Field Report

Biotechnology Knowledge Management: Case of Tissue Culture Bananas in Kisii District

Prepared for

African Technology Policy Studies Network (ATPS)

CABE
making links work

by
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Dated 19th January 2007

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ATIRI	The Agricultural Technology and Information Response Initiative
ATPS	African Technology Policy Network Services
ARDAP	Appropriate Rural Development Agricultural Programme
BTA	Biotechnology Trust Africa (BTA)
CABE	Centre for African Bio-Entrepreneurship
CBOs	Community-Based Organisations
CIG	Community Action Plan
FFS	Farmer Field Schools
GoK	Government of Kenya
GTL	Genetic Technologies International Ltd
IITA	International Institute of Tropical Agriculture
ISAAA	International Services for the Acquisition of Agri-Biotech Applications
JKUAT	Jomo Kenyatta University of Agriculture and Technology
KARI	Kenya Agricultural Research Institute
masl	Metres above sea level
MoA	Ministry of Agriculture
NALEP	National Agricultural and Livestock Extension Programme
NARS	National Agricultural Research Systems
NGOs	Non-Governmental organizations
SIDA	Swedish International Development Agency
SMP	Soil Management Project
TC	Tissue Culture

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Acknowledgement

We acknowledge ATPS staff for their support and especially the executive director, Dr. Sheila Maina for contracting CABE as a partner in this assignment. We are very grateful to the executive director of ARDAP, Mr. Macdonald Wesonga for his hands-on experience in facilitating farmer participation during fieldwork. We appreciate the executive director of BTA, Mr. Joseph Wekundah for his insights and background information for this study. We thank the Senior Research scientist at KARI-Kisii, Mrs. Nasambu Okoko for her useful comments on the opportunities and challenges of TC banana technology in KARI-Kisii mandate districts. Through Mrs. Nasambu's efforts we interviewed an entrepreneur, Mr. Okoko and also video-recorded activities of his banana nursery enterprise. We acknowledge the interest and support of the Ministry of agriculture staff at Kisii District and Marani division, especially Mr. George Simuyu, for helping us to compile data and organize meetings with farmers' groups in Marani division. We recognize the information and support given by the three farming groups, Omokonge Self Help Group, Sigona focal area group and Rio-omwando Group. In particular we are grateful to members of Omokonge Group for enabling us to carry out the Transect Walk, Community Action plan (CAP) and Farmer Field Day.

Executive summary

The pilot study on Biotechnology Knowledge Management in Sub-Saharan Africa was contracted to the Centre for African Bio-Entrepreneurship (CABE) by the African Technology Policy Studies Network (ATPS) in December 2006. The purpose of the study was to investigate the dynamics of introducing biotechnologies to farmers with particular focus to tissue culture (TC) bananas. The study contributes to the knowledge generation, brokering and dissemination of agricultural biotechnology in Africa. The study was undertaken in Marani division of Kisii District on January 2-15, 2007.

The choice of Kisii District and bananas is based on the fact that Kisii is traditionally a banana growing area where farmers have been growing various traditional varieties. Also, banana is one of the few crops that characterize development and deployment of biotechnology in Kenya. Apart from being available to farmers in Kisii, tissue culture bananas have been widely and successfully introduced to farmers in the country. It is therefore possible to explore the seed acquisition process and the cost implications, farmers' perceptions of use attributes and the performance of TC compared to the traditional varieties. This led to the main research issue of this study: With better attributes over traditional varieties, especially in yield performance and resistance to diseases, are the TC banana varieties the most preferred by Kisii farmers.

Through focused group discussions with three farming groups (viz. Omokonge, Sigona and Rio-omwando) and specifically, a Community Action Plan (CAP) meeting with members of Omokonge Self Help Group, farmers identified problems encountered and suggested possible solutions (**see summary of CAP in Chapter 4.3**). The problem of small landholdings is stands out in Rio-omwando focal area, where farmers had to abandon their TC banana multiplication site following an abrupt termination of lease by the landowner.

In Sigona focal area, where the group was recently introduced to TC banana varieties, farmers were enthusiastic towards the technology but they needed to see demonstrable benefits of TC banana varieties over traditional bananas. One successful banana farmer in the area who was gradually shifting from production of traditional banana varieties to that of TC bananas attributed this transition to his closer interaction with the staff of Ministry of Agriculture (MoA) and Kenya Agricultural Research Institute (KARI).

Through the National Agricultural and Livestock Extension Programme (NALEP), KARI Kisii introduced TC banana technology and the related knowledge to farmers in the area. But technology was largely constrained by weak distribution system and high cost of TC plantlets. Consequently, the project enhanced the capacity of nine (9) farmers' groups (250 members) and nine (9) technical staff and provided credit to farmers via K-Rep. On post-harvest handling of TC bananas, the Omokonge Group has made considerable progress by establishing a ripening chamber, which has reduced on-farm losses and improved the quality of ripened bananas.

At the same time, banana farmers are yet to be transformed from subsistence to commercial production. There was general awareness of TC bananas in the area under study in the sense that farmers were able to effectively articulate the advantages and disadvantages of TC banana varieties over the traditional ones. But it was difficult to observe progressive out-scaling of the TC banana technology in the Omokonge farming community.

Through the transect walk of the community (**see Appendix 2**), we noted that few and isolated homes had adopted the TC technology despite their close proximity to the group activities. A few of the non-adopting farmers that we interviewed (and who had also attended the initial training meetings of the Omokonge group) were of the opinion that the TC banana farmers in the Group were unhappy with the performance of the project. This was attributed to lack of organised banana markets as compared to tea, coffee and pyrethrum given that the farmers' group was trained on TC banana technology and some aspects of value addition and marketing. Equally noticeable from discussions and CAP was ineffective group leadership and dynamics to spur change of attitude and practices –which might have also contributed to farmer reluctance to change from subsistence production to commercial production of bananas.

The introduction of TC bananas varieties with better attributes over traditional ones has potential to improve the food security and incomes of smallholder farmers in Kisii. But for the deployment of the technology to be successful, the most appropriate delivery pathways should be sought. One crucial element is establishing community-based hardening nurseries where farmers can continue to access the clean planting material. Public TC nurseries and those established by private entrepreneurs should complement the satellite nurseries. With the combined public and private TC nurseries and community-based nurseries (or individual farmers), there is enough capacity for deployment of TC banana technology to farmers. However, quality control, through formal

regulatory agencies and self-governing farming groups, is very important for TC banana diffusion.

Interviews with farmers, KARI staff and a TC banana entrepreneur revealed several lessons for the technology deployment. Farmers, for example, indicated that the K-REP credit scheme was inappropriate for the banana enterprise because of the short grace period of three months required to repay the loan as compared to at least 15 months waiting period prior to getting the first banana harvest. According to an interview with a KARI scientist, "effective repayment of loans is not only dependent on frequent follow-up but also success of the technology. For the TC banana entrepreneur, linking entrepreneurs and market should enhance banana production. Indeed, effective technical support to farmers will only yield good results when packaged with sustainable micro-credit and post-harvest processing and marketing.

Farmers in Rio-Omwando focal area, who had abandoned the group approach in TC banana promotion, expressed their interest to participate in the project again. This was a result their participation in the Omokonge Farmer Field Day, where they saw for themselves the demonstrable benefits of post-harvest handling activities of TC banana varieties (including bakery, winery, flour mill, crisps, jam and juices, livestock feed ratios and crafts).

In addition to investigating the dynamics of adopting tissue culture bananas in Kisii, *albeit* briefly, the study also began cataloguing banana varieties and analyzing the potential threats and opportunities of introduced technologies on the farmer preferred banana varieties. As demonstrated by Omokonge Self Help Group, farmers and the abagusii community have experimented and accumulated knowledge regarding which banana varieties flourish under which conditions (**see details in Chapter 5.2**). Further research in this area enhances our understanding why farmers might adopt and abandon the TC banana technology and/or revert to their traditional varieties even though the latter are likely to be less superior to the introduced ones.

