.2) affected the performance of small farmer groups partnering with KARI in the multiplication of quality seed potato multiplication (Section 5.3).

5.2 Context

5.2.1 Food security, land distribution and seed potato

In Kenya, potatoes are the most important food crop after maize. It is an important source of carbohydrate, protein as well as vitamins, and plays a major role in food security (Potato Task Force 2009, Muthoni *et al.* 2010). It is also a major source of income through sales and employment for farmers and others in the value chain (Gildemacher *et al.* 2009b, Potato Task Force 2009). Potato production requires ample land for crop rotation (Verma and Shekhawat 1991, Lemaga *et al.* 2001). Furthermore, quality seed potato requires a three-season rotation programme, because potatoes cannot be planted in the same plot for more than one season due to proliferation of diseases such as bacterial wilt (Kinyua *et al.* 2001, Lung'aho 2007, Muthoni and Nyamongo 2009).

Multiplication of quality seed potato in Kenya is constrained by inadequate land availability. This already started with British settler occupation in the main production regions (Duder 1993), freehold tenure of land registration (Barrows and Roth 1990, Place and Migot-Adholla 1998), subdivisions due to population growth (Republic of Kenya 2009), and grabbing of public and government land by the elites (Republic of Kenya 2004, Manji 2012).

Before the arrival of British settlers, KARI Tigoni, otherwise called Muthanga farm was under customary land tenure (Simon 1979, Southall 2005). During this period, the phenomenon of inadequate land for cultivation and grazing was, by all indications, unheard of in this kind of tenure. The community benefitted from the existence of an open frontier which allowed for expansion of living, grazing and cultivation. However, after the Second World War, the local community's traditional land was acquired by the British settlers while the locals were resettled in the less habitable forested areas in Lari (Duder 1993). After Kenya's independence in 1964, the minority settlers were given the option of leaving the country or remain to be governed by the African majority (Leo 1978). The owner of Muthanga farm opted to leave the country. Therefore in 1967, he sold his 97 ha farm to the Ministry of Agriculture (MoA). Facilities at the farm were developed and by 1972 the farm was designated as the national potato research station presently KARI Tigoni and given the mandate of conducting potato R&D based on the British seed system model (Crissman *et al.* 1993, Potato Task Force 2009).

In this model, International Potato Centre (CIP) maintained and supplied *in-vitro* materials to KARI Tigoni, which micro-propagated basic seeds through conventional TC techniques and also conducted research, inspection, and quality assurance, while the MoA offered extension services (Potato Task Force 2009). Quality seed multiplication was then carried out by the Agricultural Development Corporation (ADC) in Molo (Muthoni *et al.* 2010). By the late 1970s, these collaborative efforts had given birth to an effective formal seed system. For instance, in 1986 ADC produced 2,100 tons of certified seed, enough to fully satisfy national demand (Potato Task Force 2009).

The efforts of this system were, however, short lived. In the late 1980s and 1990s sections of government land, including KARI Tigoni and ADC properties, were illegally allocated to local elites (e.g., politicians, professionals, businessmen, and companies), often as political rewards or patronage (Republic of Kenya 2004a, Southall 2005). Indeed more than 72.8 ha of KARI Tigoni and 7,692 ha of ADC land were grabbed. This left ADC with only 32 ha and KARI Tigoni with 20.24 ha, far too little for research and basic seed multiplication activities (Potato Task Force 2009, Kabira 2011 interview).

Land grabbing in KARI Tigoni began in 1972 when 20.24 ha were illegally allocated to a senior government official. Much more land was, however, grabbed in the 1980s and 1990s. In 1985, 12.14 ha land were given to a major general, while 10 ha were allotted to the headmistress of a prestigious school in Kiambu. Later, in 1998, 24.29 ha land were allocated to an MP, while 20.24 ha were given to Renege project Ltd (Republic of Kenya 2004a).

When the centre was almost at the verge of collapse in 1993, Dr Jackson Kabira became KARI Tigoni Director and rose to be its most vocal proponent and defender of land rights. In 1998, he was summoned to KARI HQ to be informed that the KARI Tigoni would be closed and its land deeded to Renege Project Ltd. On his return, Dr Kabira informed his staff of the government's decision to close down the centre. Moreover, Dr Kabira shared this information with the local councillor and the news spread in the community. Consequently, the staff together with the councillor and the local community organised a demonstration that destroyed demarcation fences and other properties belonging to KARI Tigoni (Kabira 2011 interview, Daily Nation 20.6.1998). This angry episode triggered the commissioner of lands to revoke the 20.24 ha title deed issued to Renege Project Ltd. The revocation was followed by intense public actions and numerous court battles of KARI and Kenya Anti-corruption Commission (KACC) against the beneficiaries of grabbed land.

In support of this action, the local MP at the time, Hon. Peter Mwathi, raised the issue of KARI Tigoni grabbed land in parliament in 2008 leading to a debate that culminated in all MPs unanimously endorsing that all illegally allocated land be returned to KARI. In fulfilment of this order, the registrar of titles made a notification of revocation of KARI Tigoni grabbed land titles which were published in a special issue of the Kenya Gazette (The Star 22.6.2010, Mus. 2011 interview, Kabira 2011 interview). This resulted in the return of 6.88 ha to KARI Tigoni. This revocation, however, provoked the beneficiaries of KARI land to go to court claiming their right to land as guaranteed in the constitution and the cases are still pending in court (Mus. 2011 interview). In one case, a retired major general was claiming his right to property while the registrar of lands opposed on grounds that the claimant's rights did not extend to illegally acquired property. The judge, however, ruled in favour of the claimant:

> Whether public land was irregularly acquired by an individual is a judicial matter and the only institutions that can determine if indeed land was unlawfully acquired are the courts and tribunals **(**Daily Nation 24.4.2012 pg. 9).

As a strategy to address the constraining land condition, KARI Tigoni forged formal and informal partnerships with other actors in the potato sub-sector. In the formal partnership various partners signed a contract stipulating their specific contributions in the joint venture, while in the informal case they complemented their resources without any official contract.

5.2.2 Formal PPPs with farmer groups

The partnership contract was signed by KARI, CIP, and other actors. In this partnership, Deutsche Gesellschaft für internationale Zusammerarbeit (GIZ), CIP, and the U.S. Agency for International Development (USAID) provided funds – USD 20,000 in total – for constructing the required TC infrastructure at KARI Tigoni. The contract had the following objectives (a) to revive the collapsed formal seed system; (b) to ensure that certified seeds of the most preferred varieties were multiplied; and (c) to distribute roles among partners in a complementary manner to ensure efficient execution of all facets in the sub-sector (e.g., research, basic seed production, multiplication, certification, and dissemination).

Additionally, the MoA provided KSH 12.5 million (EUR 110,873) to finance all operations, from basic seed multiplication at KARI Tigoni to extension services. KARI Tigoni was supposed to produce 250 tons of basic seed of the preferred varieties in two years. KARI Tigoni in collaboration with CIP was supposed to access germplasm, develop and maintain varieties, in addition to carrying out research activities on seed agronomy, crop protection, and post-harvest management to support the production process. The government was supposed to provide policy and regulatory frameworks, while KEPHIS was supposed to offer seed inspection services. Seed bulking for sale to farmers was supposed to be carried out by ADC, private farmers and farmer groups.

