Farmer Experimentation and Innovation

A case study of knowledge generation processes in agroforestry systems in Rwanda

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If farmers were resisting efforts to convince them to use "improved" technologies, but were still able to develop an agricultural system that was performing better than what science could develop and offer them, what were they doing right? In this case study of agroforestry systems in Rwanda, Dr Christoffel den Biggelaar aims to clarify both that question and its answer. This document is based on a long-term, in-depth study, in which Dr den Biggelaar aimed to gain an understanding of what farmers knew and how they obtained and further developed knowledge. It reflects a spirit of learning from farmers about their tree growing practices.

Top-down extension strategies have proven to be inappropriate for community forestry, with a very low adoption rate by farmers of methods presented by research stations dealing with...
forestry and agroforestry. The concern of community forestry is to find the right ways to learn what farmers are already doing and support them.

This case study is the first in a series of publications on the topic of farmer initiated research and experimentation - farmers' spontaneous experimentation and farmer-led research and extension processes. The goal of the series is to determine more effective ways in which farmers can be supported in their own processes of experimentation and knowledge sharing, while at the same time working towards a consolidation of local forestry knowledge.

Other case studies are being conducted in Africa, Asia and Latin America which focus on the role of trees in farmers' lives, the current management/use of trees within farming and economic systems, how farmers experiment to make better use of tree and forest resources, how they share their knowledge with other farmers, and how intermediary groups and research and extension institutions support these local initiatives.

The material from these studies will form the basis of regional synthesis papers which will focus on the approaches, methods and tools needed by research/extension institutions to design supportive research and extension strategies that both understand and respect local realities, processes and organizational capacities.

Both the case studies and regional synthesis papers will be inputs to an international conference which will be held in collaboration with The Indian Institute of Management - Ahmedabad, India in 1997. It is anticipated that out of the conference will come a Community Forestry Note and a strategy for FAO and other collaborating institutions in support of farmer initiated research and extension.

Through her leadership and support, Marilyn Hoskins, the former Senior Community Forestry Officer, Forestry Policy and Planning Division, and former coordinator of the Forests, Trees and People Programme (FTPP), made a valuable contribution to the development of this complex topic. Jean-Marie Laurent provided detailed comments on the text, based on his experience in both backstopping and coordinating activities on this topic world-wide.

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**Author's Note**

The idea for this research developed during years of working as a horticultural teacher in Burkina Faso and as an extension agronomist in the People's Republic of Congo and the Central African Republic. The difficulties of convincing farmers to adapt "improved" technologies made me realize that perhaps the technologies were not really "improved", which was borne out in some on-farm trials showing that the local varieties and methods of production were out yielding what the projects could offer farmers. Were farmers doing something right? I finally had to admit that perhaps they were, but what? How could they develop an agriculture that was performing better than what science could develop and offer them, without the aid of fancy laboratories, sophisticated plant breeding techniques and field trials, and statistical analyses? I think the first step was to realize that farmers' agricultural practices are not random acts of planting seeds and tending livestock, but are deliberate, well-
reasoned choices based on extensive experiences with and observation of locally available resources. It is not that farmers are not open to new ideas and technologies, indeed; I found quite the opposite as evidenced by the many exotic crops and trees widely cultivated by small farmers in Africa. However, like consumers everywhere, they are critical of what is offered to them and choose only those technologies that appear the most useful and/or profitable for their specific conditions.

African agriculture, therefore, is not traditional, backward or stagnant but, on the contrary, very adaptable, vibrant and dynamic. The dynamic nature of agriculture, then, formed the backdrop for my research on agroforestry systems in Rwanda. The aim of the study was to understand what farmers know of agroforestry and how they obtained that knowledge and continue to add to it. Field research was carried out in the southern prefectures of Butare and Gikongoro between February and December, 1992. During that period, the situation was tense at times due to clashes between supporters of various political parties, the bombing of taxis, markets and other public places, and periodic fighting between the army and RPF troops along the front lines in the northeast of the country. Nothing, however, prepared me for the violence ensuing in April, 1994, shortly after I defended my dissertation. The pictures and stories of the massacres taking place in the country, which were particularly severe in Butare, at first took away any incentive to incorporate the comments and recommended changes in the dissertation. As the body counts mounted, I kept asking myself questions about the purpose of my dissertation: Why should I finish it? Who will benefit from it? Would people even be interested in the information if all they can think of is survival and revenge? Will people outside Rwanda be interested if they only know about its genocide and refugee crisis? However, after several weeks, I realized that there were still farmers in Rwanda who wanted to pick up the pieces of their lives and who needed support. Many refugees who escaped massacres in 1959 and 1973 were returning and would need support as well in order to re-establish their lives in a country many had never seen. I finally managed to face the dissertation again and complete it. I convinced myself that knowledge written down is knowledge preserved and that completing the work would be the least I could do for the farmers and/or their descendants, friends and relatives who shared their knowledge and wisdom with me and who may not have survived the massacres, disease, famine, homelessness and life in the refugee camps. For those who have survived, I hope that the dissertation and this case study based upon it will be of help to re-establish your lives as farmers and/or experimenters.

The field research for the dissertation was made possible through grants from the Regional Program for the Improvement of Beans in the Great Lakes Region (East Africa) of the Centro Internacional de Agricultura Tropical (CIAT), the Characterization and Impact Programme of the International Centre for Research in Agroforestry (ICRAF) with funds from the Rockefeller Foundation, and the Office of the Vice President for Research and Graduate Studies, Michigan State University. In particular, I want to thank Drs. Louise Sperling and Urs Scheidegger of CIAT and Dr. Steven Franzel, Mr. Amadou Niang and Ms. Erika Styger of ICRAF for their support and ideas shared in numerous discussions. I also want to thank the Département de Foresterie of the Institut des Sciences Agronomiques du Rwanda for their hospitality as the host institution for this research, in particular Isaac Kabera and the late Anastase Gahamanyi. Special thanks also to Audace Karekezi and François Rugema, my research assistants and translators in the field. My thanks also go to Jean Baptiste Kayigamba, Eugene Murekezi and Esdras Bucyobukiro for transcribing and translating the tapes of the community interviews and focus group meetings. I want to thank the authorities of Maraba and Karama for their hospitality in carrying out this research in their municipalities.
(communes), and the numerous women and men in Kibingo, Maraba and Simbi districts for sharing their knowledge and wisdom with me, without which this dissertation would never have been written. While I cannot mention everyone individually, I would like to express my gratitude to the local tree experts who gave so much of their time and themselves to me: Bizinda, Gahirima, Gasamunyiga, Gasherebuka, Gihanga, Gisanabatwa, Habimana, Habiyeye, Kajeguhakwa, Kanamugire, Karwera, Kinyangote, Mugemanyi, Mukabatsinda, Mukakalinda, Mukeza, Munderere, Munyantunda, Munyashongora, Mutaganda, Mwererankiko, Ndereyehe, Ndibwami, Ngezenubwo, Niyonambaje, Niyoitya, Nsanzabaganwa, Ntamushobora, Ntawukuliriyayo, Ntawuziyambonye, Nyabyenda, Nyilikindi, Nyiradore, Nyirakamegeli, Nzigiye, Ruberwa, Ruvuzampana, Ruzibukira, Rwamurara, Sebahunde, Sebashi, Sebera, Serinda, Vuguziga, and Zigama. To all, MURAKOZE CYANE!!!

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The views and judgements expressed in this case study are entirely those of the author, and should not be attributed in any manner to FAO, ICRAF, CIAT, ISAR and Michigan State University, to members of their Boards of Executive Directors, the countries they represent nor to their affiliated institutions.

**Executive Summary**

Although Rwandan farmers have used trees for numerous purposes for centuries, the active planting and management of woody vegetation on farms is a relatively recent innovation. The goal of this research was to determine and understand farmers' processes of agroforestry knowledge generation underlying these changes in resource management and usage. In particular, the study focused on farmer experimental methods related to the integration of trees on the farm.

The research focused on a group of 44 locally-identified tree experts, chosen in a two-stage process using a ranking game and community interviews. A comparison group of 70 farmers was chosen randomly from those identified in the game as less knowledgeable about agroforestry. Methods used to study knowledge/technology generation included biographical case studies of tree experts using repeat visits, tree inventories and a socio-economic survey of both tree experts and comparison farmers, guided farm tours, participant observation, and community and focus group interviews.

Ranking game participants identified tree experts as farmers cultivating a diversity of trees on their farms in accordance with the Bantu-Rwandan philosophical meaning of knowledge: "Knowing a plurality of objects or notions". In both the ranking game and socio-economic survey, results showed tree experts had more land, trees and tree species, but the tree density on comparison farms was more than two times higher. This points to a differentiation in knowledge between tree experts and comparison farmers.
Comparison farmers did have knowledge about trees and tree cultivation and understood the need for and importance of trees. But they had little land and resources and followed a different agroforestry development strategy. The smaller the farm, the more they concentrated on fewer, less-competitive species, resulting in complex systems of low diversity with a high degree of integration of trees and crops. Low diversity/high tree density systems require farmers to have a higher level of management skills and greater knowledge of the various components and their interactions. Therefore, the agroforestry knowledge of tree experts and comparison farmers may indeed be different, confirming the initial conclusions of the knowledge ranking exercise. This study thus observed a difference in both agroforestry systems and agroforestry knowledge between individuals and groups of individuals.

As the nature and content of agroforestry knowledge varies among (groups of) individuals, the assumption that only some farmers (in this study, locally-identified tree experts) experiment proved incorrect. In reality, farmers in each of the "knowledge groups" created by the ranking game participants were engaged in the generation of their own particular kind of knowledge of trees and tree cultivation, although not all farmers were equally active experimenters. Relying on local perceptions that the persons most knowledgeable about trees and tree cultivation are the most active experimenters may, therefore, not provide satisfactory results. There are multiple ways of knowing about trees and tree cultivation, and each is based on, and evolves from, its own forms of knowledge production.

This research found that almost all farmers in the study areas practice agroforestry. However, no two farms had a similar agroforestry system because the farmers designed their own systems to meet their multiple needs using available resources. This individuality was reinforced by a large species diversity, multiple reasons for planting trees and the many uses farmers have for trees. These factors have led to diverse agroforestry systems with very complex arrangements of species over space and/or time. The individual agroforestry systems resulting from these differences in resources, objectives and contexts require better farmer and researcher collaboration to identify problems and opportunities and to develop a range of technologies that reflect these differences.

The plants found on the farm in the indigenous agroforestry systems that the farmer-consultants called "trees" included not only trees and shrubs but also annuals and perennials. The latter ("don-trees" by Western world definition) contributed to the species diversity found in the study areas and gave an additional layer of complexity to the indigenous systems. These "non-trees" should not be ignored. They provide significant benefits to the farmers and often are grown in specific niches not usable for crops or trees.

Farmer-consultants were well aware of, and sensitive to, the biological interactions of trees, crops and soils. These interactions were the main criteria used in decisions about where to plant species within the farm and/or the field, and then to evaluate performance. However, farmers cited utility and other tangible benefits as the primary reasons behind species choice.

Farmers considered agroforestry the only solution for obtaining tree products in the future. With the increasing competition between trees and crops for a limited land base, farmers recognized that decisions concerning species selection and arrangements were becoming more and more difficult. The present differentiation of agroforestry systems will, therefore, become even more pronounced in the future with increasing fragmentation of farms. In view of the continued decrease in farm size and farmers' sensitivity to biological interactions, farmers
repeatedly stressed that it was imperative to find species and arrangements with the least negative influence on crops and soils in order to further agroforestry practices.

Regarding farmer experimentation, it was difficult to distinguish new from existing practices or to differentiate experiment from normal practice in farmers’ fields. Farmers considered each season an "experiment" in which new knowledge is obtained and new ideas are generated. The tree experts consulted in this study, therefore, considered the process of gaining knowledge through experimentation (igerageza) to be a part of everyday agricultural activities, not separated from them as is the case in the scientific knowledge system. However, in spite of the interweaving of experimentation and normal production practices, experimentation was a conscious effort on the part of the farmers to build upon the body of endogenous agroforestry knowledge.

