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Preface

The present report contains methods and findings from the survey of sources of reproductive material around Mt. Kenya. The overall objective of the assessment was to contribute to an improved seed supply to tree planting farmers in Africa and the immediate objective to contribute to a comprehensive understanding of opportunities and constraints for improving seed systems for agroforestry in Kenya.

The assessment was made within the framework of Improved Seed Supply for Agroforestry in African Countries (ISSAAC), a Danida supported programme implemented in cooperation between *Forest and Landscape Denmark* and World Agroforestry Centre (ICRAF).

ISSAAC carried out surveys on different aspects of tree seed systems in Burkina Faso (with a focus on villagers' use of seed), Kenya (with a focus on sources of reproductive material), Malawi (with a focus on small-scale nurseries, and Uganda (with a focus on non-governmental organisations and community-based organisations.

The surveys are documented in the following reports:

Ræbild, R., Bassirou, B., Lillesø, J.P.B., Yago, E. L. and Damas, P. 2004.
Farmers' planting practices in Burkina Faso. A survey carried out by the project 'Improved Seed Supply for Agroforestry in African Countries' (ISSAAC). *Forest & Landscape* Working Papers No. 5-2004.

Mbora, A. and Lillesø, J.P.B. 2007.
Sources of tree seed and vegetative propagation of trees around Mt. Kenya. Development and Environment No. 9-2007. *Forest & Landscape Denmark*.

Mvula, P. and Lillesø, J.P.B. 2007.
Tree Seedling growers in Malawi – who, why and how? Development and Environment No. 5-2007. *Forest & Landscape Denmark*.

Namoto, M. and M.G. Likoswe. 2007.
Case studies of nurseries in Malawi. *Forest & Landscape* Working Papers No. 20. 2007.

Brandi, E., Lillesø, J.P.B., Moestrup, S. and Kisera, H.K. 2007.
Do organisations provide quality seed to smallholders? A study on tree planting in Uganda, by NGOs and CBOs. Development and Environment No. 8-2007. *Forest & Landscape Denmark*.

In addition to the above surveys, two preliminary baseline studies were conducted in Uganda (a district study of nurseries and farmers) and in Malawi (a preliminary investigation of organisations involved in seed supply).

Asare, R. and Pedersen, A.P. (2004).
Distribution of Tree Seed and Seedlings. A survey conducted in Kabale District, Uganda. The ICRAF/Danida Programme on Improved Seed Systems for Agroforestry in African Countries (ISSAAC). *Forest & Landscape* Working Papers no. 2-2004.

Pedersen, A.P. and Chirwa, P. W. (2005).

Tree seed in Malawi. Organisational survey. *Forest & Landscape* Working Papers no. 8-2005.

Executive Summary

The purposes of the survey were (i) to evaluate the quality of reproductive material of tree and bushes (sources of seed and vegetative material) utilised by smallholders, (ii) to evaluate all available sources in an area, and (iii) identify the most important distribution pathways from production to distribution.

The survey was carried out in three steps: First an iterative procedure was followed to identify all sources in the selected districts, then a general interview schedule was followed for all 230 identified sources, and finally a subset of 72 sources was visited and evaluated. This last evaluation had the aim to estimate the precision of the general survey and to elicit additional information that could not be extracted through the general survey.

Preliminary (general) survey

A total of 41 species were encountered in the 230 sources. We classified the sources according to five general types of sources (natural forest, farmland, plantation, seed orchard and vegetative propagation) and according to ownership - formal (government organisations) and informal (NGOs, CBOs, individual farmer, farmer groups, and private companies). Informal farmland sources are by far the most numerous type with more than half of the sources, but have overall fewer species and few indigenous species.

Around 96% of sources of formal organisations are established/identified, maintained, and protected by formal organisations, sometimes in collaboration between these formal organisations. Around 84% of sources of informal organisations are established/identified, maintained, and protected by the same type of organisation. Out of the 230 sources, 20 sources are not being utilised for reasons of no production due to immaturity or due to site factors.

The overall conclusion on distribution in the preliminary survey is that there is a great deal of overlap between the formal and informal sector. In particular the formal sector is distributing germplasm from a large number of informal sources that have not been certified by the formal sector. However, the evaluation survey (see below) modifies this conclusion.

Most of the formal and informal sources produce germplasm for sale, but a larger proportion of the informal sources are producing germplasm for free (in particular for the farmland sources promoted by ICRAF, the concept is based on non-commercial farmer-to-farmer diffusion of seed). For vegetative propagation (almost exclusively grafted fruit seedlings) all material is sold.

The formal sector is not providing better quality material than the informal sector; and both sectors are not providing the best material possible to farmers.

Evaluation survey

The two purposes of the evaluation survey were (i) to find out in which areas the information of the preliminary survey was imprecise or perhaps even misleading, and (ii) to provide additional detailed information that could not be elicited from the preliminary survey.

In the preliminary survey, the overall conclusion on distribution is that there is a great deal of overlap between the formal and informal sector. The informal sector was estimated to utilise 24% of the formal sources. The formal sector was estimated to utilise 50% of the active informal sources. The evaluation survey indicates that the informal sector utilised 28% of the formal sources (a similar estimate as that of the preliminary survey) and that the formal sector utilised 8% of the informal sources. There is thus still an overlap, but the formal use of informal sources is much smaller. While the preliminary survey estimates that around 65% of the sources are utilised by the formal system, the evaluation survey estimates this to be around 24%.

In the evaluation survey, it was possible to get more detailed information on the sizes of sources, including the total number of trees in the source as well as the number of trees collected from during the previous collection season. For several sources, the inadequate number of trees collected from is a reflection of the limited number of trees in the sources. However, also in the plantations and natural forest with many trees available, the collectors often collect from a few seed trees only. Most probably the collectors do not know the importance of collecting from many trees. For the farmland sources – trees are usually spaced far apart (scattered on the farmlands), and for some species the number of trees could be a concern with respect to adequate pollination. For the plantation sources, in most cases no silvicultural thinning had been carried out and as a consequence the spacing is too small to allow good pollination and seed set for the mature trees. The spacing of trees in most of the seed orchards is too close and thinnings (if any) has not adequately opened the stands.

The preliminary survey asked who paid for establishment, maintenance, and protection. In the evaluation survey it was possible to ask respondents on perceived problems of maintenance and protection as well as for collection. The responses from the formal and informal sectors are in strong contrast. While the majority of formal sector sources have problems of maintenance and protection, this is not the case to the same degree for the informal sources. The evaluation survey also shows that both formal and informal sectors have problems of collection. The types of problems are different, however, for the informal sector the dominant type of problem is lack of technical knowledge for collection, while for formal it is limited

equipment for collection. The species collected by formal and informal are very different with respect to collection techniques. Many of the informal sources are shrubs, while many of the formal sources are tall trees.

The evaluation survey indicates that distribution problems for informal and formal sectors are in contrast. The main problems highlighted by informal sector were lack of markets, while the formal problems are less and more related to technical problems. The majority of germplasm distributed by the formal sector is normally on the request by the clients thus no problem of markets.

The study indicates that the informal sector is able to produce as good quality germplasm as the formal sector and that the informal sector has a larger capacity for expansion than the formal sector. The overall goal of the two sectors; to improve smallholders' livelihoods and farm incomes, should make it possible to think of improving the sector as a whole to the benefit of smallholders.

There are many opportunities for increasing the efficiency and reach of the tree germplasm sector, but it will require that the government accepts that a private sector of small scale entrepreneurs is beneficial for reaching smallholders and that policy and development of support systems must be implemented accordingly.

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Special thanks go to all organisations and farmers who were involved in this study for their immense contribution and support in this study. Extension agents from NGOs, government institutions and ICRAF helped in identification of individual farmers and farmer groups who are involved with tree seed production. Last but not least we would like to extend special gratitude to ICRAF Meru office staff (Sally Anne, Sammy Carsen, Jonatahan Muriuki, Anne Nyambura and Kiirimi) for their support and patience during Anne Mbora's stay in Meru.

We are grateful to the Foundation - G.B. Hartmanns Fond - for making it possible for J.P.B. Lillesø to write up and finalise the present document as part of a more general assignment of documenting tree seed supply in the tropics.

List of Acronyms

ACK	Anglican Church of Kenya
BAT	British American Tobacco, Kenya
Cat. group	Water Catchments group
CBO	Community Based Organisation
CCS	Christian Community Services
CEFA	Cooperazione internazionale, sviluppo dei popoli e tecnologie appropriate. Italian non-government organisation promoting improved agriculture systems
CGIAR	Consultative Group of International Agricultural Research
DFO	District Forest Officer
DGG	Dairy Goat Group
EMI	Embu, Meru and Isiolo project
F	Formal organisations e.g. Kenya Forestry Seed Centre
FD	Forest Department
FTC	Farmers Training Centre
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit. German Agency for Technical Corporation
ICRAF	World Agroforestry Centre
IF	Informal organisations e.g. NGOs, Farmers
KADI	Kamurugu Agricultural Development Initiatives
KARI	Kenya Agriculture Research Institute
KEFRI	Kenya Forestry Research Institute
KFSC	Kenya Forest Seed Centre
KWAP	Kenya wood fuel and agroforestry programme
LETSSDA	Laikipia East tree seed and Seedling Dealers Association
LG	Local Government
LWTSSDA	Laikipia West tree seed and Seedling Dealers Association
NGO	Non-governmental organisation
SHG	Self help group
Species type I	Indigenous (native) species
Species type E	Exotic species
MoU	Memorandum of Understanding
n/a	Not applicable

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1. Introduction

1.1 Background and purpose for the study

The establishment and/or identification of appropriate sources of documented quality are essential ingredients for sustainable production of good genetic quality tree seed. Many national tree seed centers have used seed zonation (planting zones) for selection and management of sources based on their phenotypic appearance coupled with common-sense deployment in environments similar to that of respective sources. Selection of the most appropriate source can significantly increase tree production as compared to random sources, while a poor source may result in loss - or even total failure if the source is so maladapted to the given site that the tree does not survive. (Lillesø et al, 2001).

In most African countries national tree seed centres have had the mandate for source establishment and for distributing tree seeds from these sources to plantations. In recent years, however, NGOs, CBOs, bilateral projects and private people in many African countries have started procuring seed with the aim of distributing seed to farmers.

The purposes of the survey were (i) to evaluate the quality of reproductive material of tree and bushes (sources of seed and vegetative material) utilised by smallholders, (ii) to evaluate all available sources in an area, and (iii) identify the most important distribution pathways from production to distribution.

Specific tree seed policies - that take into account the roles of the public and private sectors in production, procurement and distribution of agroforestry seed - exist only in few African countries, but tree seed has sometimes tentatively been included in proposed crop seed policies (e.g. Government of Kenya, 2005) and the government national tree seed centre is often considered the only institution in a country with an official mandate to distribute seed. This study is therefore an input to the discussion on public/private roles in tree seed systems and on the role of tree seed policies.

Box 1. Seed systems, actors - formal and informal

Within agricultural production systems it is a normal procedure to describe the input supply of planting material as a »seed system« (Jaffee and Srivastava 1994, Maredia, 1999, Tripp, 2001). A seed system is made up of organisations and individuals, also known as actors, who perform different functions within an institutional[1] environment to produce seed. These functions include breeding, multiplication, processing, storage, distribution and marketing of seed. Information exchange is particularly important for the optimum functioning of seed systems.

[1] The *institutional* environment consists of the formal and informal rules that affect the sub sector, as well as the organizations that support them.

Crop seed systems are described as formal and informal, where the formal system consists of public and parastatal breeding institutions and specialised private companies with their own breeding and seed production activities. The informal crop seed system is the seed production, selection and diffusion of crop seed between farmers, with no direct inputs from the formal system (Tripp, 2001).