In accordance with this contract, breeders in collaboration with agronomists, plant pathologists, and food scientists accessed and evaluated various germplasm both on-station and on-farm. Preferred varieties were rapidly multiplied by biotechnologists through TC techniques and aeroponic technology to produce mini tubers. Mini tubers were multiplied at KARI Tigoni and its sub-centres. This process of mini tuber multiplication was supervised and coordinated by the seed manager at KARI Tigoni. Besides, KEPHIS scientists made regular monitoring and evaluation visits to ensure quality. Additionally, the national potato coordinator facilitated, managed and coordinated all the cognitively distributed tasks. After harvest, the tubers were sorted, graded, and packaged in 0.05 tons bags after which they were inspected by KEPHIS and sealed with a certified label ready for sale to seed multipliers, with the bulk going to ADC and agricultural training centres (ATCs) of the MoA. Small quantities were sold to individual farmers and farmer groups who acted as multipliers. In the first year of this partnership operation, KARI Tigoni produced 152.5 tons of basic seed with 150 tons going to ADC and 2.5 tons going to private seed multipliers – a big improvement compared to the 25–55 tons average annual production in previous years (Muthoni *et al.* 2010). This basic seed was an essential resource for further multiplication by farmer groups.

In addition to the formal partnership, KARI entered into agreements with various farmer groups in the region, which were contracted to perform seed potato multiplication and dissemination. This was seen as a strategy of overcoming the problem of inadequate land at KARI Tigoni as farmer groups were supposed to provide land for basic seed potato bulking. KARI Tigoni provided basic seed and technical know-how to farmer groups. GIZ and CIP provided funds for capacity building of the farmer groups. MoA provided extension services, while each farmer group provided a common plot of land for planting seed potatoes and collectively performed all farm activities such as planting, weeding, and harvesting.

One of these farmer groups, the Lari SHG, is the focus of this study. Before examining performance of its four sub-groups in detail, the next section first describes the specific history of land tenure, distribution and ownership at the Lari location.

5.3 Results: farmer groups failing to perform

5.3.1 Land tenure at the Lari location

Up until 1945, the area was covered by a thick equatorial forest and inhabited by indigenous Dorobo people, who were mainly hunter-gatherers. However, after the Second World War the ancestors of the Lari community were forced to migrate there from their original homelands in Tigoni, to pave way for British settler occupation. The Lari migration was led by Luka Kahangara, a colonial court interpreter loyal to British administrators. On arrival to Lari, Luka became the paramount chief collecting taxes and executing punitive measures for non-compliance. Besides, he seized 324 ha of land for himself, while ordinary people were given 4.05 ha each. A small number of elites (e.g. colonial clerk and teachers) loyal to the government were also given substantial land. For instance, Juveniles Gitau, Luka’s confidant, received 81 ha (key informant interviews Ng-2011, Ch-2011**,** Mu-2011**).**

Land adjudication and consolidation in Lari took place in 1957, followed by demarcation and registration in 1958. During land demarcation, each plot was sub-divided amongst the sons of the owner, who received title deeds on freehold land tenure basis. As the population increased, however, land acreage decreased inversely reaching today’s 0.404 ha per household (Republic of Kenya 2009). People with big acreage came from Luka’s and Gitau’s lineage and were rich by local standards, as land was an important livelihood asset and a symbol of wealth. Besides, their parents gave them good education, which enabled them to secure good salaries and in turn to buy more land. This was exemplified by the chief, the son of Gitau, who had the most land among farmers in the four sub-groups.

This history of land distribution in the locality explains why farms in Lari were small, generally family-run, and dependent on manual labour largely for subsistence livelihood (using little external inputs). Farmers grew maize, beans, peas, cabbages, carrots and potatoes mainly for family use. Dairy cows were kept for both subsistence and cash income. In the late 1990s, demand for vegetables in big towns like Nairobi and Mombasa triggered the growing of spinach and kales for commercial and subsistence purposes.

5.3.2 Potato production in Lari

Potatoes have been cultivated in Lari since 1945; however, the production of quality seed potatoes became an important enterprise in 2008 with the KARI, MoA, CIP, GIZ partnership (key informant interviews Ng-2011, Gi-2011, Mu-2011, Wa-2011). The Lari location chief attended one of these partnership events where he received information on the partnering opportunities. When he returned home, he mobilized support for the idea among farmers in his location. Subsequently, farmers agreed with the chief's idea to organise themselves into a group and went to KARI Tigoni for a one-off technical training on the process of seed multiplication. Following the training, these farmers formed a group which they called Lari SHG and registered it with the Ministry of Culture and Social Services in 2008. After registration, members divided themselves into sub-groups according to villages: (1) Raine Njeke, (2) Kwarengi, (3) Githirioni, and (4) Scheme.

These four sub-groups were each given a bag of 0.09 tons of certified basic seed potato of Tigoni and Asante varieties by KARI Tigoni for multiplication and dissemination. Moreover, the KARI Tigoni seed manager described the agronomic and cultural crop management practices in detail, and each sub-group rented land for seed multiplication. It was envisioned that once harvested, tubers would be sold to other farmers, thus disseminating the technology. Evidence, however, shows that the sub-groups did not deliver a reliable volume of quality seed as was predicted (see details below).

This chapter tries to explain why Lari SHG did not produce a reliable volume by looking at the interaction between land tenure and seed potato production. Group interviews revealed that it was difficult to rotate potato production because there was not enough land for both collective production and for individuals. Therefore, the groups mentioned that when plant diseases manifested (see Figure 5.1) they had constrained capacity to respond with the required crop rotation (Verma and Shekhawat 1991, Lemaga *et al.* 2001). Table 5.1 shows the available land among the four sub-groups. The tension between land availability and plant diseases resulted in the collapse of sub-groups 3 and 4 after the first two seasons. Sub-group 2 opted to grow indigenous vegetables such as spider plants and amaranths that were less affected by diseases. Sub-group 1 continued multiplying seed but did not follow the recommended agronomic and cultural crop management practices for rotation and seed replenishment, which led to disease infections and declining yields. The organisational histories of the four sub-groups are presented below.

Table 5.1: Characteristics of sub-groups of Lari SHG

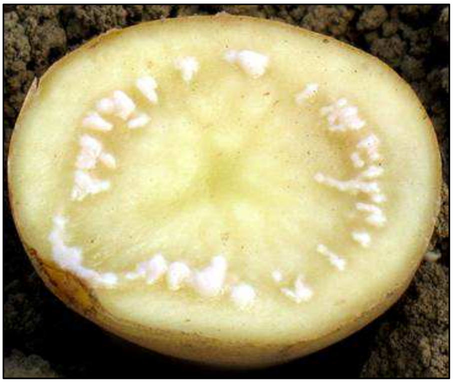
	Sub-group 1	**Sub-group 2**	**Sub-group 3**	**Sub-group 4**
Total membership	12	12	12	9
Male	8	7	0	7
Female	4	5	12	2
Age range (years)	40 to 60	38 to 63	39 to 66	39 to 60
Owns a bank account	yes	yes	no	no
Has by-laws	yes	yes	no	yes
Drop-outs	none	none	2	2
Range of members' farm acreage (ha)	0.4 to 8.5	0.2 to 1.6	0 to 2.8	0.2 to 1.6
Average acreage (ha)	0.8	0.4	0.41	0.4
Soil type	Andosols & Nitosols	Andosols & Nitosols	Andosols & Nitosols	Andosols & Nitosols
Prior history of seed multiplication (years)	none	none	none	none
Number of those with off-farm activities	4	3	0	1
Retired civil servants	3	3	2	1
Ordinary members	5	6	10	7
Group meetings	regular	regular	irregular	irregular

Source: Focus group and key informant interviews.

Late blight damage on potato plants

Bacterial wilt damage on potato plants

Bacterial wilt infected tuber



Cross section of a bacterial wilt infected tuber

Figure 5.1: Plant diseases observed in seed potato production in Lari
Source: Field observation pictures (2011).