On the way forward, the study makes the following recommendations: (i) sources of inappropriate TC banana plantlets should compensate farmers to restore their confidence in the new technology, (ii) satellite nurseries and demonstrate plots should be set up in communities to reduce the cost of transport and demonstrate benefits to farmers, (iii) evaluate and redesign the micro-credit scheme for the deployment of TC banana technology, (iv) strengthen farmer linkages to markets and (v) promote interactions between producers of knowledge, its potential users and intermediaries to foster knowledge sharing and innovation.

1. Introduction

An intense public debate has emerged on regarding the development and introduction of modern biotechnology in African agriculture. However, the debate has often stagnated on a one-sided bias of those in favour and those against genetically modified (GM) foods and crops. Yet, more interactions between these two sets of forums could lead to appropriate technologies based on a number of clearly specified economic, social and environmental criteria.

The study makes an attempt to contribute to the concept of knowledge sharing (generation, diffusion and utilization) by investigating the dynamics of introducing biotechnologies to smallholder farmers with particular focus to tissue culture (TC) bananas.

Although the origin and centre of diversity for banana is believed to be South East Asia, the East African Highlands is recognized as a secondary centre of diversity. East Africa is the largest banana producing and consuming region in Africa (Smale and De Groote, 2003). In this region, small-scale farmers predominantly grow bananas for home consumption and for local markets (Qaim, 1999). Because bananas and plantains produce fruit all-year-round, they provide a valuable source of food during hunger periods. In some communities they contribute over 80% of rural household incomes especially for women who often manage the crop(s).

Kisii[1] is a leading banana producing region in Kenya with an average farmer production of 17 t/ha while the national farmer average production is 12 t/ha. But this yield is still below the potential yield of 60 t ha-1. The yield gap is attributed to semi subsistence farming systems that are characterized by use of low inputs and low yielding banana cultivars that are susceptible to pests and diseases. From several PRA surveys conducted in Kisii, smallholder farmers in the region predominantly grow two cooking cultivars, the East African Highlands banana, 'Matoke' (AAA) and Apple Banana, 'Kisukari' (AB) (Kwach et al., 2005). Thus, in 1996/1997 Kenya Agricultural Research Institute (KARI) launched an international collaborative programme to provide smallholders with pathogen-free banana planting material through the use of tissue culture (TC) Biotechnology (Qaim, 1999).

It is within this framework that the project titled "Diffusion of Tissue Culture Banana Technology to Smallholder Farmers in former Kisii District through micro-credit scheme was prepared and

[1] The greater Kisii region comprises of three districts namely Kisii Central, Nyamira and Gucha.

implemented. The project is institutionally supported by International Service for Acquisition of Agri-Biotechnology Applications (ISAAA) and supported by Maendeleo Technology Transfer Fund (MATF)[2]. ISAAA in collaboration with KARI Kisii and K-Rep implemented the first phase of the TC banana production through the use of micro-credit via K-Rep. It aimed at establishing a self-sustaining system of production, distribution and utilization of farmer-preferred varieties of TC banana packages with suitable micro-credit component.

Seven TC banana varieties (including Grand nain, Kampala, Chinese Cavendish (medium), Valery, Uganda Green, TC Ng'ombe and Dwarf Cavendish) were introduced to farmers through their farming groups. Farmers were enthusiastic about the TC banana varieties but diffusion of the technology was constrained by weak distribution system and high cost of TC plantlets. As a result, the project was extended to the second phase, which aimed at strengthening the TC plantlets distribution networks, orchard management and post-harvest utilisation (Nasambu Okoko, pers. Commun. 2007).

Marani division in Kisii District is an area where farmers have grown both the traditional and TC banana varieties. Hence, they are better placed to identify problems encountered with TC technology and provide solutions that can be emulated or replicated in other areas where bananas are grown. The specific objectives of this Biotechnology knowledge sharing analysis presented in this report are: (i) to identify factors that influence sustainable uptake of TC bananas and (ii) to begin cataloguing banana varieties and analyzing the potential threats and opportunities of introduced technologies and the farmer preferred banana varieties. Further, some general insights shall be gained on dynamics of introducing biotechnologies in farming systems of African smallholders.

1.1 Methodology

The study investigates the dynamics of introducing biotechnologies to farmers with particular focus on tissue culture (TC) bananas and how farmers have shared knowledge and their interactive learning process of TC banana Biotechnology. As these learning processes and their impact was not easily observable within the study period, the analysis builds upon participatory rural appraisal (PRA) and interactive learning approaches.

[2] Maendeleo Technology Transfer Fund (MATF) in East Africa is established by FARM AFRICA in partnership with Gatsby Charitable Trust (UK) and Rockefeller Foundation (RF).

The secondary literature review especially project documents provided background information on the introduction of TC banana Biotechnology in Kenya and specifically Kisii District. For the information on banana production in Kenya and Kisii District, the study used Ministry of Agriculture National Report (2005), Kisii District Annual Farm Management Guidelines (2005-2006), Kisii District Annual Report (2006) and NALEP reports of Marani division. The author collected the required data for the analysis on 2-15 January 2007.

In addition to secondary sources, two different semi-structured interviews were carried out. The first interviews with (12) agricultural professionals in Nairobi and Kisii focused on the various aspects of TC banana research and extension (R&E) services. The rationale was to gain diverse opinions on the TC biotechnology R&E priority setting and implementation processes. It is through these meetings that Marani division was selected as a study site. Upon consultation with the Ministry of Agriculture Extension staff at Marani division, we selected and worked with three farming groups that had grown both the traditional and TC banana varieties. The group approach was also chosen to get an overview of possible group differences in the uptake of TC banana technology and farmer interactions. The selected groups were Omokonge, Sigona and Rio-omwando --and the selection criteria was based on the experience of their members having growing both the traditional and TC banana varieties. Omokonge Group with 25 active members was considered advanced because it had already established a banana-ripening chamber. 20 members of Sigona focal area were recently introduced to TC banana varieties. In Rio-Omwando Group 22 members had established a TC banana multiplication site but abandoned it mainly due to failed land-lease arrangements.

The second survey included visits to three farming groups (45 members). The group discussions focused on sources of planting material, advantages and disadvantages of TC banana varieties over traditional varieties and group dynamics especially with respect to knowledge sharing and learning on TC banana biotechnology. The subsequent field study activities focused on Omokonge Group where a transect walk was conducted to map farming activities, institutions, banana varieties and to develop a Community Action Plan (CAP). Through the CAP meeting, farmers identified problems encountered with TC banana technology and provided solutions which they should address and others that should be addressed by other stakeholders. On the last day of the fieldwork, five representatives from Sigona and Rio-omwando farming groups participated in a one-day Farmer Field Day meeting, which was organized by members of

Omokonge Group. Apart from providing feedback to farmers, the Field Day enhanced knowledge sharing through interactive learning and initiated cataloguing and documenting farmer knowledge on opportunities and threats of introducing TC banana varieties into their farming systems.

1.2 Study overview

Chapter 2 presents an overview of Kenyan banana sector with special focus on the traditional and modern knowledge systems. Owing to the fact that Kisii is the leading banana producing region in Kenya, attention is given Marani division in Kisii Central District where farmers have grown both traditional and TC banana varieties. Thus, the study draws on primary data collection from Marani division. We highlight the prevailing smallholder farming systems in the division within which TC banana technology is being introduced. The elements of TC banana technology project that are relevant to the study are discussed in Chapter 3. Chapter 4 presents results of focused group discussions with members of Omokonge, Sigona and Rio-omwondo groups based on their uptake of TC banana technology and interactions. This is followed by discussion on the results of the Transect Walk and CAP meetings with the Omokonge Self-Help Group before the knowledge gained through these PRA events are shared with representatives of the other farming groups and agricultural professionals in the Farmer Field Day in Chapter 5. The chapter also outlines farmers' perceptions of potential benefits and threats of introducing TC banana technology in their smallholder farming systems. This initial catalogue is based on the farmer preference characterization of the traditional and TC banana varieties. In Chapter 6 the study outlines some of the lessons and concludes the report.