The distinction between formal and informal seed systems is reflected in most country crop seed policy documents, which are meant to be instruments to improve the quality and often access to seed by large and small scale farmers. During the past decade there has been an ongoing discussion concerning the efficiency of crop seed systems (e.g. Jaffee and Srivastava 1994; Maredia 1999; Tripp 2001), where the major concern has been the limited access of smallholders to good quality seed for a large range of crops. An important part of the discussion for crop seed has been on the respective roles of the public and private actors in the crop seed systems. The distinction between formal and informal seed systems in crop seed systems is also relevant for agroforestry tree seed systems. However, an important difference between crop systems and tree seed systems is that there are very few (if any) commercial organisations specialised in breeding and producing quality tree seed and seedlings. We therefore assign the NGOs as part of the informal system – no NGOs are specialised in breeding and production of quality agroforestry species, although many NGOs produce tree seed and seedlings as one of their many activities to improve farmers' livelihoods.

There is a rich literature on analysis of crop seed systems and some of the terms of this study have been borrowed and modified from crop seed systems (see box 1). In this study the government organisations that are involved in source identification and establishment in Kenya are categorised as formal - Kenya Forestry Seed Centre (KFSC), Kenya Agricultural Research Institute (KARI), Forest Department (FD), Farmer Training Centre, Ministry of Agriculture (FTC). These organisations have established sources on public land and as such also control their management and use. KFSC has had the official mandate for seed provision in the country and has over the years provided guidelines for source establishment and the government organisations have had full access to this information. World Agroforestry Centre (ICRAF) has also established seed orchards in collaboration with KEFRI and KARI. However, recently many of these orchards have been handed over to these two government organisations. These ICRAF orchards are also categorised as formal.

We have chosen to distinguish between formal and informal sources by one main criterion: ownership of the land where the source is situated. Our expectation is that if the government allows the establishment of a source, then quality criteria are used that ensures that the source will produce quality seed. The quality criteria have been established by KFSC and should in principle be available in any government office. Furthermore the land owner (government, communal, or private) also decides on the use of the source and if it should be converted to other use or simply removed. This

distinction made it unequivocal to categorise almost all the source into one of the two categories, and it is an objective criterion.

Formal tree seed provision has a long history in Kenya dating back to 1902 when the forest administration issued the first regulations for tree seed collection of indigenous trees. Before the First World War, a forester (seed man) was appointed exclusively for seed collection (Dyson, 1964; Dyson, 1974). In 1925, 5,500 kg of seed of various indigenous species[2] were collected and processed (Gardener, 1926). In 1930s the forestry profession started gaining knowledge of the genetic processes of trees and in 1936 the first sources of indigenous species were established (Paterson, 1967, Warmald, 1975). Some of the early introductions of exotic species were of dubious genetic quality. For example a forester brought a handful of seed from South Africa, which was used to establish 12 parent seed trees of *Cupressus lusitanica* at Elburgon in 1916; this was used as the source of most of *Cupressus lusitanica* established in East Africa (Gardener, 1926).

In 1985-1993 the Kenya Forestry Seed Centre (KFSC) was set up by GTZ/KEFRI to facilitate tree seed production of high quality in the required quantities. KFSC is, however, currently not the only provider of seed in Kenya and the study aims also at evaluating the genetic quality of reproductive material (seed and vegetative material) produced by various other organisations.

Many sources have been established without a formal approval by KFSC and without necessarily adhering to the recommendations by KFSC on seed source establishment. This informal source establishment by NGOs, CBOs, private companies, churches, schools, individual farmers and farmer groups include farmland sources (controlled by farmers on farmland), which is a source type that has not yet been described by the formal system in terms of genetic quality. In addition to ICRAF's collaboration with the formal system, ICRAF has in recent years also supported establishment of farmland sources, e.g. *Calliandra calothyrsus*, and *Leucaena trichandra* sources, planted by farmers on their land. In fact it appears that ICRAF's support role has changed paradigmatically from the formal system to informal system.

Classification of tree sources should ideally correspond as closely as possible to international standards in order to facilitate exchange of seed and information. The 'OECD Scheme for control of forest reproductive material moving in international trade' (OECD, 1974) provides some definitions. These definitions are based on single species plantation forest in temperate areas and are unfortunately of little relevance to tree species in tropical forests and landscapes. Furthermore the categories of the OECD Scheme - Source Identified/Selected/Untested Seed Orchards/Tested - cannot describe in an operational meaningful way the majority of seed moving to farmers in the tropics because most seed is from trees that are scattered on farmland or from natural forests.

[2] *e.g. Olea africana*, *Olea welwitchi*, *Olea hochstetteri*, *Brachylaena hutchinsii*, *Prunus africana*, *Warbugia ugandensis*

Box 2. Aspects of genetic quality of trees and shrubs

There are two aspects of genetic quality of trees and shrubs.

The first aspect is related to the fact that most trees and shrubs are outbreeders, *i.e.* they must receive pollen from unrelated trees to avoid inbreeding. For example a common seed collection practice in agroforestry is to collect seed from farmland. The trees that are planted in farmland will therefore not only produce agroforestry products for farmers, but will also be the mother trees for the next generations of trees to be planted. To maintain a healthy population of trees in the landscape it is therefore very important that the population continue to consist of many unrelated trees, and this is best done by collecting seed from many trees throughout the landscape.

The second aspect is related to the fact that trees adapt to the environment in which they grow. Tree species with distributions across different environments may develop different ecotypes. For example, if a species is distributed in areas with relatively low rainfall and high temperatures as well as in areas with relatively high rainfall and low temperatures, the species may have developed two different ecotypes (also called provenances), such that one provenance grows optimally only in its own environment. Most often it is only possible to discover ecotypes through long term tests. A common sense approach to avoid this potential problem is to develop a planting zone system, which can provide guidance on where to collect seed for planting of different species at different sites. Such a map was prepared by Kenya Forest Seed Centre (Braun *et al.*, 1993)

We have utilised a classification of sources that take into account the different ways seed can be described genetically in accordance with the way it is procured. In general five types of sources (four from seed and one from vegetative material) can be distinguished (see table 1) and also takes into account that different species may require different types of production/value chains (Dhakal *et al.*, 2006; Lillesø *et al.,* in prep. Lillesø and Moestrup, in prep.).

Table 1. Sources - from seed or vegetative material - determine the production and distribution chain of seed/seedlings

Seed Source Type	Brief description
1. Natural Forest	Natural vegetation, ranging from high forest to woodland
2. Farmland	Tree species on farms – planted or remnants of natural vegetation
3. Plantation	Trees planted in plantation or woodlot
4. Seed Orchard	Trees planted in plantation or woodlot, specifically for seed production
Source Type	
5. Vegetative propagation	Grafts (fruit trees), stem cuttings, micro cuttings or somatic embryos propagated from selected clones or seedlings

Source: Dhakal *et al.* (2006); Lillesø *et al.* (*in prep*)., Lillesø and Moestrup (*in prep*)

Although all 5 types can produce reproductive material (seed and vegetative material) of good quality, evaluation of the quality aspects of these sources cannot be carried out by the same criteria, because each type of source has its own combination of merits and limitations. Two basic criteria common to all types is documentation of sources and the origin of seed. Source type is often linked to the species that are used, for example indigenous species mainly occur in natural forest and to some extent in farmland. Exotic species most often are new introductions in farmland, plantations or seed orchards, and in some cases old introductions have developed landraces from an unknown and often small number of mother plants and origin (see for example the above case for *Cupressus lusitanica*). Box 3 and appendix 1 provide brief criteria and descriptions of the source types (a more comprehensive discussion can be found in Dhakal *et al.* (2006); Lillesø *et al.* (in prep).

Box 3. Criteria used for the evaluation of the 5 types of sources are:

Farmland seed sources: Ideally a farmland seed source should consist of a minimum of 50 trees with a minimum of 30 trees contributing to a seed lot. This strategy will increase the likelihood that the collection is broad based and minimize inbreeding for the next generation.

Natural forest seed sources: Ideally a natural forest seed source should consist of a minimum of 50 trees, preferably more - all of which should be more than 100 m from other trees of the same species with a minimum of 40 trees contributing to a seed lot.

Plantation seed sources: Ideally the minimum size of a plantation source should be 75 trees with a minimum of 40 trees contributing to a seed lot. The spacing of trees collected from should be around 10 to 14 meters and therefore a minimum size of one hectare can be acceptable. The likelihood that a plantation originated from seed collected from one (or few trees) will be lower for plantations of large areas, and for species with large seed.

Seed orchards sources: Ideally a seed orchard with family control should start with at least 50 families, whereas a bulked seed orchard should start with at least 80 families.

Vegetative propagation sources: The question on the number of trees for vegetative propagation is largely irrelevant as vegetative reproduction does not involve sexual recombination of genes (the number of clones used for production of a particular product is, however, an important parameter for sustainability and insurance). Generally propagation through seed sources will probably be the most cost effective methods for mobilisation of gene resources and scaling up. However, vegetative propagation has its advantage for fruit trees; where grafting is required in order to provide improved varieties.

Why we recommend these criteria: Trees that are introduced to agroforestry land-scapes become the future seed trees for farmers. The extra cost of collecting from many trees is for most species very small per seedling planted, while the effect is very large.

In the questionnaire, the size of source was to be provided in hectares or number of trees per source; we expected that this would enable respondents to report in at least one of the sizes. The intention was to obtain a measure of the potential genetic quality of the sources as measured by the number of trees pollinating each other in the source and the number of trees collected from.

1.2 The research questions

The quality and long-term survival of sources are two major issues in the seed/seedling production chain. The purpose of this survey was to investigate the status and scope of sources established by different types of organisations in particular with respect to the following guiding research questions:

- What are the types of sources by different organisations and how well are they maintained and utilized?
- How have considerations for genetic quality influenced the design, maintenance and collection from the sources and how is it documented?
- What elements (technical/social/economic) can be identified and controlled - that have influence on sustaining tree seed systems of high quality in Kenya.

1.3 Research objectives

The objective of the study was to provide an evaluation of the genetic quality of the sources established by different organisations and identify main constraints and opportunities for the long-term survival and use of different types of sources that produce seed for farmers' use.

The specific objectives are:

- To determine what criteria of genetic quality of sources is utilised by the organisations and individuals establishing sources, how the sources are documented and to evaluate the sources according to our criteria of genetic quality for source types
- To determine how sources are established, maintained and utilised
- To identify constraints and opportunities for improving quality and survival of sources

1.4 Research hypotheses

(a) Formal sources are well documented and of high genetic quality, but protection and maintenance are major constraints for long term survival.
(b) Informal sources are not well documented and of unknown quality, and protection and maintenance is ensured only during the lifetime of the project under which a source is established.

1.5 Implementation of study

The study consisted of three major steps:

(i) Identification and listing of all organisations and individuals that own and/or control sources. This step was an iterative procedure with the aim of providing a complete (or near complete) list.
(ii) Interviewing all identified organisations for a general description of their sources
(iii) On-site evaluation of a subset of the sources to verify information and get additional information

2. Methods and materials

2.1 Identification and listing of all organisations and individuals that own and control sources

An area around Mt. Kenya was selected as a case study since a wide variety of NGOs, projects, government agencies and farmers have tree-planting activities and KFSC has a large number of sources there (Mbora and Simons, 2003).

The survey was conducted in Meru Central, Meru North, Meru South (Chuka), Tharaka, Mbeere, Embu, Isiolo and Laikipia districts. These districts were selected, since they are the ones where most NGOs and government institutions carry out or have carried out seed production activities and with individual farmers and farmer groups controlling many sources. The study area is situated within the Eastern and North Eastern side of Mt. Kenya[3]. Nyeri and Kirinyaga districts were left out since they have only few available sources which are owned by KFSC and EMI with all the seed stands replicated in Meru Central e. g. *Vitex keniensis* seed stands in Meru forest station, the *Grevillea robusta* and *Eucalyptus camaldulensis* seed orchards of the NGO EMI in Meru Central. In Murang'a no organisations were identified carrying out seed production activities. The list of the sources was exhaustive of the sources in the districts. A previous inventory of agroforestry related work around Mt. Kenya (Mbora and Simons, 2003) provided a background for identifying organisations.