5.3.3 Sub-group 1

This sub-group comprised twelve members, four female and eight male, out of whom one member was the chief, two sub-chiefs, one pastor, three retired civil servants, and five ordinary farmers. The members were 40 to 60 years old, with no drop-outs since group formation in 2008. Members had between 0.4 and 8.5 ha of land with an average of 0.8 ha. The sub-group had by-laws to safeguard collective interest, and a bank account where funds were deposited and saved. Members used to meet every Wednesday to discuss and perform group activities, with a penalty of KSH 250 (EUR 2.50) for non-attendance. The sub-group was managed by an executive committee comprising a chairman, secretary and treasurer, all elected through a secret ballot. The chairman, a retired civil servant and a respected charismatic leader, coordinated all the activities. The sub-group was divided into two sub-committees, each performing a distinct task. These sub-committees were: (a) the management committee, and (b) the marketing committee. The marketing committee comprised of four members whose task was to scout for markets to sell the group's outputs at premium prices. They were also responsible for purchasing inputs. The management committee had five members, including the executive committee and two ordinary members. Their tasks were to manage, plan, monitor and evaluate the group's activities.

After receiving the technical training and 0.09 tons of certified seed of Tigoni and Asante varieties,[14] from KARI Tigoni in 2008, the sub-group rented 0.30 ha of land from their chief for quality seed multiplication. Land for lending was only available from the chief because he had the biggest acreage of land (owing to his lineage). This land had Humic Andosols soil type that was well drained with a pH of 5-6 (Jaetzold 2010). The plot had a cultivation history of being under maize and beans but over the previous ten years it was planted with pears under grass fallow. Members had no prior history of seed multiplication but had been cultivating potato for subsistence using a rainfall pattern that allowed three planting seasons per year. The sub-group therefore planted seed potato three times per year without rotation, from October 2008 to August 2011, which led to seed degeneration, disease infections, and yield reduction as demonstration below.

During the 2011 season, when the researcher followed the group's activities closely, she observed that on the day members were supposed to dehaul,[15] the leaves had started drying up. Observations revealed that the leaves were turning brown and were drying because of late blight (*Phytophthora infestans)* infection as demonstrated in (Figure 5.1). Instead of dehaulming, the group decided to harvest. During harvesting, the researcher observed two plants that were infected with bacterial wilt (*Ralstonia solanacearum*) (see Figure 5.1). Phytosanitary regulations dictate zero tolerance for the disease (Kinyua *et al.* 2001, Potato Task Force 2009).

Bacterial wilt is regarded as the most important disease for reduced yields (Muthoni *et al.* 2010, Gildemacher *et al.* 2011). The disease is considered more problematic than late blight because there is no known chemical control; once infected the plant cannot be treated

[14] The two varieties are the most preferred by farmers and consumers due to their high yields and good culinary attributes like texture and taste.

[15] Dehaulming, or the destruction of haulms before the crop matures naturally, is carried out to (a) reduce the risk of late season virus transmission by winged aphids; (b) prevent further growth of tubers, thus ensuring good size for seed; (c) promote the skin of tubers to harden and prevent bruising during and after harvest; and (d) prevent spread of airborne fungal diseases such as late blight from spreading within the crop.

(Lung'aho 2007). The symptoms of bacterial wilt included wilted leaves where the stems branch out. Additionally, tubers from infected plants had bacterial white ooze that had collected at the tuber eyes (see Figure 5.1) and stolon's end, causing soil to stick on the surface of the tubers. When the tubers were cut in half, blown rings were visible (see Figure 5.1). These tubers were selected and destroyed but diseased haulms were not destroyed nor were they removed as required by field hygiene protocols. Diseased haulms were, instead, left on the plot which is a production risk as it facilitates spread of the bacteria.

After harvesting there were 0.9 tons of ware potato and 0.65 tons of seed potato from the Asante variety, while the Tigoni variety yielded 0.34 tons of ware potato and 0.14 tons of seed potato. In total the group had 1.24 tons of ware potato and 0.79 tons of seed potato from both varieties with an overall total of 2.03 tons from the 0.202 ha. During this season only 0.202 ha were planted with seed potato; the remaining 0.098 ha was planted with kale. This translated to tuber yield of 10 tons/ha – much lower than the 45 tons/ha produced at KARI Tigoni research station during the same season. The sub-group's yield, however, was higher than the 7 tons/ha usually obtained by ordinary farmers (Potato Task Force 2009). During the previous four seasons, the group's yields were 20, 19, 17, and 14 tons/ha respectively. This declining trend prompted the researcher to interview members on their farming practices:

> **Researcher:** Do you cultivate potato in rotation with other crops in this plot?
>
> **Farmer 1**: No, but we know that if our plot is planted with potato this season, the second season should be planted with other crops not related to potatoes following a suitable crop rotation schedule. The third season should be left under grass fallow before potatoes are grown. But our problem is that we do not have any other land where to practice rotation.
>
> **Farmer 2**: We were trained that rotation helps in the reduction of build-up of diseases such as bacterial wilt, improvement of soil fertility, and avoidance of volunteers. But our biggest constraint is inadequate land to practice this rotation.
>
> **Extension staff**: Although farmers are multiplying seed, I find it hard to convince them to practice a suitable crop rotation plan. I have tried in vain to tell them to divide their land into four different portions where they can practice rotation. They usually tell me to get them more land, but I have no power over land.

All farmers admitted that seed potato cannot be planted in the same plot for more than one season. In practice, however, they had been planting seed potato on the same plot for the previous four seasons since 2008, without practising the recommended three-season rotational programme because, according to them, they had no land for rotation. Additionally, they did not practice the three season flush-out seed production system because of inadequate basic seed leading to disease build-up, seed degeneration and lower yields. This explains why the sub-group yield of 10 tons /ha was much lower than the 45 tons/ha obtained at KARI Tigoni.

5.3.4 Sub-group 2

The group was comprised of seven men and five women, aged between 38 and 63 years old (see Table 5.1). Among them were two retired teachers, one carpenter, two businessmen and the rest were ordinary farmers. The group had by-laws, a chairman, a treasurer and a secretary. It also had a coordinator of activities, a welfare officer and a marketing officer. The group held meetings every Tuesday to discuss and implement group activities. All group tasks were performed communally, with a penalty of KSH 250 (EUR 2.50) for non-attendance. Members owned between 0.2 and 1.6 ha, with an average of 0.4 ha.

After receiving technical training and a bag of 0.09 tons seed from KARI Tigoni in 2008, the sub-group rented 0.3 ha plot from one of its members, a teacher who owned the most land. The teacher had used part of his savings to buy land in addition to what he had inherited from his parents. This plot was under grass fallow for four years. It had well drained fertile Humic Andosols and Nitosols that had a general pH of 5-6 (Jaetzold 2010). The group members had no prior history of quality seed multiplication as they used to grow potato only for subsistence. During their first season of seed potato multiplication, the crop’s vigour and appearance was quite impressive, attracting many visitors, especially neighbouring farmers, to view the new and ‘famous’ Asante and Tigoni varieties. The crop, however, was affected by bacterial wilt leading to its disqualification as quality seed potato. All harvested tubers were, therefore, to be cooked and not planted because planting this seed would spread the bacterial wilt virus. Accordingly, members divided all the tubers equally among themselves, abandoned the plot whose soil was already infested by the bacterium with the hope of finding other suitable land. The sub-group was, however, unable to secure another plot of clean land.

Frustrated by the twin problem of bacterial wilt and lack of land, the sub-group that was quite cohesive signed a contract with Uchumi supermarket and started growing the less risky indigenous vegetables (spider plants and amaranths). These vegetables were grown in individual farms but sold collectively. Members chose to plant vegetables because they were less disease prone, required less stringent crop rotation programmes, were less management intensive, and did not require high level technical expertise and strict adherence to field sanitary procedures. Besides, these vegetables had a ready niche market at Uchumi supermarkets in Nairobi. Other crops grown by members included maize, beans, peas, carrots, kales, and spinach. Dairy cows were also kept.