2. Banana production

2.1 Overview of Banana production in Kenya

The Banana crop has emerged as a major income earner and food item in almost all the provinces in Kenya. The crop is used for cooking and dessert. The main varieties grown includes giant and dwarf Cavendish, Mkono Wa Tembo, Bokoboko, Shale, Kisukari, Uganda Green, Sweet bananas, Gros Mishel, Lacatan, Valery, Somali Shuttle, Robust, William's hybrid, Golden beauty, Pisang, Paz, Muraru, and Apple Bananas. The demand for planting materials is high especially for Tissue culture (TC) banana varieties. The sources of TC technology in Kenya are: Jomo Kenyatta University of Agriculture and Technology (JKUAT), National Horticulture Research Centre, Thika, Africa Harvest and other private breeders in Juja and Kabete (Provincial Reports, MoA, 2004/2005).

The production statistics in Table 1 show that the area increased by 2193 ha or 2.7% but the production decreased by 29,268 or 2.8 % and value increased by Ksh. 5,733,578,813 or 75 %[3]. The general constraints facing banana production in the country are:

- Availability of disease free planting materials
- Pests - banana weevils, nematodes
- Diseases- Sigatoka, panama disease, cigar-end rot, fusarium wilt
- Poor husbandry practices and management – no pruning; little or no use of fertilizers and/or manures, hence, low soil fertility
- High cost of farm inputs – pesticides, fertilizers
- Poor post harvest handling
- Poor road infrastructure results high post harvest losses of horticultural produce and higher transportation costs of produce.
- Inadequate horticulture extension services due to inadequate technical information and skills with the extension staff and farmers and staff mobility
- The reduced level of funding for horticulture extension activities

[3] Provincial Reports, MoA 2004/2005

Table 1: Banana Production 2004/2005

Province	Achieved Area (Ha)		Production (MT)		Value (Kshs.)	
	2004	**2005**	**2004**	**2005**	**2004**	**2005**
Central	15,520	16,051	164,171	194,305	1,813,335,000	2,095,900,000
Coast	7,124	7,357	54,237	24,027	785,166,000	288,000,000
Eastern	9,538	9,853	88,442	92,500	857,699,000	987,796,000
Western	11,753	12,591.5	146,036	139,232	1,005,386,687	4,338,888,800
Nyanza	34,401	34,534	532,886	504,366	3,535,580,000	5,262,254,000
Rift Valley	2,861	3005	44,291	49,878	439,416,800	364,131,500
Nairobi	54	27	354	71	7,080,000	6,900,000
North Eastern	422	448	5721	2,491	57,210,000	34,883,000
Total	**81,673**	**83,866**	**1,036,138**	**1,006,870**	**7,643,174,487**	**13,376,753,300**

Source: Provincial Reports, MoA 2004/2005

At an achieved area of 35,000 ha production of 532,886 MT in 2004, Nyanza (and especially in the former Kisii District) is the leading province in banana production (Provincial Reports, MoA 2004/2005). In the same period (2004), Kisii district, which is the focus of this study, produced 229,600 MT on an area of 11,485 ha. This averages to 20 MT per ha (Kisii District Annual Farm Management Guidelines, 2005-2006; Kisii District Annual Report, 2006).

2.2 Smallholder farming in Kisii District[4]

Kisii Central District is one of the 12 districts in Nyanza Province. It shares common border with Nyamira District to the east, Trans Mara District to the South, Migori District to the Southwest, Rachuonyo District to the North and Gucha District to the Southwest. The district covers an area of 648.9Km^2 and is administratively divided into 7 divisions, 31 locations and 92 sub-locations. The seven divisions are Marani, Mosocho, Suneka, Kiogoro, Keumbu, Kiamokama and Masaba.

The dominant people in the district are the Abagusii (100%). The rest of the tribes constitute 1% of the population and are mainly found in urban areas. The rural population is largely composed of subsistence farmers with a fast growing interest in commercial agriculture. The rainfall is adequate with not more than three fairly dry months (July, Jan and Feb). The major food crops

[4] This information is drawn from the Kisii District Annual Farm Management Guidelines (2005-2006) and Kisii District Annual Report (2006).

are maize, beans, finger millet, sweet potatoes, various vegetables and bananas. However bananas, vegetables, passion fruits, sweet and Irish potatoes are cultivated in specific areas for both food and cash. The major cash crops are tea, coffee, pyrethrum and chewing cane. Indigenous vegetables such as black nightshade and spider plant are drawing much attention among commercial farming folks because of the high returns to a small unit of land. The major livestock kept in the district are dairy, both indigenous and exotic poultry, dual-purpose cattle and bee keeping. Sheep and goats are also kept but in small numbers per farm. The demand for dairy goat is fast growing. Crop produce and livestock products are sold at both the markets within the district as well as outside the district. Bananas, finger millet, chewing cane, fruits and vegetables commonly sell in outside markets. Among the crop commodities brought in from outside the district include maize, beans, cassava chips, potatoes (Irish), tomatoes, cabbages, mangoes, citrus fruits, pears, pineapples and groundnuts. Livestock commodities in the same category are milk, eggs, beef cattle for slaughter, honey, fish, indigenous chicken as well as goats for slaughter.

Demographic and extension data

Kisii District is a densely populated with area of 648.9 ha supporting a population of 608,333 people. The average population density was approximately 647 persons per Km^2 in 1999 and is projected to reach 790 persons per Km2 in 5 years, with only 78 percent of the district's land being suitable for cultivation. The population distribution in Kisii District is greatly influenced by a number if factors among them the physical, historical, patterns of economic development and policies pertaining to land settlement. As shown in Table 2, this population is only served by 38 extension workers in the district which means that one extension worker serves 3.339 farmers.

Table 2: Demographic and extension data

Division	Area (Km^2)	Projected Population 2005	No. of Sub-locations	No. of Households	Households size	Divisional Technical staff	Staff: Farmer Ration
Marani	123.7	99,207	13	19,841	5	5	1:3,968
Mosocho	87	102,044	12	14,578	7	4	1:2,083
Suneka	126.4	103,735	14	20,747	5	7	1:4,149
Kiogoro	61.3	78,597	10	15,719	5	7	1:3,144
Keumbu	71	57,333	9	11,467	5	7	1:2,293
Kiamokama	71.6	57,333	14	11,487	5	4	1:2,547
Masaba	89.9	63,681	18	12,736	5	6	1:2,894
Township	18	46,301	2	11,575	4	-	-
District Figures	648.9	608,333	92	118,150	5	38	1:3,339

Source: District Annual Farm Management Guidelines (2005-2006

Land use

The landholdings are small and due to high population pressure many people have bought land in other neighbouring areas especially in Migori, Homa Bay, Rachuonyo and Trans Mara District. The district is mainly hilly with several ridges in the eastern part. Most parts of the district have red volcanic soils – the Mollic NITISOLS. The soils are deep and rich in organic matter. The rest of the district has clay soils, red loam and sandy soils, which are poorly drained. There are also small fractions of black cotton soils and organic peat soils in the bottom of the valleys.

Agricultural interventions

The district has four agro-based projects /programmes which are implemented under the auspices of National Agricultural and Livestock Extension Programme (NALEP), The Agricultural Technology and Information Response Initiative (ATIRI) and Soil Management Project (SMP) (see Table 3). The NALEP interventions are supported by the Swedish International Development Agency (SIDA) and Government of Kenya (GoK) and implemented by the Ministries of Agriculture and Livestock and Fisheries Development. These programmes use focal area and Farmer Field Schools (FFS) approaches. It is within these extension approaches that KARI-Kisii and MoA introduced TC banana varieties in the area.

Table 3: Agro-based Projects and Programmes

Project/ Programme	Implementing Agency	Division Covered	Donor	Activity
NALEP	Min. of Agriculture/ Ministry of Livestock and Fisheries Development	District wide	SIDA	Focal Area extension
NALEP	Min. of Agriculture/ Ministry of Livestock and Fisheries Development	District wide	GOK	Selected site extension
ATIRI	KARI/RRC, Kisii	District wide (where proposals are written, presented and approved	World Bank	Issue grants to CBOs and SHGs
Soil Management Project (SMP)	KARI RRC, Kisii	Mosocho, Suneka and Marani Divisions	Rockefeller Foundation	Fertility improvement using FFS approach

Source: District Annual Farm Management Guidelines (2005-2006

Banana production in Kisii District

As mentioned in the introduction chapter, Kisii is a leading banana producing region in Kenya with an average farmer production of 17 t/ha while the national farmer average production is 12 t/ha. As shown in Table 4, the area under banana production in the district has remained 11,400 ha with a total production of 229,600 MT. The average yield of 20 MT/ha achieved in the District is still below the potential yield of 60 t ha-1. The yield gap is attributed to semi subsistence farming systems that are characterized by use of low inputs and low yielding banana cultivars that are susceptible to pests and diseases. The traditional methods that are used by farmers in banana production involve the use of suckers. These suckers are infested with soil borne pests such as banana weevils and the burrowing nematodes. These pests decrease yield production. One of the areas where case studies can be made in banana product in Kenya is Kisii.