Identification of organisations that have sources in the districts was carried out in collaboration with Registrar of NGOs at Nairobi office, KEFRI, government officers at the district and divisional level in the area of forestry, agriculture, livestock and soil & water conservation, Meru Dryland Farming project, Farm Africa project in Meru and ICRAF office Nairobi. Extension agents from NGOs, government institutions and ICRAF helped in identification of individual farmers and farmer groups who are involved with tree seed production and also in the identification of various sites with sources and the location of organisations offices. The interviews were carried out from 20th May 2004 to 16th September 2004 and the main emphasis was on genetic quality and included questions on documentation and type of source, history, status and future plans, including utilization and identification of main constraints, opportunities for long-term survival and use of the sources.

Population density in districts is on average 48 people per km^2 - excluding the dry Isiolo and Embu with a large township the average of the other districts is 89 people per km^2 (Central Bureau of Statistics, 1999).

[3] The questionnaire was prepared by the authors with assistance from Richard Coe, ICRAF (see appendix 3). Extension agents and the enumerators assisted with translations of questions into local languages

2.1.1 Preliminary survey and evaluation survey

Preliminary survey

During the preliminarily survey, the respondents for the formal sources were mostly the forest department officers stationed where the sources are located. Many of the stands or plantations were established by forest department and the first records were written by forest department before the sources were handed over to KFSC. The respondents for farmer groups were mostly the chairperson or the extension officers, who have been working with the groups. For most of the individual farmer's sources[4], the respondent was the farmer himself or one of the family members. The accuracy of the preliminary survey as compared with the evaluation survey is discussed in the text.

Evaluation survey

The two purposes of the evaluation survey were (i) to find out in which areas the information of the preliminary survey was imprecise or perhaps even misleading, and (ii) to provide additional detailed information that could not be elicited from the preliminary survey.

Data for the evaluation survey were obtained through field checks of the selected sources. The information collected during the survey was generated from individual and focus group interviews. Criteria for selection of sources for evaluation was carried out as elaborated below. Selected sources were visited and evaluated.

The evaluation survey is different from preliminary survey since the evaluated sources were physically visited and observations made on the site as well as interviewing the source controller. In the preliminary survey the respondents were often extension officers (for the informal sector) and the officer in-charge of various stations where sources are located (for the formal sector). In the evaluation survey the respondents were the actual controllers of the sources and this provided the opportunity to evaluate the validity of the responses given in the preliminary survey.

The evaluation process took around six weeks in the eight districts. The main author and one of the officers from KFSC/KARI visited all the selected tree sources, carried out interviews at the sites and recorded the status of the each source from field observations in agreement with the source controller. The respondents were officers working with the relevant institutions owning the source or the owner or a member of the family for the farmland sources.

The selection was done to provide as closely as possible a representation of organisations, source types and species identified during the preliminary survey.

The selection of organisations for evaluation and the sources for evaluation was done by the main author with support from ICRAF's Research Support Unit. All the formal organisations (KFSC, FD, FTC, KARI, Local govern-

[4] The preliminary survey also identified that many of the individual farmers involved in tree seed production were former employees of Forest Department or Ministry of Agriculture

ment and ICRAF) were selected, and various source types were selected considering the representation of the species and the number of occurrences.

All the four big NGOs (EMI, KADI, CEFA, Meru Dryland project), and all the religious NGOs/CBOs (CCS, Catholic Church and ACK church) were selected, but the particular sources for evaluation were selected considering the representation of species. One of the two farmers' associations (LETSSDA) was selected.

7 Farmer groups out of 55 were selected at random since most had *Calliandra calothyrsus* and *Leucaena trichandra* seed sources established with the same design and same recommendations on management; 5 individual farmers out of 13 were selected considering the diversity of species to ensure that most of the species were represented in the evaluation. The only youth group in the survey was also selected.

Table 2 shows the selected sources for evaluation.

Table 2. Evaluation survey, organisations selected

Category	Organisation	Preliminary survey No of sources	Evaluation survey Selected no of sources
Formal	FD	14	8
	FTC	1	1
	ICRAF	6	6
	KARI	3	3
	KFSC	16	8
	Local Government	6	4
Total Formal		**46**	**30**
Informal	Church_CBO	11	3
	Farmer Group	111	10
	Individual. Farmer	42	18
	NGO	13	7
	Private Company	1	1
	School	6	3
Total Informal		**184**	**42**

72 sources out of 230 were selected from the preliminarily survey. For the formal sources: 4 of the 8 natural forest seed sources, 19 out of 29 plantations, both vegetative propagation sources , all the 3 seed orchards and 2 out of 4 farmland seed sources were selected. For the informal sources: 25 farmland sources out of 153, 5 of the 9 plantations, 8 of the 21 vegetative propagation sources, and 4 out of 5 seed orchards were all selected. Informal selection took into account all organisatorial projects. Selction of additional source types was random.

All the highly demanded species according to the occurrences were evaluated and the number of sources evaluated was done considering the number

of occurrences, e.g. 11 of the 23 sources of *Grevillea robusta,* 5 each out of the 11 sources of respectively *Vitex keniensis* and *Mangifera indica*. The most frequent medicinal species (*Prunus Africana, Warburgia ugandensis, Azadirachta indica*) were included; the major fruit species (*Mangifera indica, Persea Americana, Citrus sinensis*) and the major timber species (*Ocotea usambarensis*, *Vitex keniensis*, *Cordia africana*, *Grevillea robusta*, *Podocarpus falcatus*, *Eucalyptus camaldulensis*, *Eucalyptus saligna* and *Eucalyptus maculata*).

26 out of the 41 species in the preliminary survey were evaluated, 9 out of the 26 species evaluated are indigenous - 17 species of the formal sector (of which 8 are indigenous); and 16 species of the informal sector (of which 2 are indigenous).

Only a small fraction of *Calliandra calothyrsus* and *Leucaena trichandra* sources were evaluated since all were planted in the same design (in a line/fence) for the same purpose (fodder production) with a few trees left for seed collection.

The selected sources in various districts is shown in table 3.

Table 3. Evaluation survey , location (sites) of selected formal and informal sources

Selected sources – Evaluation Survey				**Sources – Preliminary Survey**		
SS District	**Total # of seed sources**	**Formal**	**Informal**	**Total # of sources**	**Formal**	**Informal**
Embu	22	9	13	105	11	94
Isiolo	2	2		5	4	1
Laikipia	7	6	1	14	10	4
Mbeere	5		5	9		9
Meru Central	26	6	20	51	12	39
Meru North	4	2	2	13	3	10
Meru South	4	3	1	30	4	26
Tharaka	2	2		3	2	1
Sum	72	30	42	230	46	184

3. Results, analysis and interpretation

3.1 Preliminary survey

3.1.1 Encountered organisations with sources

From the survey, 75 organisations and individuals were identified as controlling and utilising the tree sources in the study area. These were then grouped into two categories (formal and informal) according to ownership of the land that they are situated on. Table 4 below shows the number of sources controlled by each category. Six formal organisations operating in the area control 46 sources. Several types of informal organisations and individuals were identified, which all together control 184 sources. These informal organisations involved in tree seed production were regrouped into six sub-categories:

- 56 farmer groups were identified as groups controlling 111 sources, these were identified through extension agents; 53 of these farmer groups are supported by ICRAF.
- 12 individual farmers controlling 42 sources. 5 of these farmers were supported by ICRAF.
- Church CBOs - ACK Embu dioceses, Embu catholic dioceses and Christian Community services (CCS), controlling 11 sources. This subcategory has in many of the tables been joined with NGOs into NGO/Church_CBO.
- NGOs-EMI (Embu, Meru, Isiolo project), CEFA (Italian Agricultural project), KADI (Kamurugu Agricultural Development Initiatives) and Meru dryland farming project, controlled 13 sources;
- A private company (British American Tobacco Company) controls 1 source
- Three schools have received support to establish 6 sources
- Two farmers associations: Laikipia East Tree Seed and Seedling Dealers Association and Laikipia West Tree Seed and Seedling Dealers Association did not directly control any sources, but utilised 3 informal sources owned by individual farmers (as well as 5 formal sources).

Table 4. Number of organisations and sources identified in study area – formal and informal

SS Category	Organisation	No of sources
Formal	FD	14
	FTC	1
	ICRAF	6
	KARI	3
	KFSC	16
	Local Government	6
Total Formal		**46**

continued

5 Farmer groups were defined as informal groups of farmers who work together on a common purpose of improving their livelihoods, in our case through agroforestry activities

6 Associations were defined as a group of farmers, who have come together and registered as an association with Ministry of Culture and Social Services with set goals and vision; in these cases to collect and distribute seed

SS Category	Organisation	No of sources
Informal	Church CBO	11
	Farmer Group	111
	Individual. Farmer	42
	NGO	13
	Private Company	1
	School	6
Total Informal		**184**

The sources were categorised into five types and summarised in table 5 below by their species type (indigenous and exotic) and seed sources type. A total of 41 species were encountered in the 230 sources of which around 11% are of indigenous species. There are about twice as many exotic species in the sources as indigenous species and sources of exotic species are three times more numerous as compared to sources of indigenous species.

Farmland sources (informal) are by far the most numerous type with more than half of the sources, but overall have fewer species of both exotic and indigenous. The large number of farmland sources may correspond to less in terms of total seed production capacity as compared to the other types of sources. The seven indigenous sources on farmland are remnant trees, which farmers have conserved for other purposes, but now use for seed production for sale or own planting.

There is no vegetative propagation of indigenous species (this type of source is typically for improved varieties of exotic fruits).

Table 5. Number of species by seed source type, exotic/indigenous, formal/informal

Type of sources	No of species*	Exotic Species	Indigenous Species	Exotic sources	Indigenous Sources	Formal	Informal	Total # of Sources
Farmland	22	15	7	144	9	4	149	153
Natural Forest	6		6		8	8		8
Plantation	20	14	6	22	16	29	9	38
Seed Orchard	4	3	1	6	2	3	5	8
Vegetative propagation	5		5	23		2	21	23
Sum	**41**	**32**	**25**	**195**	**35**	**46**	**184**	**230**

* 41 species. 12 out of the 41 species occur in more than one type of source (4 species in three types and 8 species in two types).

District wise distribution of sources is shown in table 6 below. The districts Meru Central, Embu and Laikipia have the most formal sources overall (71%). Embu district has about half of the total informal sources. Formal

sources are geographically close to formal organisations, for example both KFSC and ICRAF had offices in Embu, which were later moved to Meru Central. Informal sources are close to headquarters of NGOs or other organisations handling tree seed production activities, for example the EMI project which used to operate in Embu, Meru and Isiolo.

The two semi-arid districts Tharaka and Isiolo have few farmland sources. A likely reason is that there is a concentration of tree planting support in high potential areas with higher rainfall.

Table 6. Seed source of various categories and types by districts

SS_District	Total # of Sources	Formal	Informal	Farmland	Natural Forest	Plantations	Seed Orchards	Vegetative propagation
Embu	105	11	94	88	1	5	3	8
Isiolo	5	4	1	1		3	1	
Laikipia	14	10	4	6	2	6		
Mbeere	9		9	2		1	1	5
Meru Central	51	12	39	22	1	17	3	8
Meru North	13	3	10	9	2	2		
Meru South	30	4	26	24	1	3		2
Tharaka	3	2	1	1	1	1		
Sum	**230**	**46**	**184**	**153**	**8**	**38**	**8**	**23**

3.1.2 Encountered Tree Species in various sources from the survey

Tree species encountered from all sources in the area studied are made up of 41 species with 14 indigenous and 27 exotics species.