The tree experts did not use specific research methods and procedures for experimentation with trees and tree cultivation. Trees take several years to mature or to yield usable parts, so most farmers (even those with large farms) could not afford to tie up land for experimenting with new tree species or arrangements. Thus, tests of new tree species or tree management methods were integrated within existing fields and crops which explains the interweaving of experimental and everyday agricultural activities.

Farmers faced a fundamental problem with the supply of new technologies to test on their farms. To experiment and develop agroforestry systems, it is necessary to have a range of technology options available and accessible. Farmers are able to make qualified assessments of what can (potentially) work in their individual situations, but they are obviously limited to their immediate surroundings as a main supply for information and ideas.

The diversification of species and the resulting increase in complexity of land use systems resulting from farmers' experimental efforts have been a deliberate strategy of farmers trying to overcome ecologic and economic uncertainties and looking toward a better and more secure livelihood. There was an implicit understanding that not experimenting with new ideas would lead to stagnation and would compromise an already precarious existence.

The major difference in knowledge production between experimenting farmers and scientists is not in experimental procedures and trial evaluations, but the way new knowledge and technologies are validated. In the scientific knowledge system, the primary aim of experimentation is the advancement of knowledge. Validation comes from active communication of experimental results to fellow scientists and researchers. By contrast, knowledge production in the endogenous agroforestry system is primarily use- and user-oriented. Validation comes from other farmers (neighbours and friends) who imitate the new ideas/knowledge. In other words, efforts are validated by the final technology users, not by fellow experts. However, there was not much active effort to share new knowledge.

There is also a difference in how experimenting farmers and scientists distribute and communicate knowledge. Communication networks for knowledge sharing and distribution were neither very extensive nor very well-organized. Farmer-consultants identified this virtual absence of local communication and information exchange networks as a major barrier to agricultural and agroforestry development. Better communication is needed (1) among farmer-experimenters to enhance endogenous agroforestry knowledge production through the sharing of methods, procedures and results, and (2) between farmer-experimenters and the general farm population to disseminate the results of knowledge and technology generated.
Related to methodological issues:

- Future studies of endogenous knowledge of agroforestry should combine qualitative and quantitative, participatory and formal data collection methods to provide both complementary and supplementary perspectives.

- Future studies of farmers’ experimental activities and knowledge production processes should not rely exclusively on the farmers identified by other community members as the most knowledgeable about agroforestry. A sample of farmers from different "knowledge groups" identified by a ranking game may better cover the wide range of agroforestry knowledge and associated knowledge production processes among (groups of) individuals.

- Future studies of agroforestry should follow the farmers' definition of trees and should not assume that "non-trees" are weeds of no value.

Related to furthering agroforestry practices in Rwanda:

- Extension workers should initially focus on women farmers to convince them of the benefits of new tree species and other agroforestry technologies, and subsequently explain to the men how to put these improved technologies into practice on their farms. As many species (especially medicinal and fruit trees) were planted by the men on the suggestion of their wives, this would not involve a major change in practices for the farmers. It would, however, involve a change in the habits of extension workers who primarily talk to men. Involving both men and women in the decision-making process about new species, where and how to plant and manage them, would make new agroforestry technologies more acceptable to, and adoptable by, a wider range of farmers.

- Researchers and extensionists should consider the multiple goals and needs of farmers, and differences in availability of and access to resources, in the search for new species and intercropping arrangements.

- With the help of participatory approaches, local people and communities should identify, implement and evaluate their own priorities for tree growing, which will generate more reliable research and extension agendas than top-down approaches.

The following recommendations related to furthering agroforestry practice were made by the farmers themselves:

- There should be more research on suitable species to increase the options available to farmers. The availability of a variety of tree species (both indigenous and exotic) and tree management options enhances the traditional strategy of diversification to overcome economic and ecologic uncertainties. Farmers prefer a cafeteria system of new species and technologies for a range of biophysical and socio-economic conditions from which they can choose according to their needs, goals and resources.

- New tree species to be introduced should be compatible and non-competitive with crops and non-shading; have tap roots and the ability to be used as live stakes; and
according to many of the very small farmers, should produce fruit and (fuel)wood simultaneously.

- Research and extension should ensure that new technologies (species) are made more accessible to farmers.

Related to farmer experimental practices:

- The multinational organizations and international research centres should develop and distribute visual documentation (video, film, cd-rom, etc.) of indigenous agroforestry systems and practices from around the world, and of farmers' experimental methods and procedures related to the development of same, to serve as a source of ideas for farmers' own experimental activities. This visual documentation should be accessible to institutions and persons interested in furthering farmer research and extension practices.

- Researchers and scientists involved in agroforestry technology development should be evaluated in terms of the acceptance of their results by farmers instead of by the number articles published scientific journals. This would go a long way towards increasing collaboration between the researchers and farmers and lead to development-oriented, rather than knowledge-oriented, research.

Related to enhancing informal extension networks:

- There is a need for persons with both endogenous and Western knowledge of agroforestry systems to find new methods to share information with farmers in an informative, non-prescriptive manner that treats farmers and their knowledge with respect. Possible means to accomplish this are guided farm visits and community and/or focus group discussions.

- Research, extension and NGO's should stimulate the formation of groups and/or networks of experimenting farmers which may or may not be technology and problem specific. These could take the form of study clubs in which farmers can discuss specific problems and work out solutions together. The group or club members can test the solutions on their own farms using their own experimental methods and then communicate their results to the larger community. Researchers, extensionists and NGO personnel should, however, only act as facilitators and resource persons.

Both farmer-derived and researcher-derived agroforestry knowledge and technologies have their strengths and weaknesses, and both have a role to play in developing and furthering agroforestry technologies and practices. The major strategy to enhance farmer research will, therefore, be a synthesis of the two knowledge systems that takes the strengths and weaknesses of each into account.

The greatest strength of formal (Western scientific) research is its access to information, ideas, and technologies. Formal research, therefore, has an important role in agroforestry development in increasing the options (species, management practices) available to the farmers. The design of specific agroforestry systems is best left to the farmers who are more skilled in incorporating technologies generated by each of the knowledge traditions in ways that are locally applicable and beneficial.
This study concludes that collaboration between knowledge systems may be beneficial for both and, thus, it is important to understand the processes of knowledge production. For this reason, this study has been short on specific details about particular agroforestry systems, tree arrangements, species uses, etc.; the latter are only facts used to help understand the logic of, and reasons behind, what farmers do. By themselves, facts (tree species, agroforestry systems, cropping arrangements) are meaningless. It is people who give meaning to them. Future studies of endogenous knowledge systems should, therefore, give less emphasis to collecting facts and more to process-oriented research to discover the logic and reasons behind such classifications, uses, or specific agroforestry systems and practices.

Synthesis between knowledge systems will increase the effectiveness of ongoing scientific agroforestry research and development as well as empower, legitimize and enhance the existing endogenous capacities for identifying problems and developing solutions. This synthesis should not lead to a formalization of farmer experimental methods nor to a relaxation of the rigor of scientific research. The goal of the synthesis is to build upon the comparative advantages of each knowledge tradition, leading to a participatory and collaborative strategy in agroforestry technology development. Such a strategy will assure that technologies are client-oriented, culturally appropriate and acceptable, and grounded in local dynamics of socio-economic and agroforestry development.

Chapter 1

Background

Introduction

Forest resources in Rwanda have steadily decreased over time, especially since the beginning of this century, due to rapid population growth1, a limited land base and growing competition for resources. But, in spite of dwindling tree resources, the cultivation and management of woody species remains important in Rwandan farming systems. Trees are the primary sources of energy and construction material. Their cultivation is encouraged to prevent soil erosion, to increase soil fertility through mulching and green manure, and to provide products such as fruit, medicine and fibres. Over time, farmers have generated extensive knowledge about the management of indigenous tree species for these purposes. In addition, they have acquired and adapted knowledge about exotic species and silvicultural practices introduced since the 1930s. However, researchers have generally paid little attention to farmers' knowledge-building processes which allow them to adapt to environmental, political and socio-economic changes. Surveys, rapid rural appraisals and agro-ecosystem analyses done by numerous development projects in the country have basically given the impression of stable and static agricultural and agroforestry systems because they have only dealt with one point in time.

The goal of this case study2 is to examine the historical and contemporary processes involved in the generation and adaptation of agroforestry knowledge and technology by farmers in Rwanda. It does not aim to describe existing agroforestry systems, although some description is necessary to understand the processes of knowledge building. What farmers know is a reflection of what they do and vice versa. Thus, there are extensive interactions between the
It is important to know the inner workings of the endogenous knowledge system, who the experimenters are within the system, and what their objectives and methods are, in order to improve the integration of agroforestry and tree planting policies and practices in each country, and its agrarian economy (CTA, 1988). Plugging into existing networks of experimenting farmers and thus choosing people already familiar with experimentation can reduce the cost of on-farm research. This can also help improve the designs of both on-farm and on-station experiments. Building links between farmers’ endogenous knowledge systems and researchers’ scientific knowledge systems can lead to synthesis between them. That synthesis will strengthen, empower and legitimize endogenous capacities for identifying problems and developing solutions and will be an important step toward enabling rural people themselves to alleviate their poverty.

Description of Rwanda

Rwanda is located in eastern Central Africa, bordered by Uganda, Tanzania, Burundi and Zaire (see Map 1).
Of a total area of 28 338 km², approximately 18 725 km² is usable for agro-sylvopastoral activities (Djimde, 1988). The remainder is national parks and natural forest areas. Estimates of the amount of land being cropped vary from about 8 000 km² in 1970 (Delepierre and Prefol, 1973; World Bank, 1977) to 13 500 km² (Niang and Styger, 1990). The additional land is being cropped at the expense of natural forest areas, pasture land and land only marginally suitable for cultivation (i.e. land on
very steep slopes, highly readable land and the very acid, low fertility soils of the Zaire-Nile Divide).

Estimates of forest land range from about 126,000 ha (World Bank, 1977) to 225,000 ha (Sorg, 1980). Both estimates include natural forests as well as forest plantations. Using an average of these two estimates and a population of 6 million, Niang and Styger (1990) evaluated the area of forest available per inhabitant at 0.3 ha. Wood is used for 95 percent of Rwanda's energy needs, particularly at the household level.

**Relief:** The country ranges in altitude from 1,000 m in the east to 4,500 m in the northwest. The highest peaks are the Birunga volcanoes found in Volcanoes National Park which straddles the border of Rwanda, Uganda and Zaire. It is the home of the famous mountain gorillas. A 160 km mountain range in the western part of the country forms the division between the Zaire and Nile watersheds (see Map 2).

A series of long, sharply-defined hills, with steep, convex slopes and flat ridges are intersected by deep valleys, the bottoms of which form marshy plains. These steep slopes do not prevent farmers from using the land for cultivation. The steepest slopes are found along the Zaire-Nile Divide and in the northern highlands. Seventy percent of the area cultivated has slopes greater than 10 percent. Fields on five percent of the cultivated area have slopes greater than 80 percent (Rossi, 1984).
Climate: Rwanda is located just south of the equator. Because of its high altitude, its temperature and rainfall are more moderate than the surrounding hot and humid equatorial regions, even though the climate follows the same annual cycles. Average temperature on the central plateau is about 19-20°C and changes about 0.5°C with every 100-m change in altitude. Temperatures are rather stable, with small annual variations.
Precipitation increases with higher altitudes and varies from about 800 mm in the east to about 1600 mm in Volcanoes National Park (see Map 2). Rain falls in a bimodal pattern. In the first rainy season (September to December), about 27 percent of the total annual precipitation is recorded. This is followed by a short dry period (mid-December to January) during which rains do not stop completely except in the eastern part of the country, but slow considerably. Forty percent of the annual precipitation falls during the long rainy season (February until mid-May or early June) followed by the long dry season which lasts from two months in the northwest and on the ZaireNile Divide to four months in the east (mid-May to mid-September).