5.3.5 Sub-group 3

This sub-group had twelve females aged between 39 and 66 years, two of whom were retired civil servants with the rest being ordinary farmers (see Table 5.1). Members had between 0 and 2.8 ha with an average of 0.41 ha. The sub-group had neither a bank account nor by-laws. After technical training on the process of seed multiplication at KARI Tigoni in 2008, the sub-group was given 0.09 tons bag of Asante and Tigoni varieties. It rented 0.31 ha of land from one of its members. The plot was located near the homestead and was under grass fallow for five years. It had well drained fertile Humic Andosols and Nitosols soils with a pH of 5-6 (Jaetzold 2010). Members planted seed potatoes and performed all farm operations collectively, with a penalty of KSH 250 (EUR 2.50) for non-attendance. They had no prior experience with seed multiplication. The group followed the recommended agronomic and cultural management practices, and the crop passed field sanitary regulations. After harvesting, the seed for the following season was stored; however, during the second season the owner, Mrs Ki, decided to take her land back:

> The family has only 0.81 ha. On this land we grow subsistence crops (e.g., maize, beans and Napier grass). The family rented 0.31 ha to the group because we felt obliged to do so as there was no other land to demonstrate the technology in our village. (Ki-2011 interview)

During the second season, the sub-group rented another 0.35 ha from another member, who was a retired civil servant. After the first season, the owner became unhappy with the group's management. She disagreed with the chairlady and stepped out of the group. After dropping out, Mrs Ma repossessed her land for family use:

> The family needed the land for its own use as we do not have enough land to meet all our food and financial needs. (Ma- 2011 interview)

Sub-group 3 searched in vain for another piece of land. Frustrated by their fruitless efforts, members decided to share the seed amongst themselves. Once members received their share, they were at liberty to do whatever they wanted with it. Some members shared their seed with their sisters or mothers or gave them to friends and neighbours, thereby disseminating the technology. After this incident, the group disintegrated as it did not have any other common activity to perform. After its collapse, some members continued growing seed potato in their own plots for their own use but they did not practice rotation due to inadequate land. In addition, they did not replenish their original seed due to lack of certified seed. This led to disease build up in the soils and a reduction in seed quality and quantity. Other members abandoned seed potato production and went back to growing traditional crops (e.g., maize, beans, peas) and dairy cattle rearing.

5.3.6 Sub-group 4

This sub-group had nine members, two females and seven males, aged 39 to 60 years. It had one pastor, three businessmen and five ordinary farmers. One male dropped out during the initial stages of the group's activities. The members had between 0.2 and 1.6 ha with an average of 0.4 ha. They had a chairlady, a treasurer and a secretary elected through a secret ballot. The sub-group did not have a bank account or rules to regulate group behaviour.

After their technical training on the process of seed multiplication at KARI Tigoni in 2008, the group was given a 0.09 tons bag of Asante and Tigoni varieties. The group rented 0.30 ha from one of their member, a pastor who had 1.6 ha. The pastor had more land than other members because he had a taxi business and all his children lived abroad. Therefore, he used the profits from the taxi business and remittances from his children to buy more land. This plot was previously under grass fallow for six years and had well drained fertile Humic Andosols and Nitosols with a general pH of 5-6 (Jaetzold 2010).

The members had no prior history of seed multiplication since they used to grow potatoes only for subsistence. All group activities were performed collectively with a penalty of KSH 250 (EUR 2.50) for failure to attend a group working day. The seed passed the field sanitary regulation, was harvested and stored in the pastor's house while the ware tubers were divided equally among the group members for home consumption. Unfortunately, soon after harvest, the pastor dropped out of the group and repossessed his land. The sub-group, whose members had an average of 0.4 ha, was left with no land to continue the task of seed multiplication. It searched in vain for another clean land plot. When its efforts proved futile, the sub-group divided the seed equally among its members. Having no more common activity to necessitate regular meetings, the group disintegrated. After the collapse, members reverted to growing their usual crops (e.g. kales, carrots, maize, beans and peas) and keeping dairy cows in their own plots for cash and subsistence.

5.4 Discussion

This study of the PPP initiated by KARI and the case studies of four farmer sub-groups multiplying and disseminating seed potato demonstrates that the formal and informal partnerships with smallholder farmer groups did not provide a reliable volume of seed potato. Although the formal partnership produced basic seeds with improved yields at KARI Tigoni – from 55 tons Muthoni *et al.* (2010) to 152.5 tons per season – this volume was insufficient to cover the domestic market. KARI Tigoni had limited access to land and sought to increase seed volumes by working with farmer groups; however, these collaborations were not successful also due to precarious access to land. A better solution would have been for the partnership to directly buy additional acreage or repossess grabbed land.

Land was also a constraining factor for the contracted farmer groups which provided collective land for bulking and performed all the activities of quality seed multiplication. However, the constrained land distribution resulted in lack of rotation and disease infestations. Hence, to explain why the partnerships did not perform as predicted, the study suggests looking at conditions outside the internal logics of the farmer groups.

The informal partnership with farmers groups acting as quality seed multipliers did not deliver a reliable volume and had little influence over the land issue. When the crop's yields declined, the public extension officers could not solve the problem. Even when it became apparent that poor access to land was jeopardising quality seed multiplication, as seen in sub-groups 2, 3 and 4, the partners were not able to come up with specific tailor-made solutions to solve the contextual constraint of land availability.

Left on their own, the farmer groups responded to their problems in different ways. Sub-group 1 multiplied seed potato on the same plot without rotation for five seasons, which led to bacterial wilt infections and declining yields (from 20 tons/ha in the first season to 10 tons/ha in the fifth season). Moreover, the sub-group continued to plant the same seed without practising the recommended three-season, flush-out seed production system (Lung'aho 2007, Gildemacher *et al.* 2009a, Gildemacher *et al.* 2011). Sub-*g*roup 2 already failed in seed multiplication during the first season. The group, however, remained viable but opted to grow indigenous vegetables that were less risky and sold them collectively to a supermarket. Sub-*g*roup 3 rotated their crop once by accident, because they lost the first plot of land. However, the group collapsed after the second season when the second owner repossessed her plot. Sub-*g*roup 4 collapsed after only the first season due to lack of land access.

Looking at the case outcomes, this chapter argues that effectiveness of multi-layered partnerships in realising technical change not only depends on institutional and managerial dimensions within the boundaries of the partnership, but is deeply rooted in the specific material dimensions of the tasks and performance central to the partnership. These results suggest that partnerships should not be seen as silver bullet solutions for solving persistent development problems (Kilelu *et al*. 2013, Ayele *et al.* 2006). Hence, explaining the performance of partnerships needs to go beyond internal dynamics (Pray and Umali-Deininger 1998, Spielman and von Grebmer 2006a, and Spielman *et al.* 2010) and include capacities of partnerships to influence external conditions (e.g. land distribution).

Furthermore, the results imply that a successful partnership in a specific context cannot automatically be replicated in another context. For instance, the banana case (Chapters 2 to 4) shows that partnerships performed well in quality seed multiplication and dissemination. But the same cannot be said for similar partnerships in the Irish potato case. This finding conforms to the conclusions of De Vaus (2001) and King *et al.* (1994) who asserted that replicating the successes from one case in another is unlikely. This highlights why it is not always right to perceive one successful case, such as that of bananas presented in the previous chapters, as the best practice that should be replicated.