Figure 4 shows that the rank abundance of species in sources follows an inverse J curve with a few common species: *Calliandra calothyrsus, Leucaena trichandra*, followed by *Grevillea robusta, Vitex keniensis* and *Mangifera indica* and a long tail of relatively rare species.

The two dominant species - *Calliandra calothyrsus* and *Leucaena trichandra* have been promoted by ICRAF for fodder and for local seed production for the farmers (informal), while a number of NGOs (EMI among others) support *Grevillea robusta* and *Eucalyptus camaldulensis*. *Grevillea robusta* which occurs in 19 sources is a popular species with the farmers due to its compatibility with other crops on farm. *Vitex keniensis* is one of the most popular indigenous species due to its fast growth and its qualities for timber. *Mangifera indica* (superior varieties) has also become popular for fruit production. *Citrus sinensis* occurs in 7 sources and farmers are selling the fruits locally. These superior varieties of fruits have been introduced by KARI together

with the Ministry of Agriculture in the area. The two species occurring in 6 sources are *Eucalyptus saligna* (Forest Department) and *Eucalyptus camaldulensis* (EMI).

Most of the seed sources of indigenous species encountered during the survey are rare except for *Vitex keniensis*.

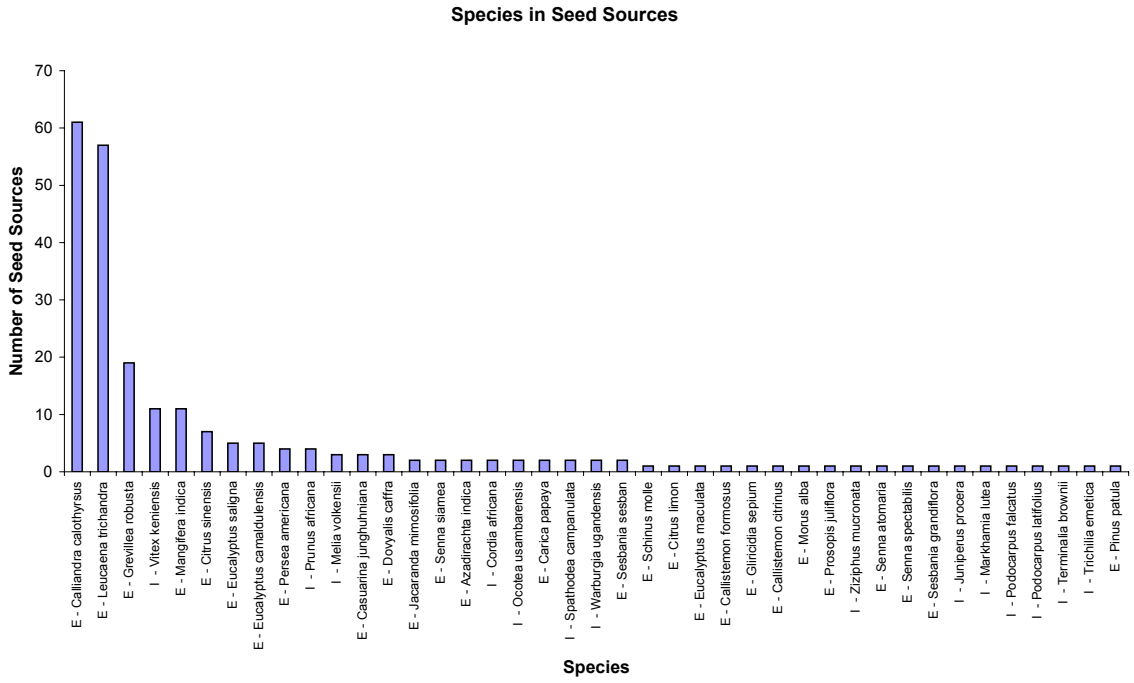

Figure 1. Number of seed sources by species ('E' or 'I' in front of species name denotes 'exotic' and 'indigenous' respectively).

3.1.3 Source, year of establishment

The earliest farmland sources were identified/established in 1969. Most have been established by planting of exotic species, but a few are from indigenous species occurring in farmland as remnants of the natural vegetation or through natural regeneration. Farmland sources drastically increased in 1999 and 2001. This was mainly due a project implemented by ICRAF and the NGO Farm Africa promoting two species *Calliandra calothyrsus* and *Leucaena trichandra* for fodder production, while suggesting to farmers to leave trees for seed production in the process.

Most of the designation of natural forest sources took place in the period from 1988 to 1998 by KFSC (Rode, 1986a; Rode, 1986b) and the number of sources is relatively small. These natural forest sources are made up of five species e.g. *Prunus africana*, which was designated by FD and farmers in 1995, *Melia volkensii* which was designated by KARI, *Ocotea usambarensis* in 1988 and *Spathodea campanulata* in 1989 by KFSC. *Podocarpus falcatus*, which is situated on local public land was designated by an individual farmer.

Year of plantation establishment is known for almost all the plantations and identification of their use as plantation sources was carried out by KFSC in the same period as for natural forest sources. The oldest plantation source planted by the Forest Department was established in 1936 of an indigenous

species (*Prunus africana*) and many plantations established since then are in use as sources. Most of the plantations used as sources are of timber species (indigenous and exotic).

There are very few Seed Orchards[7]. Four were established by an NGO (EMI) of two exotic species between 1990 and 1992; KARI established one source of indigenous species in 1999; and ICRAF established two sources of exotic species in 1997 and one of an indigenous species in 2000.

Vegetative propagation is mainly for production of scions or buds and rootstock of well known fruits. Superior fruit varieties are propagated. The number of sources established has been quite constant and low over the years from 1979 to 2003.

Figure 1 presents an overview over time of source establishment of the sources in the area.

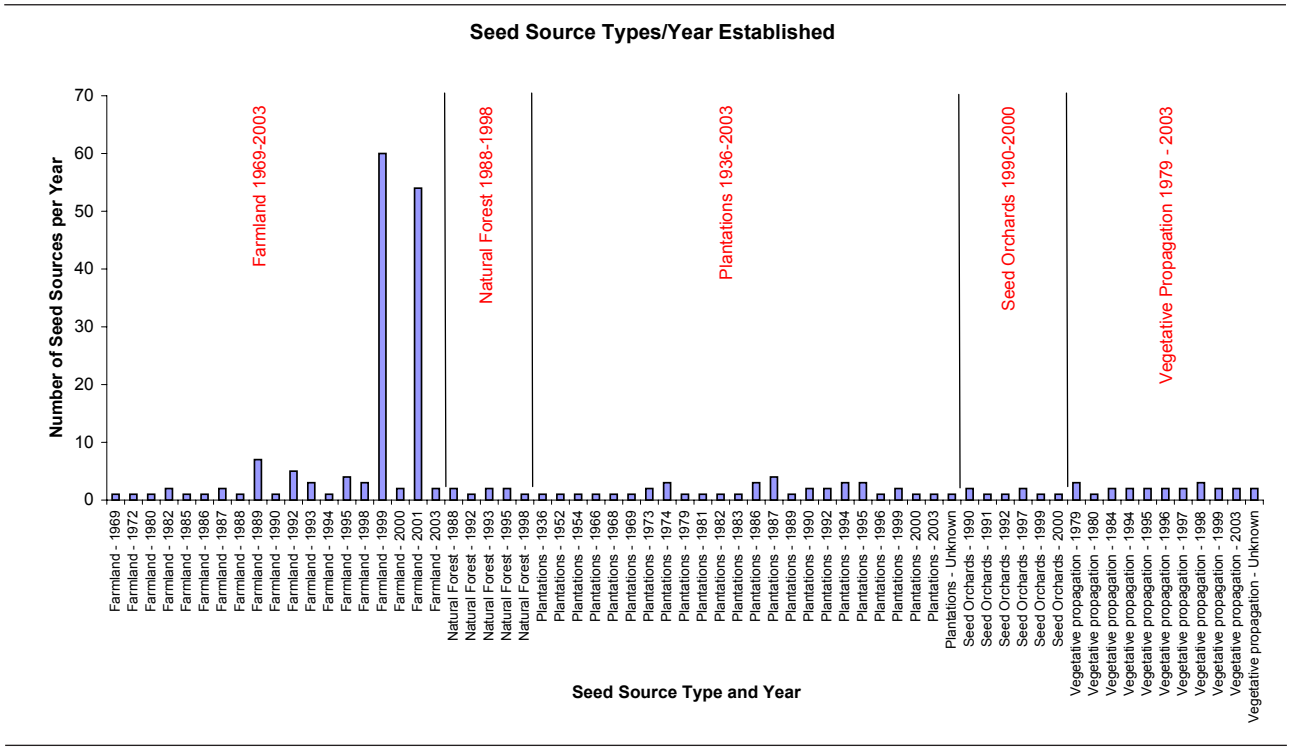

Figure 2. Source types and year established

3.1.4 Status of Land ownership

All sources occur in one of the three types of land ownership (public land, private/farmland, communal land) encountered in the region during the survey. As discussed in the introduction we have chosen to distinguish between formal and informal sources by one main criterion - ownership of the land where the source is situated. Our expectation is that if the government allows the establishment of a source on public land, then the quality criteria used ensure that the source will produce quality seed.

[7] Forestry Research established seed orchards close to Nairobi of industrial tree species in the 1960s and from 1988 to 1990 KFSC established seed orchards close to the eight regional sub-centres. The closest sub centre for Mt. Kenya is Nyeri, a district which was not included in this survey. See appendix 3 - Seed sources at KFSC sub centre at Nyeri - for a list of sources established there

The quality criteria have been established by KFSC and should in principle be available in any government office. Furthermore the land owner (government, communal, or private) also decides on the use of the source and if it should be converted to other use or simply removed. This distinction made it unequivocal to categorise almost all the source into one of the two categories, and it is an objective criterion. In 4 cases out of the 230 sources the logic of assigning this distinction is somewhat blurred, but we have maintained the original distinction and discuss the cases below.

Communal land ownership is land where sources occur on a community land or land set aside by government for benefiting a community e.g. church land or market land or a coffee society land. None of the sources established on private land were managed by the government agencies within the natural resources sector.

With respect to sources on school land, the distinction also makes school sources informal because school land ceased to be public land with a decree in 1998, which transferred these properties to communities and associations managing these educational institutions. We therefore consider it most logical to classify them as informal sources. None of the sources established on communal land were managed by the government agencies within the natural resources sector.

Only a few of the formal sources are farmland sources - those sources were trees scattered in towns or along roads under the jurisdiction of local government. All three species are ornamental trees and most likely established for that purpose - *Jacaranda mimosifolia* with trees along the road - identified and utilised by FD. *Callistemon citrinus* trees scattered in Nanyuki town - identified or utilised by LETSSDA, a farmers' association. *Spathodea campanulata* in Nanyuki town - utilised by an individual farmer. From a genetic quality point of view they can be treated by the criteria of farmland sources:

In 4 cases out of the 230 sources the logic of using tenure for differentiating between formal and informal sources is somewhat blurred because the ownership of the land has been transferred from public land to communal land since the sources were established. We consider the sources as belonging to the informal category as they were established at the initiative of non-specialist organisations for the specific purpose of producing seed and have since been managed by non-specialist organisations (see also appendix 2 for a description of the sources). In three of the cases an NGO or a school voluntarily requested help from KFSC to ensure that high quality seed could be produced from the sources. KFSC has since the establishment not been involved in the management. In the fourth case the school did not involve KFSC. In all four cases the land belonged to the government at the time of establishment and has since been transferred to an association or community running the school (3 cases) or to a community by the market place where the source was established (1 case).

Table 7 below shows where the sources of the two categories of institutions (formal & informal) are situated with respect to the three different kinds

of ownership of land and the five types of sources. All formal sources (46 sources) are situated on public land (as predicted by our criteria). The three farmland sources of formal organisations are sources identified or utilised by several organisations, but all situated on local public land.

The large majority (134 sources) of informal organisations of farmland source type are situated on private farmland, while a sizeable proportion (15 sources) of farmland type are situated on communal land (community land such as market places, church land, village meeting places or coffee society land).