Population: Rwanda has one of the world's highest population growth rates (3.1 percent). Its population density of 252 persons per km² is comparable to Bangladesh. According to the 1991 census, Rwanda has a population of 7.1 million, 2.3 million more than in the 1978 census. The population is not evenly distributed over the country and local densities may be as high as 800 persons per km² agricultural land.

Ninety-five percent of Rwandans live mainly from subsistence farming. The largest city, the capital Kigali, has about 200,000 inhabitants. As early as the 1920s, Belgian colonial rulers predicted wide-spread famines in Rwanda because of the rapidly-growing population, which at that time was between 1.5 and 2 million, and severe land degradation due to over-cultivation and deforestation. In spite of these predictions, agricultural production of subsistence crops broadly kept pace with population increases until about 1977, mainly by expanding to new land in the east and by draining the previously uncultivable valley bottoms. Since then the area of land annually made available for subsistence crops has increased by only 1.4 percent (Reyntjes, 1991) and crop yields have decreased because of erosion and declining soil fertility.

Economic conditions: According to 1989 estimates, gross national product (GNP) was equivalent to US$ 310 per capita. These same estimates pointed to an annual 1.3 percent increase in GNP although on a per capita basis the GNP declined by 1.9 percent during that same period.

The agricultural sector accounted for about 40 percent of Rwanda's gross domestic product and 91 percent of the labour force in 1989. About 95 percent of the total value of agricultural production is provided by subsistence crops including, in order of importance, bananas, sweet potatoes, cassava, beans, sorghum, rice, maize and peas. The major export crops are coffee (65 percent of export revenue in 1990) and tea (21.5 percent of export revenue). Until the mid-1980s, there was considerable revenue from pyrethrum (Rwanda was the third largest producer in the world in 1980) and quinquina, but production and revenue of both these crops has severely declined.

Rwanda's small industrial sector is dominated by processing plants for coffee, tea, sugar and tobacco, and a brewery. The country has mineral deposits, mainly gold, tin and wolframite, but its long distance from any ports (Mombasa, Kenya is 1200 km away) and volatile world prices make profitable exploitation difficult.
Land use systems and their principal constraints: There have been several attempts to divide the country into areas with similar characteristics in order to facilitate agricultural policy and development planning. The most widely used is the agro-ecological zones defined by Delepierre (1974). He distinguished twelve north-south zones based on topography, soils, altitude and precipitation but did not include farm crops or animals.

To assess the potential for agroforestry, however, it is necessary to consider not only biophysical conditions but also socio-economic factors, present land-use patterns, cropping systems and trees. A nation-wide diagnosis and design (D&D) exercise conducted in 1987-88 by ICRAF, with the help of the Institut des Sciences Agronomiques du Rwanda (ISAR) and the Université National du Rwanda (UNR), divided the country into five zones, namely Plateaux et Collines, Non-Volcanic Highlands, Volcanic Highlands, the highlands of the Zaire-Nile Divide and the Eastern Lowlands. Table 1 provides an overview of the major features of each zone, its farming systems and the major constraints which could potentially be solved by agroforestry.

Soil erosion, declining soil fertility and shortage of wood for fuel, timber and staking material are major constraints throughout the country. In spite of considerable development efforts for more than 50 years, these problems remain similar to the ones identified by Belgian colonial rulers in the 1920s and 1930s (Thomas, 1940, Tondeur, 1937) except for the occurrence of periodic famines.

An arboretum was established at Ruhande in 1932 to identify suitable species to reforest the countryside and prevent erosion and soil fertility decline as well as to provide various wood products to the local population. Similarly, the Belgians introduced a number of new crops, both subsistence crops (cassava, vegetables, potatoes) and export crops (coffee, tea) to combat Rwanda's frequent episodes of famine in the first decades of this century (Fallon, 1930). These introductions have had a profound effect on the agricultural systems of the country, in terms of crops produced and woody vegetation found in the landscape. The present acceptance and cultivation of cassava, eucalyptus and grevillea introduced at that time provide evidence of the changing nature of agroforestry systems, point to the necessity of agricultural research to bring about such changes, and provide an example of how the successful blending of endogenous and exogenous knowledge can make new technologies and crops work in the local context.
TABLE 1: CHARACTERISTICS OF THE AGROFORESTRY SYSTEM ZONES

| Source: Djimde 1988; Niang & Styger 1990 |

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<thead>
<tr>
<th>Plateaux &amp; Collines</th>
<th>Non-Volcanic Highlands</th>
<th>Volcanic Highlands</th>
<th>Zaire-Nile Divide</th>
<th>Eastern Lowlands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Altitude</td>
<td>1500-2100 m</td>
<td>1900 m</td>
<td>1900-1600 m</td>
<td>&gt;2000 m</td>
</tr>
<tr>
<td>Rainfall</td>
<td>1000-1400 mm</td>
<td>1400-2000 mm</td>
<td>1300-1600 mm</td>
<td>1400-1800 mm</td>
</tr>
<tr>
<td>Temperature</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>9°C</td>
<td>16°C</td>
<td>15°C</td>
<td>18°C</td>
</tr>
<tr>
<td>Minimum</td>
<td>7°C</td>
<td>5°C</td>
<td></td>
<td>22°C</td>
</tr>
<tr>
<td>Maximum</td>
<td>25°C</td>
<td></td>
<td></td>
<td>26°C</td>
</tr>
<tr>
<td>Soils</td>
<td>Histicollin &amp; inceptisols in valleys</td>
<td>Humulites and humicnuts, medium to low fertility, acid to very acidic, high humus content</td>
<td>Humicnultes, low fertility, highly acidic (pH 3.7-4.5)</td>
<td>Ultisols, vertisols and entisols of low fertility and highly erodible</td>
</tr>
<tr>
<td>Avg. farm size</td>
<td>1.1 ha</td>
<td>1.0 ha</td>
<td>1.0 ha</td>
<td>2.0 ha</td>
</tr>
<tr>
<td>Principal crops</td>
<td>Maize, peas, potatoes, wheat, barley, bananas, beans, sorghum, sweet potatoes</td>
<td>Maize, peas, potatoes, wheat, barley, bananas, beans, sorghum, sweet potatoes</td>
<td>Maize, peas, potatoes, wheat, barley, bananas, beans, sorghum, sweet potatoes</td>
<td>Bananas, sorghum, beans, peanuts, cassava, maize</td>
</tr>
<tr>
<td>Cropping system</td>
<td>Mostly monoculture, intensive</td>
<td>Moroculture, predominant intensively, intensive</td>
<td>Extensive cropping</td>
<td></td>
</tr>
<tr>
<td>Major cash crop</td>
<td>Coffee</td>
<td>Tea</td>
<td>Tea</td>
<td>Teas</td>
</tr>
<tr>
<td>Livestock</td>
<td>Cows, pigs, goats and sheep; intensive, semi-stabled</td>
<td>Shee, goats; cows (1/5 of households); intensive, semi-stabled</td>
<td>Cows, sheep and goats; intensive, semi-stabled</td>
<td>Cows; extensive</td>
</tr>
<tr>
<td>Predominant trees</td>
<td>Eucalyptus, Grevilina, A. marim, Marhania, Ricas sp., Acacina, Pinus sp., Erythrina, Dracaena, Euphorbia, Caltris; On the ground and around the fields</td>
<td>Eucalyptus, Acacia, Pinus sp., Erythrina, Mostly on the ruge, rarely in the fields</td>
<td>Polyesos. Eucalyptus, Euphorbia, Bamboo; On the ruge and as field markers</td>
<td>Acas sp., Telesa nebois, Apycles</td>
</tr>
<tr>
<td>Major constraints</td>
<td>Low soil fertility, soil erosion, lack of land, shortage of woody fuel, timber and fodder</td>
<td>Soil erosion, acidity, Small farm sizes, declining soil fertility, shortage of fuelwood and stacking material</td>
<td>Shortage of timber, fuelwood, fodder and stacking material; Erosion less important</td>
<td>Very acid soils; hail storms; violent winds during the dry season; low insolation</td>
</tr>
</tbody>
</table>

SOURCE: Djimde 1988; Niang & Styger 1990

History of tree growing practices in Rwanda

Deforestation is believed to have begun in Rwanda as far back as 3000 BC and was well underway before the Tutsi pastoralists arrived in the 1500s. By the early 1900s, dense forests had decreased to about three percent of the Rwanda-Urundi territory, or 6.5 percent if including the savanna areas (Everaerts, 1939). Colonial agronomists often considered trees more of an obstacle than an aid for agricultural development and, other than fruit trees and a few economic woody species such as coffee, tea, and oil palm, they made no mention of trees in their descriptions of the farming systems (see for example Mortehan, 1921 and Everaerts, 1939).

A later ethnographic study by Bourgeois (1957) provided more extensive information on traditional agroforestry systems, confirmed the lack of economic woody species in
the farming systems. Bourgeois' study described the planting and use of several indigenous species and gave detailed descriptions of trees and shrubs planted in and around the home compound (rugo), including a number of species propagated by planting large leafless branches. The latter were often used to build dense enclosures to protect against animals and thieves but also provided food; wood used for cooking, construction and fabrication of utensils and tools; bark for fibre to make clothing and rope; and medicines for people and animals. Trees within the compound were primarily planted for timber. No information was given about the use of woody species outside of the compound.

Reforestation and tree cultivation have been promoted in Rwanda since the 1930s. Due to the imposition by the Belgian territorial administration, numerous rapidly growing exotic trees (eucalyptus, grevillea, black wattle, cypress, cassia, etc.) were planted in community and private woodlots and along contours as a means to limit deforestation, provide fuelwood and timber, and help combat soil erosion (Lens, 1949; Dubois, 1954; Languy, 1954; Derenne, 1989). In spite of severe deforestation, the cultivation and management of woody species on farm actually increased. Before Independence, farmers depended on the natural vegetation in the landscape to meet their needs for tree products, but over the years they began to plant and manage trees and shrubs on their land to provide products and services such as fruits, fuel, medicines, fibres, fodder, fences, boundary markers and staking materials.

Agroforestry, as it is now called, is not a new idea in Rwanda. An extensive knowledge system has developed around the incorporation of both indigenous and exotic trees in its farming systems, especially during the last 30 years. For example, Balasubramanian and Egli (1986) found that 86 percent of the farmers in the Bugesera Gisaka-Migongo (BGM) region of southern Rwanda had an average of nine fruit trees (avocado, citrus, mango, guava, jack and passion fruits) on their farms, in addition to many other species (Eucalyptus, Grevillea, Ficus sp., Sesbania, Cassia, Markhamia, etc.). Hummel's research in Muyaga (Butare Prefecture) counted an average of 89 trees per farm (84 per ha).
These people are standing against the backdrop of a tree known locally as umuravumba (Tetradenia riparia). It is widely known locally as a medicinal plant, used to treat various illnesses.

Farmers' knowledge has become more extensive over the years as they have become tree producers as well as tree consumers and as ideas from outside have been incorporated into the local knowledge system. Farmers now plant exotic fruit trees such as mango, avocado and prune, and timber/fuelwood species such as Grevillea, cypress and Eucalyptus. Some of these species have become so firmly entrenched that farmers have given them names in the local language (umuzonibari/cypress and inturusu/eucalyptus).