From several participatory rural appraisals (PRA) conducted in Kisii, two dessert cultivars, East African Highland banana Amatoke (AAA) and Apple Banana (AB), are predominantly grown by farmers. Five exotic banana (AAA) cultivars (Valery, Lacatan, Giant Cavendish, Dwarf Cavendish, Green-Red) and two local checks (Amatoke and Apple Banana) were field-tested between 1990 and 1993 (Kwach et al., 2005). The two local checks had a shorter average cycle period (17-24 months) while the exotic cultivars needed 18 to 32 months. The farmers prefer Valery and Giant Cavendish as good cultivars because of their yield, taste and strong pseudostems, which do not require propping.

Table 4: Banana production in Kisii

Item	Unit	1997	1998	1999	2000	2001	2002	2003	2004
Area	Ha	11435	11236	11288	11460	11460	11470	11,485	11,485
Production	Tons	182,960	224,720	225,760	206,280	206,460	206,460	229,700	229,600
Yield	Tons/ha	16	20	20	18	20	18	20	20

Source: District Annual Farm Management Guidelines (2005-2006

2.3 Marani Division

Box 1: A bird's view of Marani division

Population size:	*99,1000 people*
Agro-ecological zones:	*UM1*
Altitude:	*1450-2200m above sea level*
Arable land:	*109 km^2*
Average farm size:	*0.8 ha*
Average Annual Rainfall:	*1800mm*

Marani Division is one of the seven divisions that form the large Kisii Central District. It borders Nyamira District to the North and East and Mosado Division to the West. The Division is sub-divided into 6 locations namely (i) Kagogi, (ii) Mwogichane, (iii) Sensi, (iv) Ng'enyi, (v) Mwakibogendi and (vi) Mwomonari. The locations are further sub-divided into 13 sublocations as shown in Table 5.

Table 5: Administrative units

Name of Location	**Sub-locations**	**Area in km^2**
Kegogi 22.3 km^2	Metembe	13km^2
	Ngokoro	9.3km^2
Mwangichane 15.9km^2	Igemo	10km2
	Kiomongo	5.9km^2
Sensi 13.7km^2	Sensi	5.7km^2
	Kiong'anya	8.0km^2
Ng'enyi 38.2km^2	Matongo	9.4km^2
	Ikuruma	9.4km^2
	Gesengero	15.3km^2
		13.5km
Mwakibogendi	Nyamoga	6.4km^2
	Onywere	7.6km^2

Source: Marani Division NALEP Reports (2005)

The Division has an area of 123.7km^2 of which 109km^2 is arable land with deep and well drained mostly the nitisols soils. The Division has an altitude range of 1450m – 2200m above sea level. It has a population of 99,200 people with 19,800 households with a population density of 840 people. The division consists of native people, the abagusii and a few settled communities mainly the Moragoli and Luos who accounts for only 2% of the total population. It is believed that the Abagusii originates from this Division.

Approximately 80% of the population is mainly smallholder farmers practicing mixed farming – thus, raising trees, crops and livestock. The common crops grown in the division include: tea, coffee, bananas, maize, onions, tomatoes, groundnuts, avocado, and intercropped maize and beans and avocado. An indigenous vegetable, the black nightshade, is gaining popularity besides the noble chewing sugarcane. Table 6 shows the ranking of 6 enterprises produced in the division.

Table 6: Ranking of key enterprises

Crop	Ranking
Bananas	1
Maize	2
Tea	3
Blacknight shade	4
Dairy	5
Finger Millets	6

Source: Marani Division NALEP Reports (2005)

Of these enterprises, it estimated that 50% of the crop area is occupied by tradition varieties while is 50% occupied by improved varieties with a very crop area under biotechnology crops such as TC banana varieties (George Simiyu , Pers. Commun. January 2007).

Cropping Calendar

The area receives a well-distributed bimodal type of rainfall with average rainfall of 1800mm which supports two cropping calendars for different enterprises, the long and short rains. Table 7 shows the type of crops, activities carried in different months.

Table 7: Cropping calendar

ACTIVITIES						
Crop	**Land Prep.**	**Planting**	**Weeding**	**Harvesting**	**Selling season**	**Season**
Maize	Jan-Feb	Feb-March	Mar-April	Jul-Aug	Sept.	LR
Beans	Jan-Feb	Feb-March	March			
Bananas	Jan-Feb	Mar.-April	Mar-Aug	-	-	
Tomatoes	Jan-Feb	Mar-April	Mar-April	May-Jun		
Onions	Feb-Feb	Mar-Apr.	Mar-Apr.	May-Jun		
Kales	Feb	All year	Mar-Apr	All year		
Tea	Feb-Mar.	March				
Finger millet	Feb	March	Mar-Apr.	"	Jul-Aug	

Note: Short rains begin in August where they plant the crops in August-Sept and harvest in January for maize, beans and harvest in November.

Institutions

Marani division is served by a host of institutions (see Table 8)

Table 8: Institutions and their roles

INSTITUTION	THEIR ROLES
Western Seed Company	Promotion of improved maize seed varieties and provision of demonstration materials.
K-REP	Provide credit to dairy farmers
ICIPE	Control of striga weed
VET	Extension Services for animal health
Provincial Administration	Mobilization of the community
Nyaro CBO	HIV/AIDs awareness
Twiga Chemicals	Promotion of Agro-chemicals
OSHO Chemicals	Promotion of Agro-chemicals and provision of demonstration materials.
GTZ	Energy Conservation
KTDA	Extension Services to tea farmers
KARI-Kisii	Research Extension Livestock
Kenya Seed Company	Provision of improved seeds
Public Health	Public Health Education
Social Services	Registration of Groups
Forest Departments	Agroforestry extension service
Kumekucha Kenya	HIV/AIDS awareness/credit for members
Farm-Chem	Promotion of Agro-chemicals
Lachan Kenya Ltd.	Promotion of Agro-chemicals

3. Why Tissue Culture Biotechnology

3.1 Modern Knowledge application in Banana Production in Kenya

In applying modern science and knowledge to banana production, it is important to harness the potential of genetics. In a country where commercial, small scale and subsistence farmers practice farming, the value of good planting material should be widely understood and accepted. Commercial farmers should invest in good planting material; small-scale farmers should buy good planting material when if it is needed, available and affordable, while subsistence farmers should retain, share and swap material that performs well in their growing environment.

Although genetics alone will not address the problem of food production in Kenya, but the studies presented show that this is not a good enough reason to ignore the benefits of biotechnology and the improved planting materials being derived through this technology. For instance, the TC banana technology has shown relative benefits in Kenyan farming situations at all resource levels (Qaim, 1999, Wambugu et al., -).

The other related technology that is proposed by science studies is the use of endophytes. An endophyte is an organism that at some time during its lifecycle lives within plant tissues yet does not cause any disease symptoms to its host. The association is mutuality. It provides the Plant with antagonism against pests and diseases. Further it provides an activation of biochemical and structural plant defense mechanisms. Some studies conducted in Kenya indicate that the use of modern technology in the production of bananas leads to high yields and decrease of pests. It involves the application of tissue culture by adopting the endophyte enhancement mechanisms (Dubois et al., 2005).

The level of biotechnology crop research is growing in Kenya and the technology is being applied to constraints in a growing range of African crops. In the use of modern technology and knowledge, the banana plants are produced by tissue culture in local laboratories and distributed to small-scale farmers through coordinated, multidisciplinary implementation projects that included farmer consultations; public-private partnerships; extension support; micro-lending; cooperative marketing; feedback and monitoring. This ensures that the products of the biotechnology research and disease free planting materials reach the target group and are successfully implemented by the small scale farmers.