Most of the vegetative material by the informal sector is on private land, while all informal seed orchards are situated on communal land. Table 5 shows the summary of the types of sources and types of land ownership.

Table 7. Categories of sources and type of land ownership

Category	Source type	Communal Land	Public Land	Private land	Sum
Formal	Farmland		4		4
	Natural Forest		8		8
	Plantations		29		29
	Seed Orchards		3		3
	Vegetative propagation		2		2
Informal	Farmland	15		134	149
	Natural Forest	0		0	
	Plantations	5		4	9
	Seed Orchards	5		0	5
	Vegetative propagation	3		18	21
Grand Total		**28**	**46**	**156**	**230**

3.1.5 Establishment, maintenance and protection

Establishment, maintenance and protection of sources is physically the first steps in the line of production of reproductive material (seed and vegetative material). Establishment of sources in natural forest, plantations - and also farmland sources of already existing trees, is in principle the identification and selection of areas that contain certain tree species that are suitable seed sources of a particular planting zone[8]. Establishment of seed orchards and farmland sources by planting is the selection of species, provenances and families for planting[9] according to certain criteria. Establishment of vegetative material is the selection of a source with suitable clones and mass production of these clones.

Around 96% of sources of formal organisations are established/identified, maintained, and protected by formal organisations, sometimes in collaboration between these formal organisations. Around 84% of sources of informal organisations are established/identified, maintained, and protected by the same informal organizations.

The bulk of the large number of farmland sources is where ICRAF has

promoted adoption of fodder crops for milk production, ICRAF initially provided the seed[10] for establishment, but sowing, planting, maintenance and protection is carried out by the farmers themselves, usually in groups.

The informal mixed lines are primarily NGOs trying out different combinations of maintenance and protection of sources (see table 8). The two formal mixed lines are two seed orchards of high quality *Eucalyptus camaldulensis* and *Gevillea robusta* established by the NGO (EMI) in collaboration with the Forest Department.

Table 8. Who paid for establishment, maintenance and protection of sources

Sub Category	Who paid for Establishment/ identification	Who paid for maintenance	Protection	Count of Protection
Pure lines				
Formal	Formal	Formal	Formal	44
Informal	NGO/Church_CBO	NGO/Church_CBO	NGO/Church_ CBO	17
	Farmers	Farmers	Farmers	152
	Private	Private	Private	1
	School	School	School	2
Sum of pure lines				**216**
Mixed lines				
Formal	NGO	Formal	Formal	2
Informal	NGO	Formal	Formal	4
	NGO	Farmers	Farmers	1
	NGO/Formal	Farmers	Farmers	2
	NGO/Formal	Formal	Formal	1
	NGO	School	School	4
Sum of mixed lines				14
Grand total				**230**

EMI also established four informal seed orchards from high quality Australian seed on communal land to be maintained and protected by the formal KFSC. The NGO (CEFA) established together with the formal Forest Department three sources on communal land. Two were farmland sources to be maintained and protected by farmer groups and one was a plantation to be maintained and protected by the Forest Department. CEFA also established a farmland source to be maintained and protected by a school and now utilised by farmers. The NGO (Meru Dry Land Farming) established three plantations on communal land to be maintained and protected by schools. ICRAF acting as an NGO established one source of *Warburgia ugandensis* on communal land, with the intent that a farmer group should maintain and protect it (and benefit from the products by use or sale).

[8] Based on criteria of phenotypical and genetic quality of trees and assumptions on, in which areas the seed of the source can be planted and grow well.

[9] Based on criteria of genetic quality of provenances and families (sometimes also of clones) of diverse and sometimes superior material coupled with assumptions on, in which areas the seed of the source can be planted and grow well.

[10] Seed is an insignificant part of the total cost of tree establishment, therefore the provision of seed alone does not qualify to paying for the establishment of a seed source

3.1.6 Seed collection and distribution for Seed source categories through formal/informal systems

Out of the 230 sources, 20 sources are not being utilised for reasons of no production due to immaturity or due to site factors (we have included them in the survey as they were identified as sources during the survey[11]), 46 sources belong to the formal sector and 184 to the informal sector. The number of active formal sources is 45 (plus 1 inactive one). The number of active informal sources is 165 (plus 19 inactive ones).

In table 9 the sources have been listed according to type of source (formal and informal) and the informal sources have been further divided into four types of controllers of the source, Farmers (153 sources), NGO/Church CBO (24 sources), School (6), and private (1 source belonging to British American Tobacco Company (BAT)), mainly to promote the growing of firewood for tobacco curing). The types of sources have then been further divided according to which actors collect from the sources. The distribution from sources have been divided into formal and informal sector participation in distribution (a large proportion of the sources are utilised or distributed by a large number of actors and a detailed division would have made 43 different combinations of different mixtures of actors).

The overall conclusion on distribution is that there is a great deal of overlap between the formal and informal sector. Out of the 45 active formal sources, the informal sector is distributing from 11 sources (24% of formal sources). Out of the 165 active informal sources, the formal is distributing from 83 sources (50% of the informal sources).

However, the evaluation survey (see below) modifies this conclusion to some extent (see section 3.2.3).

[11] 2 of the informal sources have not yet reached maturity age, 1 formal source is a *Markhamia lutea* progeny trial, from which seed has never been harvested, 17 informal sources are planted in areas that are too dry or in areas with insufficient dry season, thus seed production is severely reduced

Table 9. Sources – collection – distribution, formal and Informal channels – preliminary

Not Utilised	# SS	SS Categories	# Collection	Collection categories	Distribution	
					Only Informal Utilising	Formal (also) Utilising
1	46	Formal	31	Formal		31
			5	Farmers	1	4
			6	Association	2	4
			1	Mix: Formal + Association		1
			2	Mix: Formal + Farmers		2
18	153	Farmers	130	Farmers	61	69
			1	Formal		1
			1	NGO/Church CBO		1
			3	Association	1	2
1	24	NGO/Church CBO	15	NGO/Church CBO	9	6
			4	Farmers	4	
			3	Mix: Farmers + School + Formal		3
			1	Mix: Farmers + School	1	
	6	Schools	2	Farmers	2	
			1	Formal		1
			3	NGO/Church CBO	3	
	1	Private company	1	Private company	1	
20	**230**		**210**		**85**	**125**

3.1.7 Mode of seed supply free-sold

Out of the 45 active formal sources, 84% produce germplasm for sale. The formal sources producing seed for free are the five sources of ICRAF, two sources of KARI and one local government source. Out of the 165 active informal sources 62% produce seed for sale, 28% are distributing seed for free and 10% are producing for own use. Farmer groups own 70% of »free« sources, while 17% belong to NGOs. All »own use« sources belong to farmer groups.

From vegetative sources (almost exclusively grafted fruit seedlings) all material is sold. From natural forest sources around 88% is sold. The farmland sources have the lowest proportion of seed sold because a large proportion of these sources were established by farmers' for own use. Table 10 shows the mode of seed supply (free or sold or not distributed at all) of all the sources identified during the survey.

Table 10. Seed for sale or for free by category and by type

	Total # of Sources	No distribution	Free Procurement	Sold
Source Category				
Formal	46	1	7	38
Informal	184	19	62	103
Sum	**230**	**20**	**69**	**141**
Source type				
Farmland	153	17	59	77
Natural Forest	8		1	7
Plantations	38	1	7	30
Seed Orchards	8	1	2	5
Vegetative propagation	23	1		22
Sum	**230**	**20**	**69**	**141**

3.1.8 Source provenance

The most frequent course for failure of planting of exotic tree species is the use of the wrong species or provenance (Zobel *et al.*, 1987). Successful tree planting requires a certain degree of ecological and technical skills: the species should be planted at a site where it is able to survive and grow well, and it should be planted and nursed in an appropriate way depending on the species requirements and the use of the trees. Performance of different species and provenances varies with planting site and the challenge is to match species and provenances to planting site.

The experience of successes and failures of forestry plantations shows that the first point in tree planting is to know the true origin of seed and seedlings that are to be used and this can be defined by provenance, geographic

source, geographic race, and seed sources (Zobel *et al*., 1987). The interpretation of these terms varies to some extent by different authors, but the two important criteria are (i) what is the provenance of origin for a species, and (ii) the location of the source, where seed is collected? Here we will call the two criteria »provenance of origin« and the »local provenance« (location of the source).

Provenance of origin refers to the area or stand from where the first material was collected. For example for one of the main species promoted by ICRAF – *Calliandra calothyrsus* – superior provenances originating from Central America have been identified and some of the most promising provenances have been tested in Kenya. The selected provenance in the Kenyan moist highlands is called Patulul from Guatemala.

Local provenance refers to the location of the seed collected. For example a seed orchard of *Calliandra calothyrsus,* Patulul provenance have been established at KARI in Embu and that local provenance is therefore Embu[12], and provenance of origin Patulul, Guatemala.

Table 11 shows to what extent the provenance of origin and local provenance of 195 sources of various species is known in the survey. For formal sector sources the origin of exotic species is not known for 77% of the sources, while for the informal sector the origin is not known for 54%. For 23% of the formal exotic sources and 46% of the informal exotic sources both the provenance of origin and the local provenance are known.

The proportions of types of sources used by the two sectors are quite different (see table 11), so a comparison of the absolute numbers is less relevant than to note two important points: (i) that the formal sector is not providing better quality material than the informal sector; and (ii) that neither of the sectors are providing the best material possible to farmers. An overall comparison shows that local provenance is better known for informal sources than for formal sources (P 0.006, Fisher's Exact Test).

Table 11. Category species type (E&I) local provenance, provenance of origin

Category	Local Provenance Known	Provenance of origin Known	# SS per category
Exotic species			
Formal	Yes	Yes	5
	Yes	No	2
	No	No	16
Informal	Yes	Yes	79
	Yes	No	65
	No	No	29
Indigenous species			
Formal	Yes	Yes	22
	Yes	No	1
	No	No	1

continued

[12] The first introduction of *Calliandra calothyrsus* to Kenya was probably made by an NGO (KWAP) and the provenance of origin was never documented. KARI also has a seed source in Embu established with these seeds of *Calliandra calothyrsus* and the local provenance of these is known as Embu provenance, but the provenance of origin may not be the same. The two types have never been compared in trials.

Category	Local Provenance Known	Provenance of origin Known	# SS per category
Informal	Yes	Yes	7
	Yes	No	1
	No	No	3

Note: Known varieties of fruit trees have been treated as known origin and known local provenance

The high numbers of unknown origin is mainly due to the frequent use of local landraces of exotic species. Several of these landraces may be as good as a new import of seed, but in almost all cases this is not known with certainty. *Grevillea robusta* is an example of a local landrace, which is inferior to new imports from the place of origin - probably due to a very narrow genetic base of the first introduction (Harwood *et al.*, 1992).

3.1.9 Size of sources

Genetic quality of reproductive material must take into account that trees and shrubs are outbreeding and the production of quality reproductive material requires that inbreeding is minimised to the largest extent, both in the first and subsequent generations of trees (Dhakal *et al.*, 2006; Lillesø *et al.*, see also box 3). It is therefore important to know the number of unrelated mother trees that produce seed from a certain seed source (or clones from a vegetative source).

Farmland sources: The responses were not consistent for this seed source type, for example the response from farmland sources was below 50%, probably due to the fact that the local extension officers were the respondents for many sources and in most cases they did not know the exact size of the source. In fact for the farmland sources supported by ICRAF (116 farmland seed sources), the concept is to bulk seed from many sources to ensure a broad genetic base (presumably also taking species-site matching into account).

The formal institutions have identified and utilised four farmland sources, which have varying sizes; with one source having less than 9 trees, another one with 42 trees (30-49 trees) and two with 10 to 19 trees per source. These numbers are likely to be correct and indicate that genetic quality was not a major concern for the identification of these farmland sources.