Rwanda's oldest agroforestry project, the GTZ financed "Projet Agropastoral de Nyabisindu", which started in 1969 and was still operational in 1992, promoted the use of trees on farms as a low-input, ecologically sustainable method of agricultural development. The project served as a model for agroforestry projects elsewhere in Africa and has been described extensively in the literature. Since 1980, many other projects in Rwanda have had agroforestry components or were established to promote agroforestry systems in a particular area of the country (CARE-Gituza and Muhura/Ngarama projects in Byumba, the BGM project in Kigali/Kibungo, Swiss
Aid Projet Pilot Forestier in Kibuye, UNDP/FAO Projet d’Intensification Agricole in Gikongoro, USAID Farming System Research and Natural Resource Management projects in Ruhengeri, etc.). These projects have been successful in developing agroforestry technologies or what Thrupp (1989) called "scientized packages". They work under research station conditions and with large inputs of technical assistance but there have been low rates of adoption of the packages as a whole (Kerkhof, 1990; N’Diaye, 1988), even though farmers do plant large numbers of trees. The low success rate, as elsewhere in Africa, has been due, mostly, to the imbalance of technical and social expertise (oversimplification of production systems, 'homogenization' of landscape, acceleration of resource degradation and impoverishment of the poorer farmers, especially women) and from lack of accountability to their rural clients (Rocheleau et al., 1989). For example, in Rwanda most projects emphasize alley cropping using leucaena, sesbania or cassia, and thereby neglect any locally-developed systems that integrate indigenous species into the landscape. Given a choice and without pressure from (project) extension agents, farmers appeared to favour fruit trees or Eucalyptus and Grevillea for timber production instead of leguminous species for soil fertility and fodder (Kerkhof, 1990).

Research questions

The existing tree-crop-animal systems of Rwanda have evolved from centuries of experience and reflect peoples' needs choice of plants and animal species, and their ideal spatial and temporal arrangement. Even though the systems are "not well-managed agroforestry systems" (Balasubramanian and Egli, 1986) as defined by outsiders, they are not necessarily bad, static nor unchanging. From the local point of view, they offer the best that can be achieved to guarantee a sustainable, albeit minimal, subsistence income and food supply.

Thus, for agroforestry to be relevant as an approach, it needs to be implemented with sensitivity to peoples' needs, priorities and sociocultural and economic conditions. Surveys can assess existing farm situations and determine peoples' needs, priorities, problems and constraints, but they have three major limitations: (1) they provide only a static picture (a snapshot) of a situation at one point in time; (2) they do not reveal the context of the needs, priorities, problems and constraints; and (3) they do not give an historical account of why particular systems exist and farmers' roles in developing those systems, as producers of crops and livestock as well as landscape managers and reproducers of the systems. That is why it is important to determine how such systems and technologies came into being, what the meanings are that people assign to them, how the knowledge upon which they are based is generated and how they evolve because of changes in sociocultural, economic, political and environmental conditions. When viewed this way, the systems appear to be in almost perpetual flux to meet new needs and adapt to ever-changing conditions.

This case study concentrates on the active role of farmers who take existing ideas, technologies and uses and then experiment to arrive at new ideas, technologies and uses that optimize integration of woody species on their farms. It also focuses on the time and space needed to adapt agroforestry practices within prevailing and evolving socio-economic, cultural and political conditions. The active role of farmers in these efforts should be seen as diametrically opposed to the passive adoption of externally-developed technology packages from the formal research/extension establishment.
However, such technology packages (e.g. alley cropping) are not entirely useless, even though they may have very low adoption rates. They are often a prime source of inspiration and material for farmers who tinker with them to make them work in their own farm conditions or develop new technologies on the basis of them (Sumberg and Okali, 1988). The numerous exotic crops, fruit, timber and fuelwood species introduced by Belgian researchers that now form common elements of the farming systems attest to both the extensive tinkering of the farmers and the usefulness of scientific research.

The basic assumption underlying this case study is that not all farmers have the same propensity for experimentation and risk-taking because of differing socio-economic and political positions within the community and differing biophysical conditions on their farms. Neither does every farmer have the same aptitude towards experimentation and innovation. Thus, different farmers experiment with different technologies, methodologies and approaches. Even if farmers experiment with the same technology or basic idea (i.e. a certain tree species), they may arrive at completely different solutions. A pastoralist may emphasize leaf and pod production while a sedentary farmer may be more interested in timber.

The following questions guided the research and aimed at understanding farmers and their experimental practices within the changing agricultural landscape of Rwanda.

1. How have tree growing practices changed over time, in general or as a result of experimentation?

   This question includes such topics as species choice, arrangement, uses, placement, management, intercropping practices and interactions between trees, crops and animals. While the answer to this question could be a case study in itself, this information is needed to build a frame of reference in which to place the other questions.

2. Who are the experimenting farmers and what differentiates them from other farmers in the community?

   This includes socio-economic status, farm size, land quality, external sources of income, travel, gender, connections, political position and aptitude.

3. Why do farmers experiment? What are their objectives for experimentation?

4. Where did the idea, practice... forming the basis of the experiment originate?

5. How do farmers themselves define "experimentation"?

   a. Are there common elements in the methodology experimenting farmers’ use?

   b. What, how, why and how long was testing done before adoption or rejection?
c. What are the adoption/rejection criteria (why or how is a particular practice better or worse than existing practices)?

d. When and under which conditions can a new practice or technology be used?

During a visit to a woodlot to discuss its history and inventory its trees, the woman pictured here (centre) with her daughter and grandchildren, collected medicinal plants. Although the greater part of the woodlot consisted of Eucalyptus spp., a part was left under natural vegetation especially to preserve its many medicinal trees and shrubs and to attract wildlife (which were occasionally trapped for food). The farmer left the woodlot open to enable people to collect medicinal plants as needed.

Overview of the case study

This case study consists of eight chapters. Chapter I introduces the topic, the basic characteristics of Rwanda and the history of its tree growing practices. Chapter II addresses the methods used to study and understand the agroforestry knowledge-building processes. Chapter II also explains the choice of study areas: Maraba and Simbi districts (secteurs) located in the municipality (commune) of Maraba (Butare Prefecture); and Kibingo district in the municipality of Karama (Gikongoro Prefecture). Chapter III describes their characteristics and major features.

Chapter IV focuses on the farmers who participated: 44 locally-identified tree experts (i.e. farmers highly knowledgeable about trees and tree cultivation) and 70 comparison farmers. The chapter analyses a socio-economic survey of demographic characteristics, education, socio-economic status, farm size, land quality, livestock, external sources of income, political position and connections.
Chapter V is based on extensive discussions with farmers and presents their perspectives on historical agroforestry practices and present possibilities and reasons for practising agroforestry. It also looks at tree cultivation practices in relation to gender and farm size and presents the results of a tree inventory that shows the richness and complexity of contemporary agroforestry systems. The diversity of these systems shows that multiple solutions are possible even though they are based on similar principles that come from a small but expanding knowledge base. Experimentation is not so much carried out for the development of a specific agroforestry system, but to gain new knowledge about trees, their utility and their interactions with crops, soils and animals.

Chapter VI discusses knowledge and experimentation. Since experimentation is above all a knowledge-generating process, the farmers' connotations of "knowledge" and "being knowledgeable about agroforestry" are explained, followed by a discussion of farmer experimentation.

Chapter VII covers farmers information gathering/sharing. Farmers acquire new knowledge and technologies from a variety of sources, but not all farmers have equal access to nor are equally active in seeking out new information, discussing problems or sharing experiences. Chapter VII examines farmers' knowledge acquisition in three categories: the active seeking of new species and ideas during travel; the passive acquisition of species and tree management ideas from visitors to the farm (eg. researchers, extensionists, friends, etc); and cooperation with development or other agencies for on-farm testing of new practices. This chapter also describes how farmers share experiences with new species and methods, and the accessibility of help from extension or specialists.

The concluding chapter summarizes the key findings related to the strengths and weaknesses of farmer research, gives recommendations to enhance farmers' knowledge building and communication processes, and gives an overall conclusion.

It should be noted that none of the chapters specifically addresses research question 1: How have tree growing practices changed over time in general or as a result of experimentation? However, the information obtained from this question is woven throughout to provide the context in which the other questions are placed.

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1 The population density in 1948 was 77 persons per km², 150 per km² in 1970, and 277 per km² in 1990.

2 Participants in an international seminar on agroforestry at Kigali, Rwanda (CTA, 1988) recommended the study of farmer-based processes of innovation as the main strategy to further agroforestry practices in Africa.
For examples of such participatory technology development, see Chambers et al., 1989; Farrington, 1988; Farrington & Martin, 1988; Rhoades, 1987.

Ruanda-Urundi was the name of the Belgian protectorate. In 1962, the territory was split into two independent countries, Rwanda and Burundi.

The species so propagated were not identified. The author gave the impression that all species planted in dense hedges around the compound were propagated by branch cuttings, which may or may not have been the case.

Everaerts (1939) estimated the total area reforested at the end of 1938 at 22 000 ha, 9 723 ha in Ruanda and 9 878 ha in Urundi, the difference being tree plantings along roads and private woodlots. Communities were obliged to establish one ha of forest per 300 people each year in order to combat a shortage of fuelwood and timber as well as to combat the irregularity of rainfall (although Everaerts admitted that this would take thousands of hectares to accomplish).

Chapter 2

Methods

This case study goes beyond merely describing specific agroforestry systems or examining individual farmers’ agroforestry knowledge. It surveys farmer-designed agroforestry systems and determines how they have evolved and how they function. Methods were chosen that allow interaction of with the persons most knowledgeable about the subject and most active in producing knowledge. Figure 1 provides an overview of the methods used in the order that they were implemented.
FIGURE 1: FLOW CHART OF THE METHODS USED

Choice of study areas
Introductory meetings in study areas to explain the research
(3 community meetings, 140 participants)

Knowledge ranking game and guided farm tours
(241 informants)

Community interviews: Choice of 44 farmer tree experts
(13 interviews, 442 participants)

Farmer tree experts (44)
Case studies
(3-5 repeat visits)
Socioeconomic survey
Tree inventory
Guided farm tours
Participant observation
Focus group interviews
(8 interviews, 90 participants
(tree experts + spouses))

Comparison farmers (70)
(random sample of non-experts)

Socioeconomic survey
Tree inventory
Guided farm tours
Participant observation
Choice of study area

Two assumptions were made before selecting a site for the study. First, it was assumed that farmers everywhere would be involved in (agroforestry) knowledge and technology building processes; that such processes would not be tied to a particular geographic area. Second, while it would be ideal to study the processes in different places along an ecocline to determine whether farmers use different methods and approaches, such methods and approaches were assumed to be much more uniform than the actual agroforestry systems resulting from farmers' experimentation. Time and logistical constraints prohibited including several widely-separated sites along an ecocline. However, the mountainous character of Rwanda and the fact that farmers' fields are scattered over hilltops, slopes and valley bottoms to take maximum advantage of micro-ecological features still permitted a study of agroforestry under a range of conditions, albeit on a smaller scale.

The case study area were chosen after consultation with researchers of ISAR and local authorities in Rwanda. ISAR researchers suggested Karama municipality (commune) in Gikongoro Prefecture. Karama is located in the zone of action of Projet Agro-Pastoral de Nyabisindu (PAP), and ISAR was interested in an independent assessment of the impact of this project in promoting agroforestry. The initial visit to discuss the study with local authorities revealed that there was a second project promoting agroforestry in Karama, the Projet Agricole de Karama led by a Belgian volunteer. Since the objective of this case study was to understand how farmers build agroforestry knowledge on their own, there was a concern that the presence of these projects would unduly influence these processes. However, because ISAR was the host institution, it was politically impossible to reject Karama as a study site. Thus it was determined to look for a second site that had never been part of a
development project. Within Gikongoro Prefecture and neighbouring Butare Prefecture, three such locations existed—the municipalities of Maraba, Ruhashya and Rusatira. Maraba was chosen as the second study site. Ruhashya was rejected because the main ISAR research station, Rubona, is located there, which means that farmers are frequent targets of surveys by Rubona researchers and are suffering from ‘survey fatigue’. Rusatira was rejected because its location made it too awkward to coordinate activities at the two sites. The location of the two chosen sites is given in Map 3.