This partnership has set up a model that can be emulated and transferred to many regions as it forms part of the modern day development, where the different organizations contribute towards the eradication of hunger and poverty reduction. The varieties adopted range from the Grande nain, Giant Cavendish and William. In particular, the author notes that the project had met their expectations of technology introduction with a 15% initial penetration in the 1st year, translating to the 1,000 households (Mboya, 2005).

It is believed that one way of ensuring sustainability in the modern intellectual property systems is to use methodologies and technologies, which can easily be accepted by the people, intended to use them. Therefore, it is important to catalogue and document the traditional technology already available or traditional thinking about the particular problem to be solved before embarking on the need for the introduction of modern knowledge to the banana farmers in Kenya.

3.2 Catalogue of Banana Varieties/Cultivars grown in Kenya

Banana varieties/cultivars

In Kenya, there are a number of varieties that are grown for commercial and domestic use. They include the Dwarf Cavendish (AAA), Sukari mainly for commercial use, small in size and sweet, it is sold whilst ripe; Williams/Mons Mari/Giant Cavendish which is a giant mutation of the cultivar 'Dwarf Cavendish. The naming and identification of banana varieties can be challenging. Banana varieties are often misnamed, renamed, multiply named.Hybrids of M. acuminata and M. balbisiana are sometimes given the names Musa X paradisiaca L., Musa X sapientum L., or perhaps most accurately, M. acuminata X M. balbisiana Colla. However, a shorthand method of distinguishing hybrids and accurately representing their parentage was developed in the 1950s, and is commonplace today. Each type is given a 2 to 4 letter designation consisting of A's representing acuminata, and B's, representing balbisiana. For example, AA represents a diploid type derived only from M. acuminata, and AAB represents a triploid type with 2/3 M. acuminata and 1/3 M. balbisiana parentage. In general, the most important banana cultivars in the world are AAA, and plantains are mostly AAB, ABB, or BBB. The following is a catalogue of the Banana varieties on the above classification system.

***Dwarf Cavendish* (AAA).** This is a popular commercial cultivar grown extensively for table and processing purpose. The plant stature is Dwarf making it less prone to wind damage. The bunch size, the fruit length and size are quite good though the keeping quality is rather poor. The

average bunch weight with 6-7 hands and with about 13 fruits per hand is about 15-25 kg. The thick rind of the fruits retains to some extent the greenish colour even when the fruits are ripe. The selection yields bunches that weigh 55-60 kg. It performs well under light soils with high inputs. In combination with high-density planting and drip irrigation, Dwarf Cavendish is becoming a successful cultivar. But it is highly susceptible to Sigatoka leaf spot disease in humid tropics, thus restricting its commercial cultivation.

Williams/Mons Mari/Giant Cavendish is a giant mutation of the cultivar 'Dwarf Cavendish. This is a common commercial variety, and because tissue culture plants are relatively readily available for importation, it is attractive as a nursery plant. It is 6½ -13ft/2-4m high, the fruit are similar to 'Gros Michel', and in suitable conditions they are ready in about 12 months from planting. Its height makes it susceptible to wind damage, and it is one of the poorer performing cultivars in warm temperate areas (sap flow is said to stop below 15 degrees Celsius).

East African Highland banana Amatoke (AAA) and Apple Banana (AB): From several participatory rural appraisals (PRA) conducted in Kisii, two dessert cultivars, East African Highland banana Amatoke (AAA) and Apple Banana (AB), are predominantly grown by farmers. These cultivars are low yielding and susceptible to diseases and pests. A study was therefore carried out at Kisii to assess high yielding cultivars that are tolerant to pests and diseases for both local consumption and export.

Five exotic banana (AAA) cultivars (Valery, Lacatan, Giant Cavendish, Dwarf Cavendish, Green-Red) and two local checks (Amatoke and Apple Banana) were field-tested between 1990 and 1993. The bananas were harvested in three cycles to evaluate their production. Results indicate that the exotic cultivars had higher yields than the local checks grown by the farmers. Green-Red (193 t ha-1) out yielded all material tested in this experiment.

Giant and Dwarf Cavendish, Lacatan, Valery, Amatoke yielded a total of 165, 148, 144, 132, and 115 t ha-1 after the plant crop and two ratoons. The yields of these cultivars were similar but significantly higher than that of Apple Banana (a total 71.5 t ha-1 for plant crop and two ratoons). The two local checks had a shorter average cycle period (17-24 months) while the exotic cultivars needed 18 to 32 months. From 1990 to 1994, these exotic cultivars were introduced to various farming groups, namely: primary schools, training institutions and farmers themselves.

Banana Classification System

AAA dessert bananas

These include Dwarf Cavendish, Lacatan, Red Banana, and Gros Michel. The largest concentration of Cavendish dessert bananas is generally found in the low-lying (below 800 masl) coastal regions – in South Africa, Somalia and Ethiopia, where they are grown on large commercial farms, either by state parastatals (Ethiopia, Somalia) or by private farmers (South Africa). Gros Michel however is found around Lake Victoria region of Kenya at a slightly higher altitude range, and forms an important table banana in that area. Swarf Cavendish is grown largely in the Kisii area of Nyanza Province in Kenya.

Most cultivars of this group succumb to nematodes, black Sigatoka and Fusarium wilt although they are generally tolerant to weevil attack. In ESA these types of bananas are important in the local markets but exports remain low.

***AAB (Plantains and Prata*)**

In general these are also lowland varieties (0-600 masl) and grow very slowly above 1000 masl (De Langhe 1986). Except for Uganda and Kagera region of Tanzania where they are grown widely (but not intensively), plantains are more important in the coastal lowlands as well as in the inland low plains of Tanzania and Malawi. Plantains seem to be particularly susceptible to weevil attack. Another AAB banana called Prata (Brazilian) or Pome is also grown widely in the same ecological ranges, although in Burundi, it still does well in highlands (De Langhe 1986). The group is grown largely for subsistence purpose, save for a limited local market.

ABB cultivars

The most common cultivars in ESA are Bluggoe and Pisang Awak. The plants are quite elastic with respect to ecological conditions although they are more vigorous in regions below 1000 masl. The cultivars have been adopted in the region for use as beer bananas in Uganda, Rwanda, Burundi and Tanzania, largely because of their capacity to increase production even in sub-optimal conditions. Their acreage is on the increase in the region. These cultivars are not grown in Kenya.

In Rwanda and Burundi, the cultivars are the main stay for the beer industries. Further south in Tanzania, Malawi and Mozambique, the cultivars are used as cooking bananas. The ABB cultivars are reported to be tolerant weevil and nematode attack and tolerant—resistant to black Sigatoka but readily succumb to Panama disease. In general, the ABB group has great potential for banana—based beverage industries.

Other cultivars

A number of cultivars have been imported into the region including improved materials such as FHIA hybrids. Some of these materials such as FHIA-01, FHIA-03, FHIA-17 and FHIA-23 are indeed very promising. Other plantain hybrids developed by the International Institute for Tropical Agriculture (IITA) have been introduced for evaluation in the region.

Another set of cultivars "indigenous" to the region have yet to be characterised. They include the two acuminata wild types in Zanzibar collections and acuminata cultivars around Moshi-Kilimanjaro region. These clones are said to be different from the AAAEAHB of the lake region but these differences are not yet clearly understood. Apart from the acuminata types of Moshi-Kilimanjaro region, the identities of diverse materials in the region's NARS collections have yet to be established.

4. Banana Production in Marani Division

4.1 Focused Group Discussions

The group discussions used semi-structural interviews to stimulate informal discussions with members of three farming groups: Omokonge, Sigona and Rio-omwando. The purposes of focused group discussions were five-fold:

- Origin of farming group and group dynamics;
- Understand sources of banana planting material;
- Learn more about benefits of TC banana varieties over traditional varieties;
- Identify the constraints faced by farmers in the production and marketing of bananas;
- Understand the extent of knowledge sharing among farmers especially with respect to distribution and planting of banana suckers.

The general finding is that the main sources of banana suckers were (i) buying from KARI and buying from neighbours, and (ii) borrowing from neighbours. The specific findings of each group are provided in boxes and a summary of the discussion thereafter[5].