Ideally a farmland seed source should consist of a minimum of 50 trees with a minimum of 30 trees contributing to a seed lot. With these criteria most of the sources have too few trees, except if the seed is bulked before distribution (as is the case with the ICRAF supported seed sources, but not for the formal farmland seed sources).

Natural forest seed sources: The two responses where the size of seed source was provided in hectares belong to KFSC, which has well developed criteria for evaluating and documenting natural sources in a forest with mixed species. The responses in number of trees were from sources on land controlled by Forest Department and Local Government, but identified and utilised by different organisations, respectively KARI, an association, and

individual farmers. For one source the informal user (an association) did not know the size or number of trees.

The question on quality of the natural forest seed sources is incomplete as it requires information on size of area, density of the target species per unit area, as well as conditions for pollination of the target species. However, ideally a natural forest seed source should consist of a minimum of 50 trees, preferable more – all of which should be more than 100 m from other trees of the same species with a minimum of 40 trees contributing to a seed lot (see Box 3). With these criteria all the Natural Forest sources are too small, whether counted by number of trees or number of hectares. The sources fail their most important task – of mobilising the genetic resources of the species.

Plantation seed sources: The responses from the formal institutions KFSC, Forest Department and ICRAF provided information on the size. The size of the plantations of the formal institutions varies from less than a hectare to more than twenty hectares and from those reported by number of trees, the number varied from less than nine trees to more than fifty. For one source the informal user (an association) did not know the size or number of trees. The size of the plantations of the informal institutions range from 1 to 9.9 hectares, and from those reported by number of trees, the number was more than fifty.

Ideally the minimum size of a plantation source should be 75 trees with a minimum of 40 trees contributing to a seed lot (see Box 3). Most of the formal plantation sources reported in hectares can be considered to be of sufficient size, while almost half of the plantation sources reported by number of trees are inferior (unless they actually consist of more trees that can be collected from). Informal plantation sources reported in hectares are of a sufficient size, and the plantation sources reported by number of trees are close to acceptable (if seed is collected from all trees).

Seed orchards sources: The question for the seed orchards - of how many trees – is of much less interest than information on the number of families (unrelated mother trees) that contribute to the seed orchard). By area alone all seed orchards qualify (including the formal source of 0.5 ha in the 0-0.99 ha interval) [13].

Ideally a seed orchard with family control should start with at least 50 families, whereas a bulked seed orchard should start with at least 80 families (see Box 3). One seed orchard almost qualify since it was established with 60 families by these criteria, however, two informal sources reported to have been established with unknown number of families are likely to be inferior.

Vegetative propagation sources: The question on the number of trees for vegetative propagation is largely irrelevant as vegetative reproduction does not involve sexual recombination of genes. All the vegetative sources in the survey are of superior cultivars of well known fruit trees. The vegetative propagation with a large production of scions or buds is controlled by NGOs, in particular KADI, which has sold large quantities to ICRAF for export to ICRAF Ethiopia, ICRAF Rwanda, ICRAF Uganda and ICRAF Tanzania.

[13] The minimum number of families will depend on whether family identity is maintained in the seed orchard – if family identity is maintained, the number of families surviving in the seed orchard can be controlled during thinning.

Table 12 shows a summary of sizes of various seed sources identified during the survey.

Table 12. Sources sizes reported in number of trees or in hectares

		Trees						Hectares				
Category	**Source type**	**No information**	**1-9**	**10-19**	**20-29**	**30-49**	**=/> 50**	**0>&<0.99**	**1-4.99**	**5-9.99**	**10-19.99**	**=/> 20**
Formal	Farmland		1	2		1						
Formal	Natural Forest	1		2	3				1		1	
Formal	Plantations	1	1		1		3	2	9	1	7	4
Formal	Seed Orchards							1	2			
Formal	Vegetative propagation							1	1			
Informal	Farmland	65	44	17	8	7	7	1				
Informal	Plantations						7		1	1		
Informal	Seed Orchards					1	1		2	1		
Informal	Vegetative propagation				1		11		6	1	2	
	Total	**67**	**46**	**21**	**13**	**9**	**29**	**5**	**22**	**4**	**10**	**4**

3.1.10 Number of families in sources

The general observations in the previous section relating to the five types of sources are also relevant here. The question is mainly relevant to planted sources.

Many of the respondents in the informal sector are extension agents who work very closely with the farmers or owners of the seed sources. From the responses, it is obvious that the number of unrelated mother trees in a source is not considered an important aspect of the quality of the informal sources. For the formal organisations the respondents are all government officers who work in the area where the sources are situated.

The number of contributing mother trees was unknown for 91% of the formal planted sources, while for informal planted sources it was 62%. The large number of unknowns for the formal sector is probably partly due to frequent transfer of staff and misplacement of documents or records of sources, while in the informal sector the use of a local landrace of *Calliandra calothyrsus* for farmland sources is the major contributor to the unknowns, while *Leucaena trichandra* contributes to the known (although with the number of families

(15) on the lower side). The seed orchards with 15 and 11-25 families are on the lower side, in particular with respect to mobilising new genetic resources, while the two sources established with 60 families are well designed.

In general the formal sector is not performing better than the informal with respect to documentation and the number of families contributing to sources. Only 4 out of 32 planted formal sources were documented with respect to number of families. A main contributor to the unknowns of the formal sector is the old plantations. For the informal sector 61 out of 157 planted sources were documented with respect to number of families, a main contributor to the unknowns of the informal sector are the *Calliandra calothyrsus* farmland sources and to the known are the *Leucaena trichandra* farmland sources, both promoted by ICRAF.

The four best seed orchards is an example of the possibilities for formal sector support to the informal sector. These informal seed orchards were established on communal land by an NGO – the material used is documented seed imports from Australia, with technical advice from the formal sector.

Table 13 shows the number of families used in establishment of each source and the number of sources whose number of families used could not be provided.

Table 13. Number of families in sources

Category	Source type	Number of families	Count
Planted			
Formal	Farmland	Unknown	3
	Plantations	15	1
	Plantations	Unknown	28
	Seed Orchards	11-25	2
	Seed Orchards	Unknown	1
Informal	Farmland	15	54
	Farmland	Unknown	89
	Plantations	60	1
	Plantations	30	1
	Plantations	10	1
	Plantations	Unknown	6
	Seed Orchards	30	3
	Seed Orchards	Unknown	1
	Seed Orchards	60	1
Not planted or vegetative			
Formal	Farmland	Natural	1
	Natural Forest	Natural	8
	Vegetative propagation	Variety	2
Informal	Farmland	Natural	6
	Vegetative propagation	Variety	21

3.2 Evaluation Survey

The two purposes of the evaluation survey were (i) to find out in which areas the information of the preliminary survey was imprecise or perhaps even misleading, and (ii) to provide additional detailed information that could not be elicited from the preliminary survey.

For most of the questions, the evaluation survey gave the same responses as the preliminary survey except the size of sources were more precise, and longer lists of distributors were provided. The evaluation survey also provided more detailed answers to the questions on constraints and problems than in the preliminary survey, where most respondents could not provide any information or response to these questions.

3.2.1 Documentation availability

Documentation availability was considered as the availability of basic records for the source e.g name of the species, geographical location of the provenance of origin, number of trees in the source, size, age, geographical location, source management, original provenance of the seed used to establish the source, seed collection and seed handling documents availability in hard copy or soft copy.

Table 14 shows the documentation information or status obtained from each seed source evaluated. Only 16 out of 72 sources had any documentation, which means that for the majority of both formal and informal sources, customers do not have information about the planting material in which they are investing time, money and land.

Table 14. Availability of documentation in various sources

Category	Source type	Documentation available	Documentation not available
Formal	Farmland		2
	Natural Forest	1	3
	Plantations	9	10
	Seed Orchards	3	
	Vegetative propagation		2
Informal	Farmland		25
	Plantations		5
	Seed Orchards	3	1
	Vegetative propagation		8

3.2.2 Establishment/ identification time (year)

Discrepancies between the preliminary survey and the evaluation survey were found in 6 out of 72 sources. Except for seed source ID 151, the differences (see table 14) are modest compared to the age and type of sources. The information from the preliminary survey therefore appears to be reasonably reliable.

Table 15. Year of Establishment – discrepancies between surveys

SeedSource ID	Formal/ Informal	Seed_Source	Year_established preminary survey	Year_established evaluation survey	Discrepancy
22	Informal	Farmland	1989	1987	2
138	Informal	Farmland	1982	1988	-6
151	Informal	Farmland	2003	1992	11
52	Informal	Vegetative propagation	1995	1997	-2
229	Informal	Vegetative propagation	1996	1994	2
12	Formal	Vegetative propagation	1980	1984	-4

3.2.3 Seed collection and distribution for SS categories through formal or informal systems

In the preliminary survey, the overall conclusion on distribution is that there is a great deal of overlap between the formal and informal sector. The informal sector was estimated to utilise 24% of the formal sources. The formal sector was estimated to utilise 50% of the active informal sources.

The evaluation survey indicates this degree of overlap is an overestimate. The informal sector utilised 28% (8 out of 29 active sources) of the formal sources (a similar estimate as that of the preliminary survey). The formal sector utilised 8% (3 out of 39 active sources) of the informal sources (only a fifth of the preliminary estimate). There is thus still an overlap, but the formal use of informal sources is much smaller. While the preliminary survey estimates that around 65% of the sources utilised by the formal system, the evaluation survey estimates this to be around 24%.

In table 16, the collection and distribution information for the 72 sources of the evaluation survey has been listed as the number of different combinations of collection, distribution (from preliminary and evaluation surveys) and secondary distribution. The results for seed collection were similar for the two surveys, and shows that formal institutions utilise the informal sector (most often farmers) to collect seed from formal and informal sources. The table also shows that the germplasm often passes through more than one link before it is distributed to consumers (this information is in addition to what was investigated in the preliminary survey). During the secondary distribution, germplasm from the informal sector is distributed by the formal sector and vice versa, such that the secondary distribution increases the overlap between the two sectors.

3.2.4 Source provenance

The information provided in the two surveys (preliminary and evaluation) on provenance of origin was basically the same. For information on local provenance, only one out of 72 sources differed. Information was provided during the evaluation survey on the private (BAT) seed source of *Eucalyptus maculata* (ID 183)[14], which was labelled as »unknown« in the preliminary survey.

[14] During the preliminary survey the person interviewed was the officer-in-charge who is not directly involved in managing sources, thus could not provide all the required information. This was provided in the evaluation survey where the respondent was the person who manages the source.

Table 16. Comparison of production, collection, distribution, and secondary distribution chains in the two surveys

Seed Source Category	Preliminary Collection 3	Preliminary Distribution	Evaluation Distribution	Evaluation Secondary Distribution	Count
Formal	Formal	Formal	Formal	Formal	13
Formal	Formal	Formal	Formal	Formal, Informal	5
Formal	Formal	Formal	Formal, Informal	Formal, Informal	1
Formal	Formal	Formal, Informal	Formal	Formal	1
Formal	Formal, Informal	Formal	Formal	Formal	1
Formal	Formal, Informal	Formal, Informal	Formal, Informal	Formal	1
Formal	Informal	Formal	Formal	Formal	1
Formal	Informal	Formal	Formal, Informal	Formal, Informal	1
Formal	Informal	Formal, Informal	Formal, Informal	Formal, Informal	2
Formal	Informal	Formal, Informal	Informal	Informal	1
Formal	Informal	Informal	Formal, Informal	Formal, Informal	1
Formal	Informal	Informal	Informal	Informal	1
Formal	None	None	None	None	1
Informal	Formal	Formal	Formal	Formal, Informal	1
Informal	Formal, Informal	Formal, Informal	Informal	Informal	2
Informal	Informal	Formal, Informal	Formal	Formal	1
Informal	Informal	Formal, Informal	Formal, Informal	Formal, Informal	1
Informal	Informal	Formal, Informal	Informal	Formal, Informal	1
Informal	Informal	Formal, Informal	Informal	Informal	16
Informal	Informal	Informal	Informal	Formal, Informal	1
Informal	Informal	Informal	Informal	Informal	16
Informal	Informal	Informal	None	None	1
Informal	None	None	None	None	2

3.2.5 Size of sources

The evaluation survey was more precise since the sources were physically visited and the information obtained from the actual person managing the source.