The study recommends that in addition to ensuring that endogenous factors, such as pooling of resources and synergies, are achieved, KARI and other partners need to factor in tailor-made contextual solutions to localised exogenous constraints, such as inadequate land, lack of rotation, and disease infestation. In the case of the contracted farmer groups, this could be done by (a) working closely with farmer groups in finding more land for rotation that could be managed collectively, and (b) hands-on supervision of farmer groups by the technical team to ensure that all the recommended agronomic and cultural crop management practices are followed to the letter despite land constraints. Additionally, this requires a government policy that ensures that all grabbed land meant for research and seed multiplication is reverted to KARI Tigoni. Alternatively the government can buy or lease more land for basic seed multiplication, thus creating an enabling environment for partnerships to produce adequate volumes of clean seed potatoes for public consumption. A pre-condition for this action is to consider basic seed potatoes as public goods, i.e. non-excludable as argued in the concept of collective goods (Olson 1965, 2009, Pray and Umali-Deininger 1998).

CHAPTER 6

General discussion and conclusions

6 General discussion and conclusions

6.1 Introduction

In the mid-1990s, *Fusarium* wilt devastated banana crops in Kenya, plummeting production levels to 200,000 tons per annum, a figure less than an eighth of current volumes. This problem threatened food security and incomes for those dependent on the banana value chain. To overcome the problem, Kenya Agricultural Research Institute (KARI) and International Service for Acquisition of Agri-biotech Applications (ISAAA) initiated formation of partnerships based on the rationale of pooling resources and creating synergy, as argued by Spielman *et al.* (2010), Hall and Clark (2010), and Ayele *et al.* (2006).

In the case of the Kenyan banana sector, the private sector, linked to global R&D companies, was a major source of research expertise. Life sciences companies, in particular those specialised in TC techniques, brokered the import of Cavendish germplasm and provided technical expertise. These companies entered into collaboration with national and international agricultural R&D centres (Wambugu *et al.* 2008, Njuguna *et al.* 2008, Njuguna *et al*. 2010). This emerging network of private and public organisations sought out collaboration with associated farmers and other actors in the banana chain, in order to link R&D to the final users of TC bananas.

The availability of TC techniques resulted in a shift from traditional varieties, such as *Muraru* and *Kiganda*, which were susceptible to *Fusarium* wilt, to the adoption of resistant Cavendish varieties, such as Grand naine, Giant Cavendish and William hybrid. The thesis analysed this process as a chain of technical change and the empirical chapters described its subsequent stages. In the first stage, a select group of farmers collaborated with a multidisciplinary team of scientists to select banana varieties, offering their land for on-farm trials while other partners in the banana chain provided various resources and services (Wambugu *et al.* 2006, Wambugu and Kiome 2001, Njuguna *et al*. 2010). The selected banana varieties formed, in the second stage, the ingredients for micro-propagation using TC techniques in the laboratory. This micro-propagation task involved coordination of a team of specialists with differing knowledge and skills interacting with various tools, machines and users of TC banana varieties through feedback and response exchanges. Dissemination of the tissue-cultured banana varieties was managed by groups of farmers. This third phase is researched from the perspective of how such groups are formed and governed around the collective task of managing a nursery and how the group’s performance is embedded in emerging horizontal and vertical network relationships.

These three stages constitute the chain of technical change. The processes brought farmers and scientists together in different ways and during different phases. The banana case showed partnering processes that seemed to work well (Chapters 2 to 4). The potato case (Chapter 5) revealed that getting partnerships to work also depends on specific conditions – in this case land access.

These developments represent a more general trend towards the formation of partnerships in the agricultural sector to overcome problems in accessing new markets, competing in domestic and international markets, acquiring new cutting edge technologies, and proprietary rights (Hall *et al*. 2001, Hall *et al.* 2002, Spielman and von Grebmer 2006, Hall and Yoganand 2004). Accordingly, partnerships can be conceptualised as organisational set-ups that enable partners to share and complement resources and to create shared value (Austin 2000, Spielman and Grebmer 2006).

However, this thesis shifts the analytical focus towards what happens after the initial creation of a coalition of partners and seeks to understand how partners manage technical and organisational processes during different phases of the process. The analysis puts less emphasis on the partnership construct as an achievement, and more on the processes of partnering and the daily realities of socio-technical interactions as well as the micro-politics of decision-making in the process of technical change.

This concluding chapter presents the main insights from this thesis (Section 6.2), based on the methodological choices to study partnerships with a technographic lens, proposes a new way to conceptualise partnerships (Section 6.3) and discusses the implications for policy and practice (Section 6.4).

6.2 Insights from a technographic study of partnering and technical change

The study was conducted through a technographic methodological approach, using detailed accounts as argued by Richards (2000) and Jansen and Vellema (2011). According to Jansen and Vellema (2011), a technographic study has three dimensions comprising (a) the use of skills, tools, techniques and know-how in processes of making, (b) the functioning of task-oriented groups, and coordination in a setting of distributed cognition, as well as (c) the use of rules embedded in professional association and specialisation. Furthermore, according to Richards (2000), the approach also helps map out the various actors and processes in such a way that the analyst can see beyond the technology itself into the problems that the technological applications are supposed to solve. Using this approach, I examined not only the skills, techniques, knowledge, and tools used in the TC micro-propagation procedure but also how different actors handled unanticipated problems that emerged during the process (Sigaut 1994, Richards 2000, Baber 2007).

Beginning in Chapter 2, the technographic approach was used to show how professionals with various knowledge and specialisation agreed to integrate their experience with the farmer's knowledge and 'jointly' select banana varieties. The details of this process helped me detect the underlying micro-politics: some actors acted not only out of rational conviction but also based on emotional, social, and ethical (or rather unethical) drives.

Chapter 3 shows how different specialists linked to a TC laboratory performed and coordinated tasks in micro-propagating disease-free banana planting materials, and how this was connected to daily and routine use of skills, knowledge, tools, and protocols. The detailed study of the process included observation of production practices, correction of errors, and response to client feedback, indicated that the laboratory performed under imperfect conditions (i.e. human and financial resources) and by improvisation involving unanticipated needs. This finding follows Baber (2007) who argued that people constantly engage in a process of improvisation through creativity.

In Chapter 4, the technographic approach was used to analyse how a SHG organised collective management of a tissue-cultured bananas nursery and disseminated banana plantlets. It shows how the group constructed a set of rules (e.g. a constitution and a court) tailored to the needs of the collective task. The group managing the nursery constructed a hierarchical group structure and imposed rules on how to cooperate, allowing it to effectively deal with social deviation and successfully execute its collective tasks. The approach was also used to show how the group forged various local, national and international network relationships for provision of various resources. It also illustrated how collective tasks were performed through distributed cognition and coordination of the various tasks.

The technographic approach presents partnering as an evolving division of labour emerging in the constant use of skills, tools, know-how in daily practices. This highlights the capacity of partnerships to find solutions under imperfect conditions and to coordinate tasks. The technographic interest in socio-technical practices made it possible to trace processes during different stages and at different levels. The practices contribute importantly to the generation of an organisationally layered yet coherent whole generating technical change. How the technographic account enriches the conceptualisation of partnerships is discussed next.

6.3 Conceptualising partnerships

Partnerships are conceptualised as collaborations among various partners with the aim to provide complementary resources and spark synergies in development interventions and R&D processes (Spielman *et al*. 2010, Vellema *et al.* 2013, Bitzer *et al*. 2013). My study acknowledges this conceptualisation of partnerships as an important avenue for solving the complex problem of *Fusarium* wilt, as no single institution, actor or discipline can do it alone. However, the thesis goes further and conceptualises partnerships not only as an organisational tool for resource augmentation, as argued by many authors (Hall 2006, Spielman *et al*. 2010, Hall and Clark 2010), but also as entities that are not only rational, but also emotional and social. The partnerships presented in this thesis are viewed as an evolving chain of sequential socio-technical practices, incrementally generating technical change.