Box 2: Omokonge Self Help Group

The Omokonge Community Based Organization is situated in Omokonge village near Nyansakia Primary School of Ngokoro sub-location, Bokingoina Location, Marari Division in Kisii Central District. The group was formed in 2002 with the aim reducing poverty through farming activities. It started with a few male farmers and invited women to strengthen the group. The group initiated Merry-Go-Rounds and was registered in the same year (2002) and operates a bank account. Its members received training from Ministry of Agriculture through the NALEP programme as a focal area. The NALEP programme employed farmer field school (FFS) approach as a means to enhance technology transfer and various enterprises were applied. These include: poultry farming, beekeeping and bananas.

[5] The summary of the focused group discussion with the Omokonge is presented under community Action Plan (CAP)

The MoA introduced the TC project in collaboration with KARI and K-REP in 2003. The group has currently 10 network groups through which it distributes suckers through farmer-to-farmer extension. Its 27 members have TC banana orchards – including Dwarf Cavendish, Valery, Ng'ombe, Kampala, Local Uganda green (renamed Kisii green). The Group also received training on banana value addition –making of juice, crisps, jam and chips. At present, they exchange suckers from tissue culture material from their orchards. The group started with 65 members (i.e. 30 men and 35 women. Currently, active members are 35 (15 men and 20 women).

Box 3: Sigona focal area

Makaya Nyakundi: *Mr. Nyakundi's farm is 2.4 ha and had previously planted coffee since 1982. He uprooted coffee in 2003 because of over-exploitation by the cooperatives and planted chewing sugarcane for one year but was not pleased with the outcomes. After one year he also uprooted sugarcane and planted local varieties of bananas in 2005. This was done upon receiving training on farm planning. Prior to this period he had been planting in a "mixed manner". In the training, he leant to prepare a hole of 3ft by 3ft by 2ft. He also learned to leave a hole for 1 month before planting, and applying 15 kg of manure by mixing with the topsoil. He planted 66 stools at a spacing of 4m by 3m, which he acquired from his own farm and neighbours. The distribution of banana varieties on his farm include Ng'ombe (1 stool), Kisukari (11stool), Valery (1stool) and Kisii green (59 stools). He prefers Kisii green variety for income and food. Because It is also early maturing (12 months from planting to harvesting) and has cooking and dessert qualities.*

Although Mr. Nyakundi grows traditional banana varieties, his orchard is doing much than some of the TC banana orchards because he employs a rigorous crop husbandry and hygiene to control pests and diseases. For instance, he controls banana weevil through field hygiene. He also undertakes an integrated approach of growing trees, which he uses to stake his bananas.

John Bosire*. Mr. John Bosire is a member of Sigona focal area group, which was formed in 2003. The MoA linked the group to KARI and trained them on farm planning. Prior to this period they were doing "mixed planning" of traditional varieties. In 2003, farmers were taken to the Chief's centre for training on TC bananas. They were also taken to KARI Kisii to learn on banana nursery. The training at the chief's centre comprised of 50-60 people – where they formed CIG. The CIG comprised of 20 people (15 men and 5 women). The farmer lamented of the low adoption of TC bananas by members since the setting up of a demonstration plot on his farm.*

During the group discussion, the following factors were cited as causing low adoption rates of TC banana varieties: high cost of planting material including transport cost, land pressure, low soil fertility, enterprise competition with farmers preferring short-term crops such as black night shade as opposed to long term crops including bananas because they have not seen benefits of TC bananas, farmers are slow to adopt because of lack of experience. As one farmer put it "seeing is believing before they can venture into enterprises". Regarding markets, Mr. Bosire identified TC bananas, which are most marketable. These include Grand nain, Chinese Cavendish. He offered to sell the TC banana suckers to other farmers – who are serious about banana farming. Mr. Bosire urged other farmers to adopt TC banana varieties due to the following attributes: long shelf life, high price, good cooking quality and suckers can be sold high sugar content. The issues/solutions farmers suggested to address some of the above problems include:

- Farmer prefer short term benefits from indigenous vegetables as opposed to bananas,
- Farmers prefer production of maize as a staple food and tea due to market outlets;
- Availability of credit for accessing banana planting material; and
- Bringing planting material as closer to the farmers as possible.

Following the focused group discussion, we learned that farmers were motivated to form a group in order to actively participate in banana production.

Box 4: Rio-Omwando Group

The group was formed in 1994 as a merry-go-round group. The group membership was then 33 (21 women and 12 men). At present only 22 (12 women and 10 men) members are active. Along with Merry-go-rounds and finger millet production, the group started vegetable production and dairy goat enterprise. Later they got introduced to the idea of bulking TC banana material provided by the Ministry of Agriculture and KARI. This was done on a rented piece of land (0.5 acres) in 2002 and planted 36 stools of TC bananas that they received from KARI-Kisii. At the membership level, TC bananas planting material was sold to members.

During the group discussion, farmers identified some of the problems they are facing:- especially with respect to the TC banana bulking site: theft of bananas, land pressure, soil infertility, lack of motivation/laziness, competition from maize as a staple food crop, withdrawal of land-leasing arrangements which resulted in the uprooting of the banana orchard. The members were reluctant to discuss other reasons for abandoning banana production as a group but seemed to focus on

family welfare activities as opposed to technology adoption issues. Nonetheless, they indicated their willingness to participate in the project again.

4.2 Transect walk

The transect walk focused on mapping farming area, soils, enterprises, supporting institutions and banana varieties in Omokonge village. The walk of 17 Km was used to interview farmers along the transect walk and to invite them to participate in the Farmers' Field Day (**see Appendix 2**). Interviews with a few of the non-adopting farmers that we interviewed (who had attended the initial training meetings of the Omokonge group) were of the opinion that the TC banana farmers in the Group were unhappy with the performance of the project. During CAP meeting (**see next section**), the members of Omokonge Group attributed this problem to lack of organised banana markets compared to tea, coffee and pyrethrum. The general findings from the transect walk show that the following factors affect farming in the area.

Soil erosion: The area has good soils (i.e., red volcanic soils – nitisols on the hillside, which support the growth of cash crops such as tea, coffee, pyrethrum, maize, beans, potatoes and bananas. It has also some black cotton soils and organic peat soils in the bottom of the valleys. The soils are highly eroded especially on the hillside.

Tree shading and disappearing watershed: The area has several permanent rivers, streams and springs, and roof catchments. However, streams and springs are gradually disappearing due to high population of eucalyptus trees in the bottom of the valleys. This is also a result of land use pressure

Limited access to markets for farm inputs and farm produce: Owing to the ragged landscape and poor roads, there are obvious difficulties for most of the produce to reach the market, resulting in poor returns earned by farmers from the agricultural sector.

Water Situation: Water sources range from poor for rivers, good for springs and good for boreholes. Water from these sources is suitable for irrigation. However, there are no irrigation sites in the district.

Electrical Supplies: During fieldwork we observed Kegogi sub-location being supplied with electricity for domestic consumption. This should provide an opportunity for the Omokonge Group to acquire and use post-harvesting processing equipment for bananas.

Banana production: Through the transect walk of the community we noted that few and isolated homes had adopted the TC technology despite their close proximity to the group activities.

4.3 Community Action Plan

The CAP meeting was conducted as part of ongoing community planning activity with specific attention on TC banana technology since the MoA had already developed a general CAP for the area. The group also came up with three priority areas for the next course of action. Overall, the CAP was intended for the group to learn-by reflecting. Apart from discussing some achievements, the study focused on problems of solution/activities/indicators, responsible resource actors and /timeframe (see Table 9).

The major problems hampering the production of banana is that the majority of the fields with TC banana varieties such as dwarf cavendish, Ng'ombe and Uganda green were infected by diseases such as fusarium wilt and Cigar end rot. The experts from KARI – Kisii took samples and confirmed this problem. This resulted in banana yields. The poor crop husbandry and orchard management as well as the use of infected suckers by farmers also affected the quality and yields of bananas. Inappropriate micro-credit scheme by K-Rep affected out-scaling the TC banana technology. Farmers, for example, indicated that the K-REP credit scheme was inappropriate for the banana enterprise because of the short grace period of three months required to repay the loan as compared to at least 15 months waiting period prior to getting the first banana harvest. The exploitation by middlemen due to poor distribution channels and limited access to marketing information is another problem. Group members have selected good performing TC banana varieties and are sharing with other farmers.