The specific study sites within Maraba and Karama were selected after discussions with the local authorities and extension personnel. In Maraba, the two districts (secteurs) of Simbi and Maraba were chosen. They are located in the centre and the southwest part of the municipality respectively. In Karama, Kibingo district was chosen. It is a long and narrow, L-shaped district that dissects Karama from north to south. More detailed descriptions of the research sites will be given in Chapter III.

Selection and training of research assistants

Two local research assistants were chosen to help during the actual data collection (May-Dec, 1992), one from Maraba and one from Karama. They both had knowledge of French, a willingness to travel on foot within the chosen areas, the ability to listen to and learn from farmers but no agricultural education or training. The lack of training in agriculture was deemed necessary, as previous experience in Africa and a review of the literature on extension activities in Rwanda indicated that people with agricultural schooling often dismiss farmers’ practices as too traditional or backward. A study of endogenous knowledge, however, requires a non-judgmental approach in which farmer practices are respected and questions are asked to gain understanding of the logic behind farmers’ actions and tree cultivation practices.

As neither assistant had experience with data collection, interviewing or conducting meetings, and as the research methods were developed and refined as the study progressed, constant on-the-job training, supervision and adjustments were necessary.

The assistants participated in all stages of the research from organizing the initial meetings with farmers, to executing tree inventories and collecting historical data on agriculture and tree cultivation practices from participants. The assistants mostly worked independently, with the researcher alternating between the two research areas two or three days a week. When the researcher worked with the assistants, new data was collected in the morning and previous work reviewed in the afternoons. At least once a month, the researcher invited an assistant to visit and work in the other district, so the assistants could work together, learn from each other and learn about agroforestry in a different area. The researcher and both assistants attended the majority of focus group meetings which facilitated leading discussions and taking notes.

Sample selection

The objective of this study was to investigate the ways farmers acquire, adapt and/or generate agroforestry knowledge and technology, so it was important to work with the farmers most knowledgeable about agroforestry. Thus, a random selection of participants was out of the question. Instead a two-stage process of sample selection was used to identify local tree experts and choose the right farmers for a more in-depth study of knowledge building.
"Knowledge" and "being knowledgeable about agroforestry" were defined by the people themselves.

The first stage used an adaptation of the "wealth-ranking game" (Grandin, 1988), because it was suitable to determine the study's subjects, what "knowledge" means in the local context, and how this knowledge is distributed within the community. The second stage consisted of 13 community interviews.

**Wealth ranking procedure (adapted from Grandin 1988)**

In wealth ranking, three to four respondents, either from different predetermined social strata or picked at random, are asked to rank the farmers according to their wealth. Before proceeding with the ranking game, the term on which farmers are to be ranked (in this case wealth) has to be operationalized in local language so that informants will be sure of their meaning. The name of each head of family in the community is written down on a 3-by-5 card, and respondents group these cards in as many piles as they want from rich to poor. After that, respondents are asked why they divided families in the number of piles they did and what the differences between the various piles are. The classification of each person ranked is converted into a score. The scores obtained from different informants are averaged and ranked from high to low with the help of a spreadsheet, which gives researchers an idea of the relative wealth of each member of the community. The ranked scores are then divided in a number of strata of persons of similar wealth. One thus obtains an idea of wealth strata in the community in local terms from a local perspective. These strata can then be used for more in-depth formal or informal surveys.

**Stage 1:** The ranking game: An adaptation of the wealth ranking procedure was used to stratify the community on two variables: good farmers (Abahinzi-borozi beza) and farmers knowledgeable about trees and tree cultivation (Abahinzi-borozi nyamwete or Abahinzi-borozi bafite ubumenyi bw’ibiti bwinshi). As described in Chapter I, tree growing practices have been promoted in Rwanda for 60 years to control soil erosion and promote fuel wood production. The variable "good farmers" was chosen to determine whether, after all these years of promoting tree cultivation, farmers equate it with good farming practices. The second variable, "farmers knowledgeable about trees/cultivation", was crucial to identify the local agroforestry experts.

The game was used with two modifications. First, rather than ranking wealth, it identified the individuals most knowledgeable about agroforestry. Second, the cards did not have the names of heads of household but of individual male and female farmers. In many societies, it is the female farmers who collect and cultivate the bulk of tree crops, and they would be excluded because only around 20 percent of Rwandan households are headed by females.

Choice of informants and sample size- After initial meetings in each district with farmers and authorities, local counsellors were asked to prepare a list of all male and female farmers in their respective areas, subdivided by cellule and colline. There were 2 159 households in the three districts (704 in Maraba, 746 in Simbi, 709 in Kibingo). According to Grandin (1988), if the level of agreement within a community on the ranking criterion is high, three or four informants are sufficient. In Rwanda, the smallest administrative unit with which farmers identify is the colline (hill), and this unit was used as a "community" during the game. Given the number of informants necessary per community and the number of collines in the three
districts combined, the sample size was determined to be 241 informants, or about 11 percent of all households. A systematic sample of every ninth name was taken from the lists prepared by the counsellors, alternating men and women so the final sample contained 121 men and 120 women.

After selection of the sample size and the determination of informants for the game, 2159 cards were prepared with the name of each farmer in the three research areas. The cards contained a code for the study area (district, cellule and colline), a number for the household and the name of the person. The cards were prepared with the husband's name on one side and the wife's name on the other; for single households, one of the sides remained blank. However, men and women were ranked separately. This system was advantageous in eliminating many "unknowns" during the ranking game, especially among women. Women move to their husband's farm upon marriage, and many were unfamiliar with the names of other women unless they could place them at a particular farm identified through the husband's name.

**Stage 2:** Community interviews: The results of the ranking exercise were presented to the people in a series of 13 community interviews organized in the cellules during July and August, 1992. Dates, times and meeting places were chosen in collaboration with the counsellors of each district. The meetings were open to all. Invitations were extended orally through the counsellors and the chiefs of the cellules. The meetings were held in a central outdoor location within each cellule. On average, 22 men and 12 women attended each meeting.

The purpose of these community interviews was: (1) to discuss research activities of the first two-and-one-half months of the study; (2) to discuss the researcher's observations and impressions of agricultural and tree cultivation practices that were contradictory or not well understood; (3) to question people further on the topic of knowledge (what it means, how one gets it, gender differentiation); and (4) to discuss and confirm the ranking criteria that differentiated good from less-competent farmers, and highly-knowledgeable from less-knowledgeable farmers. A list of ten questions was prepared to help guide the discussions.

Toward the end of the meetings, the names of 10-15 persons (men and women) were given to confirm whether they were indeed the best and/or most knowledgeable farmers. From the list of most knowledgeable farmers, the audience was then asked to choose 2-4 persons who would be asked to participate in the second phase of the research (the biographical case studies, tree inventory and socio-economic survey). The audience members were also free to choose names not mentioned in the list if they thought the other persons were particularly knowledgeable but somehow had not been identified with the ranking game. A special effort was made to include persons specializing in local medicine who were often not ranked very high in the game although they possessed great knowledge about trees and vegetation histories. This helped include women since they were recognized as the most knowledgeable regarding local healing practices.

This two-stage sampling procedure resulted in the identification of a sample of 44 tree experts (11 each in Maraba and Simbi and 22 in Kibingo), who were invited to participate in the second phase of the study: an in-depth investigation of knowledge building processes through experimentation.
Biographical case studies on the history of agroforestry

The 44 persons deemed most knowledgeable of trees and tree cultivation were asked to serve as consultants to help the researchers better understand tree cultivation and use practices. A biographical analysis (the method described in this section is adapted from Box, 1988) was done for each consultant selected. These biographies used two key questions: What trees were grown on the land when you started your farm? Why were they grown? This information was then expanded to include the tree species growing on the farm up to the present in order to determine discontinuities in tree cultivation, i.e. changes in species and/or varieties, cultural practices, placement or uses. The historic context and the reasons for each discontinuity were reviewed to make sure that they were understood in the same terms.

Participant observation and guided farm tours

This method included several components broadly grouped as "participant observation" and included observation of farm activities, guided farm tours and informal discussions with people on their farms or at the market. The purpose was to (1) obtain an understanding of the daily routine of rural life; (2) observe farming practices first hand; (3) observe any experiments under way in a total systems perspective; and (4) engage in discussions to understand the logical relationships between practices and experiments, and among trees, crops and animals. The fact that their systems and practices were not ridiculed or considered backward or primitive, that they were actually the objects of a study, helped gain the confidence of people and piqued their interest in the outsider who wanted to learn about their agriculture and their knowledge of trees and tree cultivation.

Inventory of trees

As the objective of the case study was to obtain a local perspective of agroforestry, the term "tree" was interpreted broadly and defined by the farmers themselves, who were asked to show all the trees [ibiti (sing. igiti) in Kinyarwanda] they cultivated on their farm. Many species thus identified do not qualify as "trees" in the Western sense. What was found was much closer to what Kagame (1958) provided as a translation of the word ibiti: plants that are not grasses.

The inventory was undertaken with two groups of farmers (the 44 tree experts and a sample of 70 non-experts, further referred to in this case study as "comparison group"). The selection of the tree experts has been described above. The comparison group was chosen randomly from among the persons identified in the ranking procedure as having little to no knowledge of agroforestry.

In the tree expert group, inventories of all tree species were taken in conjunction with repeated visits to discuss the history and farmers' knowledge of tree cultivation for different "blocks" of the farm. A "block" is a group of individual fields used in a similar manner. Four blocks were distinguished for this research: home compound (rugo), banana fields (intoki), food crop fields (imirima), and woodlot (ishyamba).
Inventories of farms of the comparison group members were done in a single visit that combined the fielding of the survey with the collection of socio-economic household data. The same information about each tree species was collected from both groups. However, due to time constraints, the information on tree uses from the comparison group is less detailed and, in some cases, was not obtained at all.

A form was prepared to record information about each tree species, including species name, age, number of trees per species, tree tenure and location; why, when and who planted the species, or in case species were natural, why farmer left them; how the species was used and which parts of the species for each particular use; how the species was maintained, by whom and when; and who harvested the species and at which time of the year. A code sheet was developed to facilitate entering the information on the form.

**Socio-economic characteristics of tree experts and comparison farmers**

This study aimed not only to understand the dynamic nature of agroforestry knowledge, but also to determine the difference between local tree experts and the general population in the study areas. It was, therefore, necessary to collect identical information from each farmer in the two samples that could be statistically analysed in order to draw profiles of local agroforestry experts and non-experts according to the second research question: Who are the experimenting farmers and what differentiates them from other farmers in the community?

A formal survey was designed to obtain a minimal data set to differentiate the two groups of farmers. The instrument was based on the research questions plus various elements identified in the literature as important in distinguishing farmers who experiment from those who do
not. Questionnaires previously used by other projects in Rwanda were used as a guide in developing the instrument and formulating the questions.

In order to determine what differentiates tree experts from other farmers in the community, characteristics were grouped in eight categories.

1. Past and present residence

2. Family status: marital status, number of children, age, years of farming experience

3. Education and training

4. Past and present employment and/or community functions

5. Land: farm size, soil quality, fragmentation, tenure, changes in size in the last five years

6. Labour: family labour, hiring labour in or out

7. Livestock: total number present on the farm, resident non-owned animals, owned non-resident animals

8. Awareness of and openness to new ideas through contacts with the outside world, i.e. access to information and new (agroforestry) technologies through travel, visitors to the farm or collaboration with projects and/or extension; sharing of new knowledge/technologies with others; and the seeking of help in case of problems on the farm. This information helped determine the source of the ideas for any experiments or of particular species and arrangement of trees found on the farms.

After the instrument was passed for comments to ICRAF/TSAR researchers and pre-tested with several farmers, suggested modifications were made to questions and accompanying instructions. The questions were in French on the form but were translated in Kinyarwanda during the interviews. The instrument and the instructions were discussed with the research assistants before the actual start of the data collection, so they would interpret the questions similarly.