The thesis examined three connected processes that reveals how partnerships contribute to technical change: (a) selection of preferred varieties by researchers and farmers; (b) micro-propagation of varieties in the laboratory using specific skills, knowledge, techniques, tools, machines, rules, and protocols; and (c) collective tissue-cultured plantlet nursery management and dissemination, guided by norms and rules emerging in the practice and related to the group's vertical connection to other networks and horizontal embeddedness in the farming communities. In this conceptualisation, I examined not only the formation of partnerships, pooling of resources, and sharing of technical expertise, but also social issues such as politics related to biased interests, personal interests, power relations, private and financial interests.

The insights from this thesis suggest a conceptualisation of partnerships that emphasises social-technical performances in a setting of distributed cognition (Section 6.3.1) and that takes a closer look at the micro-politics of partnerships (Section 6.3.2). Both institutional dimensions help to explain in which way partnerships sustain and navigate problems that occur after their creation. Moreover, getting partnerships to work also depends on how this emerging institutional configuration functions under specific material conditions (Section 6.3.3).

6.3.1 Partnerships and distributed cognition

Distributed cognition refers to a process in which cognitive resources are shared socially in order to accomplish something that an individual agent could not achieve alone. Cognitive resources can be distributed among tools, machines and materiality (physically distributed) or among cognitive agents with various knowledge, skills and techniques (socially distributed). Here, the focus is on how the distribution of cognition distributed across people and artefacts leads to emerging coordination processes that ensure task completion (Hutchins and Lintern 1995). In accordance with this concept, this thesis shows how cognitively distributed resources such as skills, techniques, knowledge, tools, machines, and materiality (e.g., plant tissues, nutrients, and hormones) involved in the processes of performing the tasks of variety selection, micro-propagation, and dissemination are mobilised and utilised through partnerships.

Beginning with Chapter 2, the thesis shows how partnerships combined cognitive resources – i.e. knowledge from various professionals including agronomists, economists, entomologists, sociologists, pathologists, post-harvest scientists, and farmers – in the process of selecting banana varieties resistant to *Fusarium* wilt. This combination catalysed the process of technical change resulting in the jointly decided adoption of Cavendish varieties.

Chapter 3 investigates the process of performing the more complicated and delicate tasks of micro-propagating bananas using TC techniques in the laboratory. It also examines how feedback from farmers is received by a specialised team in the R&D organisation, incorporated in the laboratory, and responded to. These tasks cannot be performed by a single person. Performance of the tasks involved cognitive resources from a team comprised of various specialists including laboratory technicians, casual labourers and scientists. The team unity emerged from a certain degree of specialisation in which each participant occupied a defined distinct role and contributed one component to the whole process.

Chapter 4 examines Witikio SHG, a banana farmer group that performed three connected activities: plantlet acquisition from the laboratory, plantlet management in the nursery, and plantlet dissemination in the region. These activities were performed with a lot of enthusiasm and dedication on the basis of distribution of tasks according to gender and capabilities as well as an emerging practice of collective performance and coordination. The synchronisation of the various tasks (like fetching soil, the digging of planting holes etc.) was a model of distributed cognition underlying the emergence of group rules and structure. Additionally, this was a product of an ensemble performance and a result of practiced teamwork, all of which combine to facilitate the group's successful performance (Richards 2000, Jansen and Vellema 2011). The finding also fits the analysis of Hutchins and Lintern (1995), who argued that the coordination of cognitive properties within the task environment is conditional for producing an overall effect beyond what any individual could envisage.

This performance-based understanding of distributed cognition suggests that partnerships are formed and reproduced on the basis of what people do and how they work to solve problems in a gradually emerging division of labour and task specialisation in society. Hence, the success of partnerships in initiating technical change depends on the organisational set-up as well as on the coordination of a distributed set of skills and practices. This requirement is in addition to depending on the process of control and correction measures that are installed and used by team members.

6.3.2 Partnerships and micro-politics

This section examines the extent to which micro-politics, within the permeable boundaries of partnerships (Kothari and Cooke 2001, Kumar and Corbridge 2002, Williams 2004), affected the process of selection, multiplication and dissemination of tissue-cultured banana varieties.

Chapter 2 shows how socio-technical interactions among partners in the variety selection process brought to light micro-politics related to power relations, mistrust, bitterness and conflict of interests. The selection took place because there was a select group of farmers aligned with scientists. This group of farmers had resources that enabled their participation in the selection process and were socially and politically connected to the wider community. The required level of closure, i.e. the reduction of choice in order to pursue a certain direction of technical change, partly resulted from the commitment of this select group. Also scientists who enjoyed a privileged position of power within the partnership facilitated closure and guided decisions according to their private interests. The less powerful scientists who opposed this manipulation of the decision-making processes were transferred from the project in order to silence them. Several partners and scientists were engaged and withdrew from the partnership. The way decisions were taken did not reflect transparency and equality among parties, as argued in the concept of partnerships (Hall *et al.* 2001, Hall *et al.* 2002, Spielman and von Grebmer 2006, Pray 2001, Byerlee and Fischer 2002, Hall and Yoganand 2004). The collaboration concept promises a move away from hierarchical structures such as class in development projects (Kothari and Cooke 2001, Kumar and Corbridge 2002, Williams 2004). The unequal power relations as presented here echo other findings that demonstrate that it is not always easy to have equal power relations in partnerships ventures (Ayele 2006; McQuaid 2000; Smith 2005, 2004). Furthermore, such kind of power relations resulting in tensions and bitterness has been reported elsewhere, for example, in a case in Mexico (Grindle 1974). Kilelu *et al.* (2013) also found that tensions resulting from divergent views, and domination of meetings by older men as some of the factors that hindered collaborative projects in meeting their objectives.

This analysis implies that despite hidden dysfunctional processes – such as mistrusts, tensions, divergent views, competition for organisational power, and private financial interests – a shared interest in technical processes, such as variety selection or finding agronomic measures, may balance institutional politics and personal interests. The conclusion is that attention needs to be paid to the micro-politics of power if technological collaborative projects are to make a difference.

Micro-politics also appear in the rules for behaviour underlying the collective management of the nursery examined in Chapter 4. The group had success in the region, as reflected in increased yields, expansion of acreage under bananas and expansion into other activities such as savings and credit schemes. One of the factors contributing to its performance was its strong governance structure, with internal rules on cooperation and sanctions of transgressions (like cheating and freeriding). This set-up provided a favourable environment for performance of various tasks, a finding in line with the argument in favour of sturdy governance and institutional structures to advance positive outcomes of collective action.

Micro-politics are also reflected in the emerging hierarchical group structure. A dynamic, charismatic, and professional leader played the key role. He not only linked the group to various networks, coordinated and supervised all group's activities, but also used his technical knowledge to ensure that the crops' agronomic recommendations were followed to the letter. The functioning of the leader was embedded in mutually agreed rules on how to detect and correct unwanted behaviour of group members. Moreover, group members came from different families and were affiliated to different churches: the group managed the internal micro-politics between these different actors in such a way that the group's collective performance became embedded in the communities of users who accepted the nursery as a source of technical change.

These insights suggest that micro-politics are part and parcel of partnership operations, especially for finding practical interventions for effective decision-making or managing of internal tensions. A partnership gradually evolves rules and governance structures in accordance with the nature of the collective tasks it needs to facilitate. Recognising how micro-politics create rules for cooperation within and outside the partnership boundaries may be more productive than installing generic rules that may not always work.

6.3.3 Partnerships and materiality

The analysis above suggests that the technical change observed in the Kenyan banana sector is related to the way partnerships coordinated distributed cognition and managed micro-politics. The thesis uses the case of the multiplication and dissemination of tissue-cultured Irish potato to explore whether findings of the tissue-cultured banana case can be replicated with other crops and under different circumstances.

The chapters on the banana case suggest that people organise around the production of quality planting material, and are able to achieve social agreement. These chapters demonstrate that collective action can overcome materiality and social tensions. Also, they highlight that in an evolving societal division of labour a certain level of specialisation (e.g. the alliance of lead farmers and a team of scientists) is instrumental for constructing partnerships that are able to continuously find and implement technical solutions in a joint and layered way.