The group members have also benefited from TC bananas in terms of food security and incomes for paying school fees, hospital bills, buying of livestock and other domestic needs. Through the MoA and KARI the group members have been taught how to make juice, chips, jam and crisps from the bananas and avocado.

Table 9: CAP for OMokonge Self Help Group

	Problems ranked	Solutions	Stakeholders	Actions
1.	Low banana yields	- Choose the best performing varieties and carry out proper crop husbandly practices and expand the acreage	- Ministry of Agriculture Division –Team	- Training workshops - Soil management - Pests and disease control - Banana management - Enterprise analysis - Market organization - Value addition - Livestock integration
2.	High incidences of pests and diseases	- Choose varieties that are resistant to disease and practice field hygiene.	- KARI, Kisii - MoA - Farmers	- Disease and pest control - Selection of banana varieties - Seed acquisition and bulking sites - Training on field hygiene
3.	High cost of planting materials.	- Select the best performing varieties and establish and manage bulking sites - Organization seed acquisition as group to reduce cost	- Entrepreneurs - Farmers' groups - CDF for agricultural funding	- Market survey - Market organization - Establish hardening nurseries and demonstration plots
4.	Water shortage resulting to breakage of bananas	- Use compost, mulching on farms and on-farm water harvesting - Selection of proper varieties trainings and provision of wind breaks.	- MoA - Farmers - Social services - Churches	- Training on composting, roof water harvesting - Acquire trees for staking bananas
5.	(a) Inappropriate varieties (b) Inappropriate information	- Organise farmers to reduce costs of accessing information	- KARI - MoA - Farmers	- Training on benefits: from crop husbandly through funding. - Mechanism for value addition on processing equipment. - Information to the group of other stakeholders working in the Division/District.
6.	Poor loan repayment	Understand the terms of loans	- Councilors	- LATF, friends
8.	Exploitation by middlemen	- Organise farmers to access markets	- Farmers	- Create awareness and lobbying
9.	Lack of proper organized market for bananas	- Link farmers to markets	- Farmers - Entrepreneurs	- Organise farmers into producer and marketing association
10.	Lack of transport	- Link farmers to transporters	- Farmers	- Conduct bulking transporting

Source: Fieldwork

Through KARI, ISAAA and the contributions from the group members, made a ripening chamber at their nearest shopping centre, which facilitates banana ripening and prevents losses. In the ripening chambers, it takes three days to get bananas ready for market. This has made members to earn money from sale of ripened bananas. This has in turn led to establishment of saving and credit scheme through farmer participation in the TC bananas.

The MoA has enabled some members to participate in seminars and taken them on tours outside the district to learn more about horticulture. The group has also received local and foreign. The group members are looking development partners to assist them with grants or small loans to assist the group members in order to uplift the living standard and to eradicate poverty and hunger.

As a result of the CAP meeting the Omokonge group members prioritised the following group action to address three key problems.

1. *Low yield:* members should select better performing banana varieties and employ proper crop husbandry practices and hygiene.
2. *High cost of planting material:* members to acquire planting materials from group members who have managed well their banana orchards. A well, members should establish group-bulking site, hardening nursery.
3. *Lack of water:* Members should make compost mulching and carryout on-farm water harvest.

5. Knowledge Sharing

Through the activities of Farmer Field Day, this chapter outlines farmers' perceptions of potential benefits and threats of introducing TC banana technology in their smallholder farming systems. This is followed by documentation of farmer-preferred varieties and their characteristics. This initial catalogue is based on the farmer preference characterization of traditional and TC banana varieties. The event was hosted by members of Omokonge Framers Group and attended by five representatives of other two farming groups –Sigona and Rio-omwando.

5.1 Sharing of knowledge

This activity included sharing information on seed acquisition, field establishment, crop husbandly, value edition (ripening of bananas) and marketing. The point of reflection was the extent to which farmers are to articulate their experiences of growing the traditional and TC banana varieties.

A farmer from the Omokonge Group led the discussion on the sharing of on the measurement, preparation of the hole and selection of on-farm suckers and their treatment for planting. One farmer from Sigona focal area led the discussion on the acquisition and planting of pre-treated suckers from KARI-Kisii. Two other farmers from the Omokonge Group took the participants on a tour of the banana orchard in which they observed the on-farm performance of traditional and TC banana varieties. Upon completion of the tour another farmer from Sigona Group shared his experience on banana husbandry and crop hygiene. The farmer presentations were interactive in the sense that participants were free to share their own experiences, seek clarifications and ask further questions. The agricultural professionals provided and advice and clarifications on some issues. On farmers' knowledge on post-harvest handling of banana varieties, the banana-marketing manager from the Omokonge Group led the discussion. Again, his presentation was interactive –where many farmers especially those from Sigona and Rio-Omwando expressed interest to learn more about banana processed products.

The study used Steve's farm in Omokonge community to document knowledge on the farners' preferred banana varieties and attributes (**see Table 10**). Steve grows the following banana varieties: (i) Grand nain, (ii) Uganda green (now renamed Kisii green), (iii) Ngombe "bandia" (iv) Chinese Cavendish (medium), (vi) Kampala, (vi) Dwarf cavendish, (vii) Valery.

Table 10: Banana Varieties/cultivars and prioritization by farmers

Banana variety	Characteristics	Order of priority
Grand nain	- Early maturing - Big fingers - Uniform ripening - Average sugar content - Good food source	1st priority
Kampala	- Wider market - Long shelf life - Average sugar content	2nd priority
Chinese Cavendish (medium)	- Big bunch - Many fingers - Good for market	3rd priority
Valerie	- Uniform fingers	4th priority
Uganda Green (or Kisii green)	- Faster cooking and ripening qualities - Small fingers –not good for marketing	5th priority
TC Ng'ombe	- Referred to as false Ng'ombe - Not performing better the original Ng'ombe	6th priority
Dwarf cavendish	- Not asked for by farmers - Highly susceptible to Cigar end rot disease	7th priority

Source: Fieldwork

The traditional varieties of bananas commonly grown in the area include: Ng'ombe, Ongonje, Kisukari and Ugnada green (Kisii green). In terms of preference for cooking farmers prioritized: Ng'ombe (1st), Ongonje (2nd) and (Kisii green (3rd). Among the dessert bananas, farmers preferred Kisukari (1st) and bokoboko (2nd).

5.2 Adaptation and innovation

Although the scientific sources of information on TC banana technology were KARI and MOA farmers adopted and adapted the technology to their prevailing agro-ecological and socio-economic conditions. Of particular importance here was farmers to share their insights on the domestication of TC banana varieties especially with respect how farmers adopted the research/extension recommendations and came up with their own adaptations or innovations.

One adaptation relates to spacing. Farmers adapted the recommended spacing of 6' by 9' to 9'by 9' and adjusted the planting holes from 2'by 2'x2' to 3'by3'by 3'. Given prevailing topography and declining soil fertility, farmers were shifting their banana

orchards from the hillsides to bottoms of the valley bottom where soil fertility and moisture were relatively higher.

The farmers' knowledge about bananas and how the knowledge is distributed in the community is summarized in Table 11 below.

Table 11: Farmer innovations

Use value	Distribution of knowledge		
	Science-knowledge (S-K)	Community-knowledge (C-K)	Omokonge-Knowledge (G-K)
1. Stems used as livestock	Yes		
2. Leaves as thatch			Yes
3. Charcoal cover			Yes
4. Compost	Yes		
5. Erosion control		Yes	
6. Herbal medicine –blood purifier		Yes	
7. Male bud as vegetable	Yes		
8. Crafts (baskets, hats, mats, etc)		Yes	
9. Soil binding agent		Yes	
10. Hangover remover			Yes
11. Stimuant		Yes	
12. Immune booster		Yes	

6. Lessons and Conclusion

6.1 Lessons

The lessons learnt disaggregated into: farm level's technology dissemination, support services, value-addition and marketing and banana system transformation. Of particular relevance are issues such as interfacing of traditional and modern knowledge, articulation of demand and domestication of TC banana varieties.