**Focus group interviews**

A series of focus group meetings was held after completion of the biographies and the data collection (November-December, 1992). The meetings, held indoors because it was the rainy season, were hosted by one of the tree experts. Each meeting was held with four or five tree experts and their spouses. A total of 90 persons attended eight meetings. Discussions focused mainly on the findings of the case studies with a particular emphasis on the nature of knowledge (knowledge building in general and agroforestry knowledge in particular). The farmers’ research methods and their methods of evaluating experiments were also discussed and hypothetical situations were presented to test their approaches and reactions to problem-solving and experimentation.
Each meeting lasted between one and two hours. When possible, both assistants attended so one could lead the discussions, while the other could take notes and assist the discussion leader as necessary. Tape recordings of all the meetings were later transcribed and translated into French by various persons who had university-level linguistics training but had not been involved in the interviews.

![A group of women during a community interview in Karama.](image)

**Chapter 3**

**Characteristics of the Study Areas**

There are two classifications of the agro-ecological zones where Maraba and Karama are located. According to a classification using climatic data (Delepierre, 1974), Maraba and Karama are both located in the Central Plateau. But according to a diagnosis and design (D&D) exercise conducted by ICRAF that used socio-economic variables, soils characteristics and actual land use systems in addition to climatic data, Maraba and the eastern and central sections of Karama belong to the Zone des Plateaux et Collines, but the extreme western part of Karama is part of the Zaire-Nile Divide zone (Djimde, et al, 1988).
Maraba

Maraba is located in the western part of Butare Prefecture and borders Gikongoro Prefecture (see Map 4). It is bisected by the main, paved road from Butare to Gikongoro and Cyangugu. Maraba has gentle, sloping hills dissected by numerous streams with fertile valleys that are intensively cultivated, especially during the dry season. The slopes become steeper in the south where the Huye mountain chain forms a border with neighbouring municipalities. The highest point in the Huye mountain chain is 2,278 m. Practically all land up to about 2,050 m is cultivated or occupied by communal forests. However, due to increasing pressure on the land, new farms are being carved out of the pastures and forests above that level.

The area is one of the oldest settled areas in Rwanda and had one of the highest population densities in the country before Independence. According to the 1948 census, the Bwanamukare region, to which Maraba belonged at the time, had a population density of 183 persons per km2 with 356 persons per km2 of arable land (Prioul, 1981).

Since the census of 1948 was based on a different administrative division, data from that census cannot be compared directly with those taken later. However, taken on a population per square kilometre basis, the population density has increased by more than 300 percent since 1948. The growth rate, however, was lower than the national average of 3.1 percent during the 13 years between the last two censuses, in 1978 and 1991. The lower population growth rate can be explained by the out-migration resulting from land scarcity. Most have migrated to the Mayaga region in eastern Butare, Bugesera in southern Kigali Prefecture and Kibungo Prefecture in the eastern part of the country. Less than one quarter of the population has migrated within Maraba, principally by carving out farms on steep slopes and former pastures only marginally suited for agriculture.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Maraba commune</td>
<td>84.8</td>
<td>32,016</td>
<td>41,281</td>
<td>378</td>
<td>476</td>
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<tr>
<td>Maraba sector</td>
<td>7.0</td>
<td>3,114</td>
<td>3,871</td>
<td>445</td>
<td>553</td>
</tr>
<tr>
<td>Simbi sector</td>
<td>8.5</td>
<td>3,236</td>
<td>3,595</td>
<td>381</td>
<td>423</td>
</tr>
</tbody>
</table>

**SOURCE:** Min. du Plan 1982 and 1992
FIGURE 3: PERCENTAGE DISTRIBUTION OF HOUSEHOLDS ACCORDING TO FARM SIZE, MARABA COMMUNE

The high population density is also reflected in the size of the farms in Maraba. More than half the households cultivate less than 0.25 ha of land, with only 14 percent of the households cultivating more than 1.5 ha (Figure 3). Farm size appears to be independent of household size, since the amount of land cultivated does not increase with the number of persons in the household and farmers with more land do not necessarily have more children. For example, the majority of households of more than eight persons still cultivates less than 0.25 ha. Given the traditional inheritance pattern of dividing the land equally between sons, it is not difficult to imagine the future of farming in Maraba.

SOURCE: Commission Communale de Planification 1989
TABLE 3: CHARACTERISTICS OF AVERAGE HOUSEHOLD

<table>
<thead>
<tr>
<th></th>
<th>Maraba commune</th>
<th>Maraba secteur</th>
<th>Simbi secteur</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>2.41</td>
<td>2.35</td>
<td>2.44</td>
</tr>
<tr>
<td>Woman</td>
<td>2.57</td>
<td>2.47</td>
<td>2.67</td>
</tr>
<tr>
<td>Total</td>
<td>4.98</td>
<td>4.82</td>
<td>5.11</td>
</tr>
<tr>
<td>0-14 years</td>
<td>2.25</td>
<td>2.04</td>
<td>2.28</td>
</tr>
<tr>
<td>15-64 years</td>
<td>2.58</td>
<td>2.63</td>
<td>2.69</td>
</tr>
<tr>
<td>&gt;65 years</td>
<td>0.16</td>
<td>0.15</td>
<td>0.15</td>
</tr>
<tr>
<td>Know how to read</td>
<td>1.97</td>
<td>2.00</td>
<td>2.02</td>
</tr>
<tr>
<td>Know how to write</td>
<td>1.91</td>
<td>1.91</td>
<td>1.98</td>
</tr>
<tr>
<td>Primary education</td>
<td>0.78</td>
<td>0.78</td>
<td>0.89</td>
</tr>
<tr>
<td>Secondary education</td>
<td>0.05</td>
<td>0.07</td>
<td>0.06</td>
</tr>
</tbody>
</table>

SOURCE: Commission Communale de Planification 1989

FIGURE 5: PERCENTAGE OF HOUSEHOLDS WITH FARM ANIMALS OF VARIOUS KINDS AND AVERAGE NUMBER OF ANIMALS PER HOUSEHOLD

SOURCE: Commission Communale de Planification 1989

Livestock rearing was prominent in Maraba before Independence, when large tracts of land were reserved for the royal cattle. Due to increasing population pressure and declining farm
sizes, the majority of households can no longer afford to keep animals. Nearly 62 percent of all households have no animals, the others have only one or two. Goats are becoming more numerous than cattle, a reflection of decreasing farm sizes and lack of sufficient pasture for larger animals. Figure 5 shows the distribution and the number of different animals per household.

Also, a majority of houses can no longer afford to keep woodlots. On average, 40 percent of households in Maraba do not have woodlots. Existing woodlots are usually very small, less than 500 square meters.

There is a small market twice a week on the border between Maraba and Simbi that attracts farmers from a wide area. During the coffee marketing period from June to September, many merchants try to sell their wares (cloth, used clothes, luxury items, hardware, etc.) to take advantage of the flush of money during these weeks. The buying and selling of animals also is more active during this period, with many farmers selling off their animals before they lose weight in the dry season.

**Social conditions:** Simbi and Maraba districts each have one primary school. The Simbi school is run by the Catholic mission, while the school in Maraba is a state school. The mission also operates a small clinic, maternity and health education centre.

![Distribution of different animals per household](image)

**SOURCE:** Commission Communale de Planification 1989

The two districts have good drinking water in centrally-located spigots. A municipal employee maintains the water pipes, spigots and water tanks. There is also a national electricity network which few can afford.
Karama

Karama is in Gikongoro Prefecture approximately five km north of Gikongoro town and 36 km from Butare (see Map 5). The dirt road between Gikongoro town and Karama is a major road and is passable year-round. Karama is at a higher elevation than Maraba and covers two agro-ecological zones, Plateaux et Collines in the east and the Zaire-Nile Divide in the west. Eastern Karama looks much the same as Maraba, with rolling hills intersected by many streams and valleys. Kibingo is located between the two zones where there are steep hills with narrow valleys, and gully formations and landslides are common. As a result, Kibingo has only a few springs which are trickles originating from numerous places along the hill crest. The western and southern borders of Kibingo are formed by wide valleys whose cultivation is shared with farmers from other districts. Parts of these valleys have been improved with better drainage systems and improved field arrangement.

Before Independence, Karama belonged to the chieftaincy (chefferie) of Bufundu. Bufundu roughly covered the area of the present municipalities of Mudasomwa, Nyamagabe, Kinyamakara, Karama, and Rukondo. According to Noel Macumu (pers. com.), a former sub-chief (sous-chef), the entire area of Bufundu had less than 20,000 population in 1955. By 1978, the population of Karama alone was 24,716 with a population density of 328 person per km2 (Delepierre, 1980). According to the census of 1991, the population had reached 30,631, and the population density increased to 406 person per km2. In the period between 1978 and 1991, the population of Kibingo increased from 3,465 to 4,895, while the population density increased from 347 to 490 persons per km2. From Table 4, it can be seen that population growth rates in Karama were much lower than the national average of 3.1 percent between 1978 to 1991. The growth rate for Karama is comparable to Maraba's. However, the rate for Kibingo has been much faster, indicating that people still see opportunities to expand farming by bringing pasture land into cultivation and thus see less need to migrate out of the district.
The average household size in Karama is 4.87, which is slightly above the national average but less than Maraba.

**Economic conditions:** As in Maraba, the main occupation of people in Kibingo is farming. The crops grown are much the same, except for bananas and coffee. Kibingo is a long, L-shaped ridge ranging in elevation from about 1,700 m in the southeast to 2,100 m in the centre and about 1,800 m in the north. Most of Kibingo is, therefore, above the range for bananas. Farmers do not grow much coffee, because Kibingo was almost exclusively pasture land until Independence, with crop cultivation limited to the area immediately surrounding the home compound. Pastures still occupy about 40 percent of the land area (Technosynesis, 1987).

**TABLE 4: POPULATION AND POPULATION GROWTH RATES IN KARAMA COMMUNE AND KIBINGO SECTEUR, 1978 AND 1991**

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Karama commune</td>
<td>75.4</td>
<td>24,716</td>
<td>30,631</td>
<td>328</td>
<td>406</td>
<td>1.67%</td>
</tr>
<tr>
<td>Kibingo secteur</td>
<td>10.0</td>
<td>3,465</td>
<td>4,895</td>
<td>347</td>
<td>490</td>
<td>2.69%</td>
</tr>
</tbody>
</table>

SOURCE: Min. du Plan 1982 and 1992
The major food crops are sweet potatoes, cassava, sorghum, peas and beans. The latter crop has made rapid inroads into the farming systems since the introduction of climbing beans by ISAR/CIAT. Previously, farmers produced bush beans but aluminum toxicity caused by soil acidity and over-cultivation and diseases almost destroyed the crop.

Because of the presence of two development projects in Karama, many of the valleys have been improved in the last ten years, streams have been canalized and a fish bone pattern drainage system installed. However, these improvements have not benefitted the majority of farmers. Many farmers previously had access to small pieces of land in the valleys but after improvement, the land was redistributed to "cooperatives" to which mostly wealthier farmers belong. Thus, small marginal farmers have been cut off from a valuable source of land for dry season cultivation critical to their family's survival.

Cattle ownership is more prevalent than in Maraba as there are still extensive areas in pasture. Many farmers raise goats and sheep, but there are fewer chickens, bees, pigs or rabbits than in Maraba. Land pressure is not (yet) as extreme as in Maraba, so farmers can still afford large animals and have not been forced to abandon their traditional attachment to cattle.

There is no market in Karama, although some farmers sell their produce daily near the secondary school and many travel five km to the Saturday market in Gikongoro town.

Kibingo’s roads are in bad condition. The bridges are unstable and roads that are passable in the dry season are almost impossible after a rain. A food-for-work project started in late 1992 to maintain the internal road system should make some more isolated areas more accessible.

**Social conditions:** There are no primary schools located in Kibingo. Children walk to the mission school in Cyanika or the government school in Buhiga along the main road to Gikongoro. The mission in Cyanika also runs a small clinic and maternity, as well as a secondary school.