The information on sizes of sources obtained from the evaluation survey confirmed information provided during the preliminary survey for 53 sources, while the sizes differed in 19 (26%) of the sources. The size differences between the results of the two surveys will be discussed in the following (see also the discussion in 3.1.9 Size of sources).

Sizes provided in hectares (ha): The size differences for four plantations between the two surveys are not important for the evaluation of their genetic quality, the differences were in the order of a small fraction of the size for three of the plantations, although one plantation had a difference of around 25% (2 ha compared to 1.5 ha). The size differences for the two seed orchards between the preliminary and the evaluation surveys (1 ha compared to 1.5 ha) does not give a new interpretation of the quality of the orchards. The size differences for vegetative propagation between the preliminary and the evaluation surveys are irrelevant for the interpretation of genetic quality (4 ha compared to 1.5 ha).

Sizes provided in number of trees: The size differences for farmland sources can be grouped into three categories: (i) Unknown in preliminary/known in evaluation, 2 sources; (ii) Small number of trees in preliminary/more exact small number in evaluation, 4 sources; (iii) Large number of trees in preliminary/smaller but still reasonable number in evaluation, 1 source. The size differences for plantations can be grouped into two categories: (i) very small number of trees in preliminary/more exact small number in evaluation, 1 source; (ii) large number of trees in preliminary/more exact large number in evaluation, 2 sources. The size differences for vegetative propagation are large number of trees in preliminary/more exact large number in evaluation, 2 sources. The differences in the estimates between the two surveys do not change the interpretation of the results of the surveys.

3.2.6 Number of families in sources

The information provided during the preliminary survey on number of families used during the establishment of sources was confirmed by the evaluation survey. The only two sources where the respondents could not provide number of families used are both plantation type where the officers interviewed for the preliminary survey are not directly involved in sources, thus could not provide all the information needed. These plantations are the *Markhamia lutea* (source ID 170) progeny trial established by formal (ICRAF) in Meru in 1992 and *Eucalyptus maculat*a (source ID 183) established by BAT. However during the evaluation survey, the respondents (person who manages sources and nurseries or directly involved in sources activities) provided the number of families used in the establishment of the two sources.

For the rest of sources the informants confirmed the information given during the preliminary survey. In most cases the seed had been bulked and then used for establishment of sources. The exceptions were the progeny trial (*Markhamia lutea* progeny trial established by (formal) ICRAF in Meru, where 46 families were used, and the seed orchards established by (informal) EMI project of *Grevillea robusta* where 60 families were used and two *Eucalyptus camaldulensis* seed orchards where 30 families were used.

3.2.7 Number of trees where seed or scions or buds or wildings are collected per source

In the evaluation survey it was possible to get more detailed information, including the total number of trees in the source as well as the number of trees collected from during the previous collection season. This latter number provides a more exact measure of the genetic quality of the seed actually collected. For several sources, the inadequate number of trees collected from is a reflection of the limited number of trees in the sources. However, also in the plantations and natural forest with many trees available, the collectors often collect from a few trees only. Most probably, the collectors do not know the importance of collecting from many trees.

Table 17. Number of trees collected from in previous collection season

Category	Source Type	Vegetative propagation	Unknown	1-9	10-19	20-29	30-49	=50 %>
Formal	Farmland				1		1	
Formal	Natural Forest		1	3				
Formal	Plantations		7	4	1	2	3	2
Formal	Seed Orchards					1	1	1
Formal	Vegetative propagation	2						
Informal	Farmland			10	8	3	1	2
Informal	Plantations			2	1	1	1	
Informal	Seed Orchards		4					
Informal	Vegetative propagation	3				1	1	1

3.2.8 Spacing of trees per source

For the farmland sources – trees are usually spaced far apart (scattered on the farms), for some species spacing could be a concern with respect to adequate pollination. For the plantation sources, in most cases no silvicultural thinning had been carried out and as a consequence the spacing is too small (the closest are 2m x 2m) to allow good pollination and seed set for the mature trees. The seed orchards were most likely established from bulked seed such that families (seed from the same mother tree) are mixed, however, the spacing of trees in most of the seed orchards is still too close and thinning (if any) has not adequately opened the stands to allow good pollination and seed set for the mature trees. The vegetative propagation sources are not established for seed production, spacing of

these sources are for the production of scions, nevertheless trees in these sources are spaced well apart (following recommendations by extension agents from Ministry of Agriculture).

3.2.9 Amounts collected from sources

It is more informative to express production from a seed source in number of seed rather than the weight in kilograms. The reported amounts of seeds in kilograms collected per source have therefore been translated to number of seeds collected per source in table 18.

Out of the four informal seed orchards, one is not yet in production, but the three other sources are in production and represent the best seed orchards of *Eucalyptus camaldulensis* and *Grevillea robusta* in Kenya. The collection from these three seed orchards is very erratic due to lack of clear ownership and limited marketing capacity of the farmers and schools, who carry out the collection.

From the amounts collected from the sources it is not possible to conclude about the potential and actual demand and supply. It is quite likely that the demand and supply of seed is limited by inadequate information flows, rather than production capacity.

Table 18. Amounts collected from sources

Category	Source type	Ranges of numbers of seed, wildings, scions, buds collected previous season
Formal	Farmland	132,000 - 830,000
Formal	Natural Forest	4,800 – 100,000
Formal	Plantations	30,000 - 35,000,000
Formal	Seed Orchards	86,963 – 171,000
Formal	Vegetative propagation	600 scions
Informal	Farmland	300 - 220,000,000
Informal	Plantations	40,000 - 3,387,500
Informal	Seed Orchards	100 - 20,000
Informal	Vegetative propagation	100 - 20,000

3.2.10 Problems of maintenance and protection of sources

The preliminary survey asked who paid for establishment, maintenance, and protection. In the evaluation survey it was possible to ask respondents on perceived problems of maintenance and protection as well as for collection. The situation in the formal and informal sectors differs strongly (table 19). While the majority of formal sector sources have problems of maintenance and protection, this is not the case to same degree for the informal sources (P 0.001, Fisher's Exact Test, for maintenance as well as

for protection). One plausible explanation for the constraints of the formal sector is that it is both more costly and more difficult for the formal sector to maintain and protect a network of seed sources. The seed sources in the informal sector are maintained and protected by local (mostly individual) owners who benefit from the continued productivity of the sources. As a corollary to this explanation, we state the hypothesis that free seed is an impediment to the development of privately owned sources and therefore free seed severely limits the contribution that trees can make to improvement of smallholders' livelihood.

Table 19. Maintenance and protection problems

	Maintenance problems	
Category	**Yes**	**No**
Formal	25	5
Informal	12	30
	Protection problems	
	Yes	No
Formal	25	5
Informal	7	35

3.2.11 Problems of collection and distribution of seed

In the evaluation survey it was possible to ask for problems of collection. It appears that the formal sector has more problems than the informal sector, but the difference was not very strong (P 0.032, Fisher's Exact Test). The main problems highlighted by the informal sector are 'lack of technical knowledge for collection' while for formal it was 'limited equipment for collection'. The species collected by formal and informal are very different with respect to collection techniques. Many of the informal sources are shrubs, while many of the formal sources are tall trees. Table 20 shows the general difference between formal and informal.

In the evaluation survey it was possible to ask for problems of distribution. It appears that the informal sector has more problems than the formal sector, but the difference was not significant (P 0.063, Fisher's Exact Test). The main problems highlighted by informal sector were lack of markets for the 12 sources, while the formal problems in 4 sources were on handling of fresh fruits/seed. The majority of germplasm distributed by formal is normally on the request by the clients, thus no problem of markets. Table 20 shows the general difference between formal and informal.

Table 20 Collection and distribution problems

	Collection problems		
Category	**Yes**	**No**	**n/a**
Formal	21	8	1
Informal	18	21	3
	Distribution problems		
Category	**Yes**	**No**	**n/a**
Formal	4	25	1
Informal	12	27	3

3.2.12 Status of land ownership and sale/free seed

The findings from the preliminary survey were confirmed by the evaluation survey with respect to the three types of landownership, public land, communal land and private/farm land.

The mode of seed supply free/sold was not repeated in the evaluation survey. As a principle it should have been done, however, we would not expect to find a significant difference. The respondents in the preliminary survey were in a good position to know the status of the sources in this respect. The respondents for the informal sector were extension agents who procured the seeds or helped in linking farmers with markets. Respondents for the formal sector were government officers who were involved in the procurement of seed from the sources.

4. Discussion and conclusions

The objectives of this study were:

(i) to determine how genetic quality of sources is defined by the organisations and individuals establishing sources, how the sources are documented and to evaluate the sources according to general criteria of genetic quality;
(ii) to determine how sources are established, maintained and utilised;
(iii) to identify constraints and opportunities for increasing quality and survival of sources.

There were two hypotheses of the study:

(a) Formal sources are well documented and of high quality, but protection and maintenance are major constraints for long term survival.

This hypothesis cannot be said to be confirmed with respect to documentation and formal sources are not generally of higher quality relative to informal sources (with respect to documentation of origin). It can, however, be confirmed that protection and maintenance are major constraints for long term survival

(b) Informal sources are not well documented and of unknown quality, and protection and maintenance is ensured only during projects' lifetime.

The hypothesis can be confirmed with respect to the lack of good documentation of informal sources. Relative to formal sources the hypothesis that informal sources are of unknown quality cannot be confirmed. The hypothesis that protection and maintenance is ensured only during projects' lifetime cannot be answered with certainty. Although it appears that protection and maintenance are perceived of as less of a problem as compared to formal sources, it is likely that protection and maintenance of informal sources in the long term will depend on how markets for germplasm will develop, i.e. if the informal sources can provide income for producers and distributors of seed.

The study shows that the two major sectors (formal and informal) involved in provision of germplasm in the study area are partly overlapping and partly complementary.

The formal sector is in principle the only sector, which has the mandate to provide seed to tree planters in Kenya and the new seed policy of Kenya has made the first tentative steps towards outlawing seed produced by the informal sector (legislation for tree seed dealers has not yet been formalised and awaits ratification by parliament).

The formal tree seed sector is lead by Kenya Forest Seed Centre (situated in Kenya Forestry Research Institute) and includes government institutions in both the forestry and the agriculture ministries[15]. The informal sector consists

[15] ICRAF, which is an international research centre under the CGIAR holds a special position – until recently ICRAF supported the national agricultural research system by establishing traditional seed orchards on public land. These seed sources are now in the process of being handed over to the Kenyan government, and ICRAF is now mainly supporting establishment of sources in farmland. ICRAF has thus changed her support from the formal to the informal sector

of NGOs, projects, farmers' organisations and individual farmers.
In terms of the number of seed sources, the informal sector is as important as the formal sector and although the establishment, protection and maintenance (and to a large extent also collection) are largely done in parallel between the two sectors, there is significant overlap in the distribution of seed between the two sectors, where the formal sector distributes »informal« seed. The recipients of the germplasm from both sectors are farmers for improvement of their livelihoods through production of products for income generation and own use.

A common argument for maintaining a legal distinction between the formal and informal tree germplasm sectors is that only the formal sector can guarantee a high standard of quality. The present study does not lend support to this argument. In hardly any respect can it be said that the formal sector provides better genetic quality germplasm than the informal sector and the study indicates that the formal system has severe problems in maintaining and protecting their sources.

The study indicates that germplasm production has become commercial and a fledgling industry may be appearing, with a potentially large involvement of small scale private entrepreneurs. This fledgling industry would be strangled by the pending legislation as it has been formulated (Government of Kenya, 2005).