Farm Level:

There is general awareness of TC bananas in the area under study. Farmers also articulated well the advantages and disadvantages of TC material. However, it is difficult to observe the progress made in the adoption of TC material (see appendix beyond initial stage.

Technology Dissemination

There is a tendency for a linear model of knowledge dissemination – such that where farmers are involved, this was done merely to validate the research findings. This means that the lessons learnt from final users (farmers) and intermediaries are not incorporated into the learning process of technology producers and promoters.

Support Service

The K-REP example was not appropriate for the banana enterprise because of the relatively short period for the crop to mature, which in turn affects servicing of the loan. Loan defaulters and the shifting of the credit scheme from bananas to dairy farming exemplify this problem. According to an interview with a KARI scientist, "effective repayment of loans is not only dependent on frequent follow-up but also success of the technology. For the TC banana entrepreneur, linking entrepreneurs and market should enhance banana production. Indeed, effective technical support to farmers will only yield good results when packaged with sustainable micro-credit and post-harvest processing and marketing.

Value addition and marketing

Farmers were trained on banana technology transfer and some aspects of value addition (e.g. ripening of TC bananas and organized marketing). However, there seems to be limited training on group leadership and accountability. Also the issue of attitude changes and practices (Viz. meeting attendance and active participation) was not done well. This has implications on farmer reluctance to change from subsistence to commercial production of banana. Indeed, even in the groups such as Omokonge, there was no evidence of record keeping reflecting the stream of incomes from bananas.

System transformation

The system had limited capacity to transform banana farmers from subsistence to commercial production. In particular, the main puzzle was the disarticulation of demand and supply. This was, for example, attributed to lack of organized markets for bananas compared to tea. The solution for system transformation lies in reflecting on the enterprise mix and a market-oriented production strategy. Equally noticeable from discussions and CAP was ineffective group leadership and dynamics to spur change of attitude and practices –which might have also contributed to farmer reluctance to change from subsistence production to commercial production of bananas.

Farmer-to-Farmer Extension

There is very little evidence or farmer-to-farmer extension. One farmer captured it by saying "Farmers only come together when there are visitors indicating the desire to get public goodies". Evidence also shows that farmers from far places such as Kuria District have visited Omokonge Farmers Group when knowledge network within the Omokonge village is very weak (see comments on the transect walk).

Farmers in Rio-Omwando focal area, who had abandoned the group approach in TC banana promotion, expressed their interest to participate in the project again. This was a result their participation in the Omokonge Farmer Field Day, where they saw for themselves the demonstrable benefits of post-harvest handling activities of TC banana varieties (including bakery, winery, flour mill, crisps, jam and juices, livestock feed ratios and crafts).

6.2 Conclusion

The project focused on unbiased access to biotechnology information with respect to banana tissue culture, which has so far reached the farmers in some parts of Kenya. The levels of engagement for this project focused on traditional knowledge (TK) versus scientific knowledge and compared this with the farmer's daily management of bananas. The conclusion from: (i) PRA, especially the transect walk in which focused on farming practices and institutional arrangements, (ii) seed cataloguing which entailed documenting farmer preferred banana varieties and their attributes and (iii) CAP in which farmers identified problems and suggest solutions, which they should address, and those to be addressed by other external actors/agents.

The CAP meeting was of particular importance especially with respect to articulation of demand and domestication of TC banana technology. How were the findings of CAP linked to the expected outcomes of the project in terms of interfacing knowledge and farmer perception of banana varieties (viz. seed cataloguing)?

First, farmers indicated that "they brought us what we did not ask for – especially the Dwarf Cavedish". Second, labels on TC banana varieties were mixed which distorted the planting pattern. Given the sharp sloping topography of Marani division, farmers were asked to plant the short varieties at the bottom of the valley, followed by the medium-height and lastly the tall varieties at the top. As a result of the mixing of labels, this pattern was not followed --with serious implications on low yields due to shading. Third, there was inadequate preparation of farmers prior to receiving planting. Fourth inappropriate micro-credit scheme affected sustainable uptake of TC banana varieties. Fifth, the degeneration of planting material relative to the performance of farmers' traditional varieties raises doubt about the new technology. This has created some misunderstanding between farmers as final users and the researchers as source of TC banana planting material. Therefore, proposes the following solutions to some of the problems raised above.

1. Sources of inappropriate TC banana plantlets should devise a strategy of compensating the affected farmers to restore their confidence in the new technology. This should include proper labeling of TC banana plantlets and allowing farmers' representatives to accompany those who purchase TC material to foster farmer ownership.

2. Satellite nurseries and demonstrate plots should be set up in communities to reduce the cost of transport and show benefits. In particular, farmers emphasized the need for" farmers to observe plants in the field and select what he or she wants".
3. Evaluate and redesign the micro-credit scheme for the deployment of TC banana technology.
4. Strengthen farmer linkages to market and non-market agents.
5. Promote interactions between producers of knowledge, its potential users and intermediaries to foster knowledge sharing and innovation.

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Appendix 1: Map of Marani Division

Appendix 2: Transect route of Omakonge Community

Appendix 3: Catalogue of banana varieties in Kisii by farmers

Appendix 4: List of people interviewed

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K. kwach
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Mr. David Nyamumbo
Deputy District Agricultural Officer
Kisii

Mr. Shedrack Kipmoi
Crops Officer
Kisii

Simiyu Mitambo
Extension Officer
Marani Division

George Simiyu
Extension Officer
Marani Division

Fredrick Ondieki
Field Extension Officer
Marani Division

Macdonald Wesonga
Appropriate Rural Development
Agricultural Programme (ARDAP)
Busia – Kenya.

Patrick Sanya
Agricultural Information Research Centre
Nairobi – Kenya.

Mr. Okoko
Banana Entrepreneur
Kisii

Appendix 5: List of farmer participants

OMOKONGE SELF HELP GROUP

No.	Name	Sex	Station
1.	Francis Ondieki,	M (V)	Min. of Agriculture
2.	George Simiyu	M (V)	Min. of Agriculture
3.	David Mutambo	M (V)	Min. of Agriculture
4.	Hannington Odame	M (V)	CABE
5.	Macdonald Wesonga	M	Member
6.	Andrew Mobe	M	Member
7.	John Orango, M.	M	- do -
8.	Pacifica Mobe	F	- do -
9.	Annah Moraa Akama	F	- do -
10.	Lydia Kwamboka	F	- do-
11.	Zephaniah Orango	M	- do -
12.	Haron Orina	M	- do -
13.	Jane Kerubo	F	- do -
14.	Paustine Nyaboke	F	- do -
15.	Irene Bogonko	F	- do -
16.	Joseph Otiso	M	- do -
17.	Tabitha Marita	F	- do -
18.	Francis Akama	M	- do -
19.	Fridah Nyandoche	F	- do -
20.	Merceline nyanchama	F	- do -
21.	Stephen Bogonko	M	- do -

SIGONA AREA FOCAL GROUP

No.	Name	Sex	Group Position
1.	Robert Nyabengi	M	Member
2.	Grace Kiroche	F	Treasurer
3.	Joice Asiago	F	Member
4.	Damaris Omwenga	F	Member
5.	Alice Seme	F	Secretary
6.	Teresia Ondicho	F	Member
7.	Esther Onyango	F	Member
8.	Belister Nyakundi	F	Member
9.	Marylyn Bosire	F	Member
10.	John Bosire	M	Member
11.	Tabitha Marita	F	Member
12.	Mokaya Nyakundi	M	Chairperson

RIO-OMWANDO GROUP

No.	Name	Sex	Group Position
1.	Alfred Mageto	M	Assist Secretary
2.	Nashon Nyandwara	M	Member
3.	Evan Ochangi	M	Adviser
4.	Nancy Kerubo	F	Member
5.	Marcella Keronja	F	Treasurer
6.	Priscilla Mutitha	F	Tea lady
	Benedette W. Osoro	F	Member
8.	Eunia Ondieki	F	Member
9.	Maurine Ochwangi	F	Member
10.	Elizabeth Onditi	F	Member
11.	Concept Ombachi	F	Member
12.	Scholastica Nyakundi	F	chair- lady