There was no running water in Karama until the end of 1992, when a water system with centrally-located spigots became operational. This system extended into Kibingo, but not all areas have spigots. Electricity is available in Cyanika but not in Kibingo.

Because Kibingo was settled later than the districts in the eastern part of Karama, the settlement pattern is somewhat different. Most households are scattered over the hills, but some houses are located along the roads (particularly in the southeast) and in groupings in the north. This settlement pattern was chosen to conserve cultivable land. Houses were built on flat hilltops or land unsuitable for cultivation (too shallow, rocky, etc.). The fact that the hills are much steeper in Kibingo than in the research sites in Maraba also forced people to concentrate their dwellings on more level ground.

**Land and tree tenure**

By law, all land belongs to the state in Rwanda. However, farmers have permanent usufruct rights, which can be passed on from father to son. Because usufruct rights are permanent and heritable, farmers consider themselves to have ownership over the land even though they do not have formal title deeds. Officially, land cannot be sold, but due to economic hardship (especially among near-landless farmers) an increasing number of plots is sold surreptitiously. Women do not have rights to land and are not allowed to own it. Widowed heads of
household manage the land of their deceased husbands and can make decisions about its use, but they do not accrue any ownership rights over the land. These women merely function as temporary caretakers for their sons, and when the latter so wish, they may reclaim all land without granting usufruct rights to their mothers. Divorced women are often in a more precarious situation, since they cannot claim even caretaker status for the land and cannot gain access to land independently.

Ownership rights to trees are independent of ownership rights to land. Women cannot own trees, but an exception is made for female heads of household. People justified single women's ownership of trees with the statement that translates roughly as "Women without husbands are men". As single women are equated with men, they can also plant trees and make farm management decisions, something which is not allowed of married women. The latter ruling is due to the fact that the land is owned by the husband. However, local custom does allow married women to plant medicinal and fruit trees on their husbands' land, as it is women's traditional role to feed and care for the family.

2 Since we were not able to obtain a copy of the Communal Development Plan for Karama commune, the information in this section is less detailed and exhaustive than that provided for Maraba.

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Chapter 4

Socio-economic Differences Between tree Experts

Demographic characteristics

One hundred fourteen farmers participated in the second phase of the study. Almost all were married and most were male. Of the females who participated, 60 percent were widowed or divorced and acted as heads of the household. The rest represented their husbands or were acting farm managers for their husbands who had salaried jobs and were mostly absent during the week. The average percentage of female headed households was 19 percent in the comparison group and nine percent in the tree expert group. The actual percentage of female headed households in the region is more accurately reflected in percentages in the comparison group, since the farmers in this sample were chosen randomly, whereas the tree expert group was selected by the ranking game.

Age and years of farming experience: The average age of the tree experts (57 years) was higher than the comparison farmers (45 years). The maximum age of both groups did not differ much, however the minimum age of comparison farmers was 22, but 34 in the expert group. Tree experts had farmed their present land for an average of 33 years, comparison farmers for an average of 22 years. This indicates expertise can be attributed, in part, to
greater experience. Almost all farmers have always lived on the land they presently cultivate. The average consultant established his/her farm unit between the age of 22 to 25.

**Number of children:** The average tree expert is both older than the comparison farmer and has more children. The average tree expert household has 7.3 children, of whom 5.2 are living at home. The average comparison farmer household has 5.1 children, with 4.2 living at home.

There is a significant difference in the number of boys who have moved outside their parents' district. There is little future for many young men as land becomes scarcer due to equal division of land among sons, so many have left the area to seek land or employment (1.2 sons of comparison farmers and 2.5 sons of tree experts). In spite of the generally large farm sizes, migration is particularly high in Kibingo, where sons have left 20 percent of comparison farmer households and 45.5 percent of tree expert households.

Division of land takes place when sons get married, not when the male head of the family dies. From the average age of farmers and the mean age at which sons establish their own farms, it is apparent that farm sizes will start to decrease when the male household head is between 45 and 50. The total amount of farm land owned may decrease even though there still may be a need to cultivate all of the land to feed the remaining family members. The dynamic of farm sizes engendered by this inheritance system may have important implications for agroforestry development.

**Education**

About 70 percent of the male heads of household in both groups have an average of four years of primary education, slightly higher than average for the area. A number of farmers, especially in Maraba and Simbi, reported completing about three years at vocational schools.

Education of women and girls in Rwanda is generally much lower than for men and boys. Only two of 14 female heads of household among the comparison farmers and one of four in the tree expert group had received primary education.

Fifty-one percent of the wives of comparison farmers and 31 percent of the wives of tree experts attended primary school, much higher than for female heads of household.

**Employment and community functions**

Although salaried employment and non-paid community functions offer stature in the community and access to additional resources that help overcome dependency on farming, there is a near-absence of employment in the rural areas to absorb the surplus labour available. Five farmers (all men) said they also had regular salaried jobs at the time of the research. Five comparison farmers and ten tree experts indicated they had held jobs in the past. The number with non-paid community functions was higher (five comparison farmers, eight tree experts), although the number of community function holders among tree experts has decreased as older farmers have retired from active involvement in the community.

Families also acquire additional resources through the salaried jobs of their children, although children with jobs do not always help their parents. Nearly one-third of tree experts reported that they had at least one child with a salaried job but only 5.7 percent of the comparison farmers. Although the farmers in the comparison group were generally poorer, younger and
had smaller holdings, three out of four said their employed children helped. In the expert group, only half the farmers said their employed children provided help. Often, these children were married and had their own families, plus a large number had moved outside their parents’ districts, making them feel less obliged to help.

**Resources: farm labour**

The question of whether farmers work for other farmers resulted in a mirror image of the question about hiring labour, with 37.7 percent of comparison farmers but only 9.1 percent of tree experts stating that they worked as labourers for other farmers.

**Resources: land**

Almost all of the farmers (98 percent) said they had sufficient labour to carry out all agricultural tasks. Whether or not this was actually the case, or whether farmers did not understand the question is not clear, because 34 percent of the tree experts sometimes hire farm labourers. A smaller number (8.5 percent) in the comparison group also hire labour.

The results of the ranking game indicate that farm size is an important determinant for separating farmers according to their level of knowledge about trees and tree cultivation.

Farm size: There is a significant difference in the farm sizes of comparison farmers (0.18 ha average) and tree experts (1.27 ha average). In both groups, farm sizes were largest in Kibingo (0.24 ha and 2.17 ha in the comparison farmer and tree expert groups respectively). In Maraba and Simbi, the maximum did not exceed 1.0 ha, even among tree experts. The smallest farms encountered were around 200 square meters, which is barely enough to build a house and have a small kitchen garden, let alone cultivate enough food to feed a family.

The larger farm sizes in Kibingo need to be qualified. Many Karama farmers obtained land grants at the time of Independence, which were usually larger in size than the average farm at that time. The largest farms were mainly in the northern part of Kibingo, where much of the land is not suitable for cultivation. Many of these farms had not been subdivided among sons for their inheritance at the time of this study and retained their original size. Thus, many of the Kibingo farmers with two or more hectares only cultivate a small portion and leave the remainder in pasture or in woodlots. In contrast, comparison farmers and the majority of tree experts in Maraba and Simbi obtained their land through inheritance and much of it has been subdivided since they started farming it.

Access to valley bottom land, which can be cultivated year-round, is especially important for small farmers, for whom a harvest of sweet potatoes is a welcome addition during the dry season. Less than two-thirds of the comparison farmers cultivate valley land compared to 91 percent of tree experts. Almost all indicated they owned the valley land they cultivated. Only one comparison farmer and five tree experts lease the valley land. Comparison farmers own and cultivate smaller pieces than tree experts.
TABLE 5: TOTAL FARM SIZE, VALLEY LAND CULTIVATED AND OWNED, AND SIZE OF VALLEY BOTTOM LAND

Note: 1 are = 0.01 hectare

SOURCE: den Biggelaar 1994

**Land tenure:** Almost all comparison farmers, 95.7 percent, obtained land through inheritance compared to 61.4 percent in the tree expert group. However, 18 tree experts (43.2 percent) received their land as a gift from the authorities compared to five in the comparison group. Two farmers reported having purchased their land.

The low number of land purchases is due to the fact that all land belongs to the State. Although families/clans are granted permanent usufruct rights which resemble ownership, it is not legal and people do not have official title to the land.

**Land leasing:** In contrast to the near absence of a market to buy and sell land, there
is an active market in leasing land. Leasing allows farmers access to land in different micro-
ecological niches not found on their own farms. Few comparison farmers (10 percent) lease
land to other farmers, as most have small farms. Among the tree experts, 27.3 percent rent
land to other farmers. In both groups, about one-third reported renting land from other
farmers.
### TABLE 6. MEAN, MINIMUM AND MAXIMUM NUMBER OF FIELDS ACCORDING TO THEIR MAIN USES, AND NUMBER OF CONSULTANTS REPORTING HAVING A PARTICULAR FIELD TYPE

<table>
<thead>
<tr>
<th></th>
<th>Comparison farmers</th>
<th>Tree experts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>KIDINGO</td>
<td>MARABA</td>
</tr>
<tr>
<td><strong>NUMBER OF CROP FIELDS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>3.9</td>
<td>3.4</td>
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<tr>
<td>Standard Deviation</td>
<td>1.7</td>
<td>1.9</td>
</tr>
<tr>
<td>Minimum</td>
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<td>1.0</td>
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<tr>
<td>Maximum</td>
<td>11.0</td>
<td>7.0</td>
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<tr>
<td>no.</td>
<td>35</td>
<td>17</td>
</tr>
<tr>
<td><strong>NUMBER OF BANANA FIELDS</strong></td>
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<td></td>
</tr>
<tr>
<td>Mean</td>
<td>2.2</td>
<td>1.6</td>
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<tr>
<td>Standard Deviation</td>
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<td>0.6</td>
</tr>
<tr>
<td>Minimum</td>
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<td>1.0</td>
</tr>
<tr>
<td>Maximum</td>
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<td>3.0</td>
</tr>
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<td>no.</td>
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<td>15</td>
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<tr>
<td><strong>NUMBER OF COFFEE FIELDS</strong></td>
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</tr>
<tr>
<td>Mean</td>
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<td>1.5</td>
</tr>
<tr>
<td>Standard Deviation</td>
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<td>0.7</td>
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<tr>
<td>Minimum</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Maximum</td>
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<td>3.0</td>
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<tr>
<td>no.</td>
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<td>13</td>
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<tr>
<td><strong>NUMBER OF FIELDS IN PERMANENT PASTURE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>2.2</td>
<td>1.0</td>
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<tr>
<td>Standard Deviation</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Minimum</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Maximum</td>
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<td>1.0</td>
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<td>no.</td>
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<td>1</td>
</tr>
<tr>
<td><strong>NUMBER OF FALLOWED FIELDS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>1.5</td>
<td>-</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.9</td>
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<td>-</td>
</tr>
<tr>
<td>Maximum</td>
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</tr>
<tr>
<td>no.</td>
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<tr>
<td><strong>NUMBER OF WOODLOT FIELDS</strong></td>
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</tr>
<tr>
<td>Mean</td>
<td>2.3</td>
<td>1.0</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>2.0</td>
<td>-</td>
</tr>
<tr>
<td>Minimum</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Maximum</td>
<td>8.0</td>
<td>1.0</td>
</tr>
<tr>
<td>no.</td>
<td>23</td>
<td>8</td>
</tr>
</tbody>
</table>

**SOURCE:** den Biggelaar 1994

**Fragmentation of holdings:** Each farm is divided into fields at various distances from the home compound and not necessarily contiguous. A field is defined as a unit of land with
distinct management characteristics cultivated for a particular purpose, i.e. food crops, bananas, coffee, permanent pasture, fallow and woodlots. The banana fields are planted with fruit and medicinal trees, condiments, tobacco and foodcrops, but are so-named because bananas form the dominant overstory. There are also isolated banana trees on the food crop fields. Mixed cropping is practised on both types of fields. Banana fields are located closest to the home compound, while woodlots are the farthest. The difference between fallow and permanent pasture is only a matter of the length of time in which a field is left to regenerate. Fallows often last only one season, particularly on the smallest farms, and the vegetation on the falls consists of weeds and low quality grasses.