The study indicates the seed distributed to farmers is far from optimal, that the informal sector is able to produce as good quality germplasm as the formal sector, and that the informal sector has a larger capacity for expansion than the formal sector. The overall goal of the two sectors; to improve smallholders' livelihoods and farm incomes, should make it possible to think of improving the sector as a whole to the benefit of smallholders.

There are many opportunities for increasing the efficiency and reach of the tree germplasm sector, but it will require that the government accepts that a private sector of small scale entrepreneurs is beneficial for reaching smallholders and that policy and development of support systems must be implemented accordingly.

Some of major support systems could be to legalise private seed production by small scale entrepreneurs and to create support systems that makes it easier to produce and distribute tree seed and vegetative material and to remove barriers that increase the cost of making business.

We state the hypothesis that free seed is an impediment to the development of privately owned sources and therefore free seed severely limits the contribution that trees can make to improvement of smallholders' livelihood. We suggest that an enabling environment for germplasm production and distribution would involve:

- help to establish good quality privately owned sources and good collection procedures for many useful indigenous and exotic species

- introduction of procedures for »quality declared seed« and/or »truth in labelling« of germplasm
- support to increase the flow of information from the market to customers
- support to increase the flow of information between producers and distributors
- a change in support by NGOs, government agencies and projects from distribution of free seed and seedlings to support of input supply chains and product value chains.

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6. Appendices

Appendix 1. Sources and good practice

Type	Location of seed trees	Genetic content	Criteria for genetic quality
1a. Farmland seed source: Natural	In agricultural landscape: Scattered trees remaining from natural forests, or natural regeneration from such	Local origin representing the original population in the area	Number of trees; Distance between seed trees; Distance from seed trees to closest tree of same species; All seed trees should be of acceptable quality; Basic documentation
1b. Farmland seed source: Planted	-Scattered trees.; -Borderline tree around/ within farms; -Trees permanently intercropped; -Roadside trees	Local or non-local origin	Number of trees; Of origin known to be suitable for farmlands; Distance from seed trees to closest tree of same species; -Number of involved farms; All seed trees should be of acceptable quality; Basic documentation
2. Natural forest	- Trees growing naturally in high forest or woodlands (pristine or subject to different degrees of human influence)	Local origin. Often influenced by human activity	Number of trees; Distance between seed trees; Size of forest; Not degraded through overexploitation; All seed trees should be of acceptable quality; Basic documentation
3a. Plantation	Trees planted in a plantation or woodlot	Trees with unknown origin	Number of trees; Homogeneous site; Optional thinning; Trees of good quality compared to plantings in the region; Basic documentation
3b. Provenance plantation		Trees with known origin (planted with seedlings from documented seedlot)	Origin and quality of founding seed source; Number of trees; Thinning and homogeneous site (=expected gain from selections); Basic documentation
4. Vegetative propagation	Graftings, Stem cuttings, micro cutting or somatic embryos propagated from selected clones or seedlings	Often quite narrow, but not necessarily so. Propagation can be based on cloning from tested clones, selected progenies, selected provenances, or random seedlings	The degree of testing of the propagated material; Superiority of tested material;- Number of clones (especially in case of poorly tested material); Comprehensive documentation
5a. Seed Orchard from seed	Trees planted in a plantation, woodlot or maybe farmland with the purpose of seed collection	Planted exclusively with offspring from carefully selected trees; Genetic diverse; Documented	Quality of founding seed trees and their origin; -Thinning and homogeneous site (=expected gain from selections); Number of progenies; Isolation; Comprehensive documentation
5b. Seed Orchard from seed		Planted exclusively with offspring from carefully selected trees; Progenies are kept separate (and mapped) in the planting; Genetic diverse; Documented.	Quality of founding seed trees and their origin; -Number of progenies; Design, thinning, homogeneous site (=expected gain from selections); Genetic quality based on quantitative genetic analysis; Isolation; Comprehensive documentation
5c. CSO Clonal Seed Orchard	Trees planted from grafting in a plantation, woodlot or maybe in farmland with the purpose of seed collection	Planted exclusively with clones from carefully selected trees. Clones are kept separate (and mapped) in the planting. Genetic diversity can vary, often quite low diversity Documented.	Quality of founding graft wood trees (octets) and their origin; Number of clones; Design and thinning; Quality of progeny trials (if available); Genetic quality based on quantitative genetic analysis of progeny trials; Isolation; Comprehensive documentation

Source: Adapted from Lillesø et al (Good Practice.., Manuscript 2005)

Appendix 2. Seed sources for which categories are somewhat blurred

ID	Site	Seed Source	Species Name	Category	Situated
43	**Kaaga primary School/ Meru Teachers college**	**Plantation**	***Spathodea campanulata***	**Informal**	**Communal Land**
Planted by school and college. KFSC collects and has included it in their identified sources. At the time of planting school land was owned by the government. All school land has now been handed over to the communities.					
149	**Marinya-ruibi**	**Plantation**	***Grevillea robusta***	**Informal**	**Communal Land**
Planted by the NGO CEFA with technical guidelines from forest department. The planting site was on a market place. Planting design was in a plantation-like block with quite large planting distance. Market places were handed over to communities by the government. The community manages the seed source.					
167	**Meru college of Technology**	**Seed Orchard**	***Eucalyptus camaldulensis***	**Informal**	**Communal Land**
The NGO EMI planted in collaboration with KFSC from seed imported by KFSC from Australia. EMI and KFSC developed MoU and protocol on management and that the source should be handed over to KFSC when EMI pulled out. Protocol also stated that farmers should benefit from collection. Situation now is that source is not managed (due to limited resources of KFSC) and collection is done by farmers.					
168	**Meru college of Technology**	**Seed Orchard**	***Grevillea robusta***	**Informal**	**Communal Land**
The NGO EMI planted in collaboration with KFSC from seed imported by KFSC from Australia. EMI and KFSC developed MoU and protocol on management and that the source should be handed over to KFSC when EMI pulled out. Protocol also stated that farmers should benefit from collection. Situation now is that source is not managed (due to limited resources of KFSC) and collection is done by farmers.					

Appendix 3. Seed sources at KFSC sub centre at Nyeri

Species	Site/station	Type of source	Size (ha)	Year of establishment
Araucaria cunningamii	Muringato	Plantation	0.7	1935
Cupressus lusitanica	Ragati	Plantation	14.6	1968
Eucalyptus calmadulensis	Ragati	Seed orchard	5	1993
Eucalyptus grandis	Ragati	Seed orchard	5	1993
Eucalyptus maculata	Kabiruini	Plantation	12.3	1970
Eucalyptus paniculata	Kabiruini	Plantation	30.4	1972
Eucalyptus saligna	Muringato	Plantation	1.5	1948
Grevillea robusta	Ragati	Seed orchard	2	1992
Ocotea usambarensis	Ragati 2(i)	Plantation	3	1940
Ocotea usambarensis	Ragati 2 (k)	Plantation	3	1941
Polyscias kikuyuensis	Kabage	Plantation	2	1937
Prunus africana	Kabage	Plantation	1	1923
Vitex keniensis	Ragati	Plantation	3	1940
Vitex keniensis	Ragati	Plantation	3	1941
Vitex keniensis	Chehe	Plantation	21	1961
Vitex keniensis	Chehe	Plantation	16.6	1971
Vitex keniensis	Chehe	Plantation	4	1958
Vitex keniensis	Chehe	Plantation	12.1	1969
Vitex keniensis	Chehe	Plantation	5.3	1948
Vitex keniensis	Chehe	Plantation	17.8	1972
Vitex keniensis	Chehe	Plantation	0.4	1948
Vitex keniensis	Ragati	Plantation	15	1969
Vitex keniensis	Ragati	Plantation	9.3	1972
Vitex keniensis	Ragati	Plantation	9	1941
Vitex keniensis	Ragati	Plantation	8.9	1933
Vitex keniensis	Ragati	Plantation	6.5	1933

Appendix 4. Questionnaires

Preliminary Survey - Organizational questionnaire (Seed Sources)

Questionnaire No: _____ Date: _____

Explain purpose of survey: The objective of this study is to provide an evaluation of the genetic quality of the seed sources established by different organisations and identify main constraints and opportunities for the long-term survival of different types of seed sources that produce seed for farmers' use.

Seed source definitions:

Table 1. Seed Source Types.

	Seed source type	Brief description
1	Natural forest	Naturally occurring populations of trees in forest, and woodland, etc. that are utilised for seed production
2	Farmland	On-farm trees that have been planted/retained for production for other services than seed production, that are also utilised for seed
3	Seed Orchards	Trees (from seed or grafted) planted in blocks specifically for seed production
4	Plantations	Tree planted in blocks for production other than seed
5	Vegetative propagation	Asexual plant multiplication through cuttings, grafting, micopropagation

1. Name of organization: _____
_____

2. Name of the person interviewed: _____
_____

3. Position of the person in the organization: _____

5. Districts where your organization have sources of seed or vegetative material? _____
_____
_____

6. Is your seed production a for-profit or a non-profit operation? _____
_____

8. Who are the clients for the seed? _____
_____

9. Is the seed sold or given free?

Species in seed sources:							
Species	**Name of site**	**Type of seed source (i-v)**	**Size of source (ha/no. of trees)**	**Estab-lish-ment year**	**On (a) Public land (b) Private/farmland (c) Communal land**	**Seed Source: Who.. (a) paid establishment (b) maintains (c) protects (d) collects seed (e) distributes seed**	**Seed Source: (a) Provenance (geographic origin of mother trees) (b) Number of families (unre-lated mother trees) in the seed source**
						(a)	(a)
						(b)	
						(c)	(b)
						(d)	
						(e)	

Additional questions on the seed source:

SS 1. What are the current main constraints for seed production from this seed source?

SS 2. How do you see the future of this stand for seed production?

Evaluation survey: Seed Source questionnaire (Field evaluation)

Questionnaire No: _____

Date: _____

GPS Readings Lat/Long/Altitude_____

Explain purpose of survey: The objective of this study is to provide an evaluation of the genetic quality of the seed sources established by different organisations and identify main constraints and opportunities for the long-term survival of different types of seed sources that produce seed for farmers' use.

Name of organization: _____

Name of the person interviewed: _____

Position of the person in the organization: _____

1. Species/provenance:		
2. Origin of parent material		
3. Documentation available	If yes, make copy	
4. Major objectives:		
5. Seed source type:	(i) Farmland	
	(ii) Plantation	
	(iii) Planted Seed Orchard	
	(iv) Natural vegetation	
	(v) Vegetative production	
6. Area (ha): Or number of trees	Fenced:	Net planted:

7. Design:	(i) Farmland	No of Farmers and No of trees per farm	
	(ii) Plantation	Distance between trees	
	(iii) Planted Seed Orchard or seed stand	Bulked or family identity Distance between trees	
	(iv) Natural vegetation	No of trees of the species per ha	
	(v) Vegetative production	No of clones	
8. Establishment date:			
9. Location:			
10. Land ownership		Public land	
		Farm land	
		Communal land	

11. Established by (labour and cost)		
12. Maintained by		
13. Protected by		
14. Annual production (kg), beginning with first year of production		
15. Who collects seed from seed source	Your organization	
	Beneficiaries (please explain)	
	Other (please explain)	
16. Who distributes seed from seed source	Your organization	
	Beneficiaries (please explain)	
	Other (please explain)	

17. Seeds supplied to	Farmers	
	Researchers	
	Group nurseries	
	Individual nurseries	
	Private seed distributors	
	Governmental institutions	
	National partners (1) Other collaborators (2) (please explain)	
18. Do you have any problems in protection or maintenance of the seed source (please explain)		
19. Do you have any problems in collection and distribution (please explain)		
20. What is the expected duration of the SS and what are the long term plans for ownership		
21. Comments (*also attach sketch map*): Current status of the seed source (evaluation):		

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