This leads to the argument that partnering processes can induce a protected functionality and use of a set of skills to minimise disruptions, both material and social. The banana chapters reveal a process of closure in which the selection of the recipe (TC Cavendish varieties), the making of the recipe (multiplication of varieties through TC techniques), and the regulation of management and dissemination (the nursery) are consolidated in a working configuration. Organising people around technical change is not merely a matter of arranging membership; rather, it is an evolving process of continuous problem solving that may eventually yield functional organisational set-ups in specific contexts.

Were the patterns visible in tissue-cultured banana case also present in the multiplication and dissemination of quality seed potato in Chapter 5? The answer is no. In both cases farmer groups were linked to R&D organisation laboratories as channels for dissemination of improved varieties. The main differences were the materiality underlying the partnership arrangements. Irish seed potato requires a three-season rotational programme, while bananas do not require much rotation and can be grown on the same plot for many years. Furthermore, banana production begins 12 to 18 months after planting, and good yields can be produced for ten years or more with little inputs (Wambugu and Kiome 2001). Potatoes require ample land for bulking of basic seed at the R&D organisation as well as for further multiplication by farmer groups, while bananas only require a small piece of land for greenhouses, where the TC plantlets are weaned, and another small piece of land for farmer group nurseries, where the plantlets are hardened and sold for dissemination. Once the banana crop is established, harvesting occurs continuously throughout the year while Irish potatoes are grown and harvested seasonally.

The materiality of the multiplication of seed potato required adequate land access for crop rotation. The Irish potato groups could not secure this land and as a result did not practise the three-season rotational programme prescribed for disease control (Verma and Shekhawat 1991, Lemaga *et al.* 2001). The ensuing disease infestation led to the group's eventual failure and collapse. The potato case also suggests that although endogenous factors such as the capacity to pool resources, capacity to exploit synergies, and cooperation among the various partners did exist within the environment – as recommended by various authors Hall (2006), Hartwich and Tola (2007), Spielman *et al.* (2010) – but other exogenous factors like an enabling policy environment for land provision were lacking.

The banana group enjoyed a continuous flow of good quality TC plantlets in and out of the nursery. The Irish potato groups could not secure enough basic seeds for stock replenishment, because of the constrained access to land for multiplication at KARI Tigoni, the R&D organisation. This is because most of the KARI Tigoni land had been grabbed by the elites (Republic of Kenya 2004, Southall 2005). In this case, the dissemination of new, high yielding tissue-cultured Irish potato varieties by a broad partnership was not successful, due to tensions outside the boundaries of partnerships. As demonstrated, context is very important for new techniques to work. Sometimes more traditional, simpler interventions may provide suitable alternatives in materially constrained contexts.

6.4 Policy implications

A policy recommendation arising out of these insights is that even though actors in a partnership appear to have the same interests and rational logic, social and emotional factors should be taken into account. Policies that seek to promote partnerships for technical change should, therefore, pay closer attention to the process of partnering, how and through which rules and procedures it is being constructed in social-technical practices. This process of partnering is made possible by institutions with their own logic, attuned to the materiality and social setting on the ground. In the banana case researchers and farmers found specific ways to select preferred varieties; the laboratory staff worked with rules to effectively respond to errors and user feedback; and, finally, the farmer group set up unique internal norms and regulations that reflected its social environment. These emerging processes resulted in certain processes of correcting behaviour, underpinned legitimacy and stamped out cheating and freeriding. Imposing an organisational fix in the form of a prescribed partnership model may undermine the potentially superior performance of such flexible collaborations.

A second policy recommendation is that the technical and organisational dimensions of partnerships need to fit the specific contexts wherein they operate. This became clear in the analysis of the unsuccessful attempts to collaborate with groups of smallholder farmers to multiply and disseminate tissue-cultured seed potato. A task for the government can be to ensure the restoration of a positive enabling environment as pre-condition for setting up partnerships with smallholder farmers. In the potato case it would mean restoring all redistributed land meant for research and seed potato multiplication to KARI Tigoni to be used for the production of a public good – TC seed potatoes ready for multiplication by farmer groups.

6.5 General conclusion: getting partnerships to work

This thesis demonstrates that the observed process of technical change, i.e. the selection, multiplication and diffusion of tissue-cultured banana varieties, is generated by processes of partnering that reflect a gradually emerging division of labour and specialisation in society. This is embedded in a layered organisational set-up of task-oriented and skilful actions guided by specific rules, and protocols. Hence, partnerships are constantly made to work in the context of daily practices, which are connected and coordinated through sometimes invisible processes. This translates into a perspective on partnerships that looks beyond the pooling of resources as an explanation for why different actors agree to collaborate. The thesis shows that the partnering processes generating technical change are heavily dependent on how partnerships handle additional issues within and outside their boundaries like conflicts of interests, power relations, and local constraints. There are no blueprints for organising R&D partnerships; each case has its unique contextual, political and institutional realities. Partnerships, as an organisational fix, are not a panacea for complicated problems, and a more thorough debate about the conditions under which partnerships may work – and for whom – is needed.

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Summary

This study examines the contribution of partnerships to on-going processes of technical change, specifically related to responding to diseases affecting crops important for food security in Kenya: banana and potato. The researched partnerships organised several stages of the process of technical change and used tissue culture (TC) techniques for the multiplication of resistant varieties. In the early 1990s, *Fusarium* wilt devastated bananas production in Kenya. Such problems require multi-sectoral, multi-disciplinary and multi-component efforts as not any single person, organisation or sector can solve it alone. To solve the problem, partnerships were seen as the best strategy for combining resources and novel technical opportunities to solve this complex problem. The thesis presents a case study of the selection, making and distribution of disease resistant banana varieties, and uses the counter case of potato to compare a similar organisational set-up implemented in a different crop and material conditions. The thesis concludes that there are no blueprints for organising R&D partnerships; each case has its unique situated and contextual political and institutional realities that determine how partnerships contribute to technical change.

In the banana case, international, national and local research institutions teamed up with government agencies, NGOs, and farmer groups to acquire TC techniques and resistant planting material. This partnership agreed to select Cavendish varieties that were resistant to *Fusarium* wilt, micro-propagate them through TC techniques and include farmer groups for disseminating the planting material to the farming fraternity. This resulted in a process of technical change reflected in a shift from the use of traditional varieties, appreciated in the local market but susceptible to *Fusarium* wilt, to dissemination and adoption of Cavendish varieties that were resistant to the disease.

The literature on partnerships tends to emphasise the rationale for the formation of partnerships: Why do actors agree to collaborate and share resources? In the case of banana planting materials this is linked to the acquisition of TC techniques and access to improved banana varieties. The interest of this thesis is to document processes of collaboration and socio-technical practices that occur after the acquisition of TC techniques for multiplication and transfer of planting materials. The thesis investigates how partnering during different stages and at different levels configures an evolving process of technical change. The thesis traces processes and maps distributed task performances to understand how and why partnerships are able to generate technical change. The research emphasises the capacity of partnerships to connect distributed competencies and to configure a chain of social-technical

practices across multiple levels. This shifts attention from an exclusive interest in the organisational design of partnerships working on technical change to the social-technical practices of selecting recipes, solving unanticipated problems, correcting errors, and coordinating actions that incrementally form the process of technical change.

Chapter two shows how the devastation of banana plants in the Central Highlands triggered the formation of a partnership of a research team and a select group of farmers. The multidisciplinary team of scientists and the exclusive group of farmers integrated their various knowledge bases in sequential activities necessary for selecting new planting material and replacing banana varieties appreciated by both farmers and consumers. The findings identify the blending with the micro-politics in decision-making processes in research and the social and political embedding of the selected farmers hosting on-farm trials as conditions for partnerships to agree upon the selection of Cavendish varieties resistant to *Fusarium* wilt.

Chapter three goes further and examines how after the phase of variety selection and acquisition of TC techniques, the banana varieties were multiplied in the setting of a public laboratory. It describes the skilful nature of micro-propagating planting materials by specialised technicians using TC techniques, and identifies the accompanying protocols, managerial procedures, rules, and organisational designs of a laboratory. The chapter uses interactions between different segments of the laboratory and farmers to explore what enabled or constrained the capacity of the laboratory to respond to farmers' feedback and needs. It suggests that the use of fixed protocols tailored to specific varieties and the absence of capacity to modify or fine-tune the performance in the laboratory to alternative varieties made it difficult to shape any new portfolio of demanded varieties that were not in tandem with the set procedures used in a setting of distributed cognition and task specialisation.

Chapter four investigates how the micro-propagated plantlets were acquired by groups of farmers located at strategic locations away from the laboratory using the case of Witikio Self Help Group. The findings shows that the group's performance was related to: the governance structure, modalities of managing conflicts, execution and coordination of specific tasks emerging in the practical realities of the joint management of a nursery and the commercialisation of the plantlets. The vitality of the group was also related to how the emerging small task group forged horizontal network relationships with friends, neighbours, relatives, and churches through which the group disseminated the tissue-cultured banana plantlets. This combined with the capacity of the group to make use of vertical network relationships with national and international organisations for provision of various resources such as funds, technology, technical know-how and market opportunities.

Chapter five compares the findings of the contribution of layered partnerships to technical change in banana (chapters, 2, 3, and 4), with the case of seed potato, another partnerships intervention to introduce technical change for responding to diseases in the Central Highlands. The Irish potato case shifts attention from the performance and task-oriented analysis in the banana case to the importance of material conditions, i.e. land distribution and the space to rotate the production of seed potato, for explaining the performance of farmer groups at the downstream end of partnership configurations working on technical change. The case shows that the farmer groups multiplying and bulking seed potato failed to deliver reliable and consistent volumes due to the combination of land tenure, crop and plant diseases interactions, and the constraining land tenure conditions for crop rotation. These results suggest that partnerships should not be seen as silver bullet solutions for solving persistent problems in agriculture and food provision. Hence, explaining the performance of partnerships needs to go beyond internal dynamics and include capacities of partnerships to operate in sometimes constraining material conditions.

Chapter six concludes the thesis by summarising the results of the technographic methodological approach used in the empirical chapters, which covers the following dimensions: (a) the use of skills, tools, techniques and know-how in processes of making, (b) the functioning of task-oriented groups, and coordination in a setting of distributed cognition, as well as (c) the use of rules embedded in professional association and specialisation. The technographic approach presents partnering as an evolving division of labour that emerges in the constant use of skills, tools, know-how in daily practices. This highlights the capacity of partnerships to find solutions under imperfect conditions and to coordinate tasks. The practices contribute importantly to the generation of an organisationally layered yet coherent whole generating technical change.

Next, the chapter suggests a new way to conceptualise partnerships and discusses the implications for policy and practice. The thesis views partnership as an evolving chain of sequential socio-technical practices, incrementally generating technical change, which entails more dimensions than is suggested by the conceptualisation of partnerships as organisational tools for resource augmentation. The insights from this thesis suggest a conceptualisation of partnerships that emphasises social-technical performances in a setting of distributed cognition and that takes a closer look at the micro-politics of performance in a partnership setting. Both institutional dimensions help to explain in which way partnerships sustain and navigate problems that occur after their creation. Moreover, getting partnerships to work also depends on how this emerging institutional configuration functions under specific material conditions.

The thesis demonstrates that partnerships, as an organisational fix, are not a panacea for complicated problems, and a more thorough debate about the conditions under which partnerships may work – and for whom – is needed. A policy recommendation arising from these findings is that, even though actors in a partnership appear to have the same interests and rational logic, social and emotional factors should be taken into account. Policies that seek to promote partnerships for technical change should, therefore, pay closer attention to the process of partnering, how and through which rules and procedures it is being constructed in social-technical practices. This process of partnering is made possible by institutions with their own logic, attuned to the specific contextual materiality and social setting.

About the author

Jessica Ndubi was born in central Imenti constituency in Meru District presently Meru County in Kenya. She holds a Bachelor's Degree in Business Administration and Management from Messiah University College in USA and a Master of Science degree from University College London UCL (University of London) in UK. Her Masters dissertation was based on gender in agriculture and agricultural research with reference to the dryland areas of eastern Kenya. She also holds a postgraduate diploma in professional capacity building in integrated agricultural research for development (IAR4D) from the International Centre for development oriented Research in Agriculture (ICRA), Wageningen, The Netherlands.

She started her career as an account assistant with World Vision in Nairobi, Kenya. She had a short stint at Lloyd Bank, Canon street London, where she worked as a loan administrator. She later got employed as a socio-economist by the Kenya Agricultural Research Institute (KARI) and was initially posted at the institute's regional centre in Embu where she worked as a gender specialist. As a gender specialist she ensured that gender issues were incorporated in agricultural research activities and was a member of the KARI national gender task force. As a member of the task force, she was part of a team that conducted nationwide gender sensitization workshops and mainstreamed gender issues in agriculture and agricultural research at KARI.

In 2002, she got transferred to KARI headquarters in Nairobi where she assumed the position of deputy coordinator of a national project called Agricultural Technology and Information Response Initiative (ATIRI). Her responsibilities included: preparing budgets for the project, scrutinizing loan applications from various KARI centres in the country, approving the applications, convening the projects' national workshops, and conducting monitoring and evaluation studies. This was in addition to being a member of a multi-stakeholder and multidisciplinary team of scientists that conducted IAR4D in Kenya until 2009 when she enrolled for a PhD program at Wageningen University, The Netherlands.

Jerika Maithekia Ndubi

Completed Training and Supervision Plan

Wageningen School of Social Sciences (WASS)

Name of the learning activity	Department/Institute	Year	ECTS*
A) Project related competences			
Research design and research methods (YRM 20860)	Social science WUR	2009	6
A practical course on the methodology of fieldwork	CERES, Utrecht university	2009	2
Qualitative data analysis for development research	CERES, Utrecht university	2009	1
Qualitative data analysis: Procedures and Strategies (YRM 60806)	Social science WUR	2009	6
Advanced Social theory (RSO 32806)	Social science WUR	2009	6
Institutional Economics.(Institutions, information and Knowledge)	University of Copenhagen, Denmark (NOVA University Network)	2009	6
B) General research related competences			
CERES Basic Training Course	CERES, Utrecht	2010	2.5
C) Career related competences/personal development			
Scientific Writing	WGS Language centre	2009	1.8
Competencies for Integrated Agricultural Research	WGS	2009	1
Information literacy for PhD including endnote	WGS	2009	0.6
Scientific Publishing	WGS	2012	0.3
Techniques for Writing and Presenting a Scientific Paper	WGS	2012	1.2
PhD Competence Assessment	WGS	2010	0.3
Voice Matters: Voice and Presentation Skills Training	WGS.	2013	0.4
D) Presentations of research results			
'Convergence of disciplines and politics of variety selection in the process of technical change: The case of tissue culture bananas in the central Kenya highland'	Interdisciplinary Social Sciences conference. Charles University , Prague, Czechs Republic	2013	2.2
'Partnership, land and quality seed potato multiplication in the central Kenya highland'	NVAS Africa studies day food in Africa conference. WUR	2012	1
E) others			
Writing research proposal	WUR	2010	4
Total			42.3

*One credit according to ECTS is on average equivalent to 28 hours of study load

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