Comparison farmers have an average of 12.7 fields averaging 142 square meters. The large number of fields indicates both farm fragmentation and intensive micro-management of the land to take advantage of variations in soil conditions, slope and aspect. Tree experts have an average of 17.2 fields averaging 738.4 square meters. Almost all farmers in this group indicated having fields with food crops, bananas, coffee, and trees.

In both groups, pastures and falls were being shortened and/or abandoned altogether, because as farm sizes diminish, all land is needed for crop production. Converting fallow and pasture land to crop land also means less fodder which leads to a decreasing manure supply. Soil fertility thus suffers from shortened or abandoned falls and pastures as well as from diminishing manure supplies.

Soils: Two soils could be specified for each field type. The names of the soils that farmers gave were the Kinyarwanda names. The table below provides an overview of the main characteristics of the soils found in the three districts of this study.

Farmers soil preferences for particular crops are not absolute because not all farmers have fields with desired soil types. In general, urusenyi was the most preferred soil type, followed by mugugu; both these soils were used for food crops, bananas and coffee. Mugugu soils and less desirable soils such as inombe, umusenga and igishonyi, were the most common soils under pasture, fallow and woodlots. Very few people were cultivating urunombe soils.

**TABLE 7. MAJOR CHARACTERISTICS OF SOILS COMMON IN SOUTHERN RWANDA**

<table>
<thead>
<tr>
<th>% sand</th>
<th>% &gt; 2 mm</th>
<th>% loam</th>
<th>% clay</th>
<th>% org. matter</th>
<th>Avg. pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urubuye</td>
<td>54.2%</td>
<td>51.6%</td>
<td>16.0%</td>
<td>29.8%</td>
<td>2.76%</td>
</tr>
<tr>
<td>Urusenyi</td>
<td>58.3%</td>
<td>40.4%</td>
<td>11.5%</td>
<td>30.1%</td>
<td>2.60%</td>
</tr>
<tr>
<td>Umusenga</td>
<td>60.8%</td>
<td>7.8%</td>
<td>11.2%</td>
<td>28.0%</td>
<td>1.64%</td>
</tr>
<tr>
<td>Igishonyi</td>
<td>46.4%</td>
<td>22.5%</td>
<td>14.7%</td>
<td>16.4%</td>
<td>1.98%</td>
</tr>
<tr>
<td>Urunombe</td>
<td>44.8%</td>
<td>14.1%</td>
<td>12.3%</td>
<td>43.0%</td>
<td>2.13%</td>
</tr>
<tr>
<td>Mugugu</td>
<td>55.4%</td>
<td>12.4%</td>
<td>8.3%</td>
<td>35.3%</td>
<td>1.91%</td>
</tr>
</tbody>
</table>

**SOURCE:** ISAR 1991

The choice of soil for a particular crop depends on location, slope, aspect and distance from the home compound. For example, people do not plant bananas at the fringe of their land even
if the soil is optimal because of the risk of theft if they are out of sight. Such land was used for woodlots. The matter is even more complicated because there is much variation within each soil type, even though it still is called by the same name (the data for each soil given in Table 7 are averages calculated from a number of samples of each soil type taken in a Département d'Etudes de Milieu et des Systèmes de Production (EMSP) of ISAR study. Also, due to the mountainous nature of the Rwandan landscape, soils can vary greatly even over a short distance.

These soil variations explain in part the active market in leasing land in order to gain access to plots of land with slightly different conditions. The high number of fields and their seemingly fragmented nature provide access to an array of sites with diverse soil and ecological conditions which can be managed (as much as possible) as homogenous units.

**Resources: animals**

Animals, especially cattle, are an important part of Rwandan farming systems. Traditionally, cows not only had symbolic value, they were a sign of wealth. Today, cattle are still a sign of wealth but are also a source of manure. Having cattle means being able to maintain soil fertility and, thus, good harvests. In the ranking games, animals were mentioned more than farm size to differentiate good and highly-knowledgeable farmers from others.

The results of the socio-economic survey confirmed the findings of the ranking games. Fewer comparison farmers possess animals (71.4 percent of comparison farmers compared to 90.9 percent of tree experts), and even if they have animals they have fewer than the tree experts.

Only 20 percent of comparison farmers have cattle, on average one cow per farm, compared to 63.6 percent of tree experts with an average of slightly more than two cows. Pigs are the most common animal, followed by goats. Sheep are the least popular of the larger domestic animals but are kept as companions for cows, since farmers believe sheep make cows more docile and easier to handle. They are not kept for meat since, according to local preferences, it does not taste as good as goat or beef.

Chickens and rabbits are not widespread, even though they are not land dependent. Bee keeping is practised by a small number of farmers, principally for honey. Honey gets a good price on the market and is also used to produce mead and to make sorghum and banana beer sweeter and more alcoholic.

Animals' presence on the farm does not necessarily mean that farmers own them. As in the case of land, animals can be leased. A farmer is obliged to take care of a leased animal but has the benefit of manure and milk. Animal owners without sufficient pasture land can maintain ownership while leasing their animals to other farmers who feed and take care of them.

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8 The total area cultivated, however, may be enhanced by renting or borrowing land from other farmers to make up for the lost amount of owned land. As is discussed later in this chapter, renting and borrowing land is common in the study areas.
In contrast, people in the Buberuka Highlands in northern Rwanda rear and eat sheep on a larger scale than farmers in southern Rwanda.

Chapter 5

Farmers' Perspectives on Indigenous Agroforestry Practices

Photographs taken in Rwanda in the early years of this century show landscapes almost devoid of trees—a stark contrast to the present. The combination of farmers’ efforts and external pressure to plant more trees has resulted in an increase in the number of trees in the landscape and affected the agroforestry systems found in Rwanda today. In order to get a more specific picture of those agroforestry systems, this chapter presents the results of community and focus group interviews with both male and female farmers about on-farm tree cultivation practices in relation to farm size, gender and crops.

Agroforestry: historical and contemporary viewpoints

According to the literature, agroforestry is a traditional land use system in many African countries, but participants in the community and focus group interviews expressed contradictory opinions as to whether or not agroforestry is traditional in Rwanda.

The majority of those present at the interviews said that agroforestry was not practised in the past because:

- people had no interest in planting trees, as they could be found freely on the hills;
- suitable trees did not exist;
- even if farms had trees, they were strictly separated from the crops; and v people did not know the importance of trees and tree planting.

Over time, farmers have learned the importance of trees and have incorporated trees in their farm systems. The participants agreed that agroforestry is possible, but that integration of trees, crops and animals depends on the species and their location and arrangement. In their opinion, all indigenous trees and a number of exotic fruit trees can be used for agroforestry, as they are less competitive with crops.
How farmers view trees species for agroforestry systems

Species that work well:

- Euphorbia tirucalli, Dracaena afromontana and Synadenium grantiifor fences around the fields and as boundary markers; the first two can also be used for the construction of the home compound. v Senecio mannii planted between crops brings "freshness"* to the fields and can be used as live staking material for beans and yams.

- Carica papaya, Euphorbia tirucalli, Markhamia lutea, Vernonia amygdalina, Tetradenia riparia, Ricinus communis, Coleus kilimandschari can be planted on the anti-erosion ditches and associated with all crops.

- Ficus thonningii, Markhamia lutea, Tedradenia riparia, Vernonia amygdalina, Erythrina abyssinica, Citrus aurantium vulgare, Citrus limon, Cajanus cajan, Ficus vallis-choudae, Botryocline ugandensis, Ricinus communis, Nicotiana tabacum (wild tobacco), Sesbania sesban and Ocimum suave are all compatible with crops and can be planted in a variety of arrangements, including integration within the field.

- Sesbania sesban, Cajanus cajan and indigofera indica are especially compatible with leguminous crops (beans, soybeans and peas).

Species considered problematic:

- Most exotic trees are considered unsuitable for agroforestry as they are too competitive or damage the soil.

- Eucalyptus sp. is considered the worst in terms of damaging soils. It provides a multitude of products, but can not be grown on small farms because its risks are too great. Farmers have learned from experience not to plant Eucalyptus in and around their fields. Eucalyptus is so widespread that some younger farmers referred to it as an indigenous tree species. Cedrela serrata and Leucaena leucocephela were mentioned as exceptions v Avocados damage crops in a circle of up to eight meters around the base of the tree but because they provide food, income from the sale of surplus fruits, and occasional fuel wood, it is considered possible to plant two or three avocado trees since the production of avocados far outweighs the production of food crops lost.

- Grevillea is widely planted on Rwandan farms as boundary markers, windbreaks, to stabilize terraces and in woodlots but as Grevillea grows larger farmers experience negative effects. Food crops growing close to the trees dry out, which farmers attribute to increased leaf fall and slow leaf decomposition. Grevillea leaves are used as mulching material under coffee bushes. However, there are negative effects from large Grevillea trees growing next to coffee fields, because of shading and competition for water and nutrients in the soil.

*The word that was used by the person who translated the tape of this meeting was fraîcheur, it is not known whether this means fertility or shade and coolness
A minority of interview participants stated that they had practised agroforestry in the past when the soils were still fertile and yields could be obtained from less land, leaving more space for tree cultivation. However, the trees that were found and maintained on the farm in the past were not planted but occurred naturally, seeded by birds or left from abandoned home compounds. Thus, farmers practised passive agroforestry. They were not actively engaged in planting and integrating trees with crops or pastures on their land. The examples they cited were the maintenance of naturally-occurring Sesbania sesban, Markhamia lutea, Ricinus communis and Indigofera erecta within crop fields and the maintenance of trees as indicators of property borders. As soil fertility declined and population increased, more land was needed for crop production and gradually trees were eliminated. The stories related by these farmers implied that agroforestry is only possible on fertile soils and is not seen as a means to restore fertility, one of the main selling points of agroforestry by projects in Rwanda.

In the discussion in the next sections, more information will be given about the reasons farmers plant trees and the relationships between tree planting and gender, farm size and field type.

**Reasons for practising agroforestry**

Farmers cultivate a wide variety of trees mainly because of what the trees provide, i.e. fuelwood, medicines, timber, stakes, etc. Preference for a certain species, individual knowledge of trees and enthusiasm for planting trees were rarely mentioned.

All consultants agreed that having many species is advantageous, because of the many problems farmers face, particularly medical problems. In order to avoid travelling long distances to find a plant when a family member or an animal is sick, farmers plant various trees in combination with crops as a precaution. As will be seen later in this chapter, the variety of tree species found on the farms studied is primarily due to the large number of species planted for medicinal uses. In most households, a number of woody species are used as a "family pharmacy" which becomes more elaborate and extensive as knowledge of healing practices increases. During the biography interviews, several tree experts mentioned that they had introduced species on their farms after being treated by a healer using that particular species.

**Tree planting and gender**

Women are primarily responsible for household food production in Rwanda but custom does not allow them to plant trees. An exception is made for fruit and medicinal trees, both of which increase household food security and well-being. By considering that fruit trees are food crops instead of trees, women have been able to circumvent the traditional ban on tree planting. Several women explained that they could also sell fruits on the market in order to buy foods they did not produce in sufficient quantity (particularly beans) and household necessities such as soap, cooking oil and salt.

The question of whether or not women could plant trees generated much discussion among group interview participants. This appeared to be unrelated to any cultural taboos but more to the fact that, as in much of Africa, the act of planting a tree establishes ownership of the land on which it is planted. This was confirmed by the statement that women can plant trees, but the trees they plant belong to their husbands because the land on which they are planted belongs to their husbands. Thus, in Rwanda, inheritance rights override rights to land that the
simple act of planting trees would establish, at least if these trees are planted by women. In addition, almost all land in Rwanda is being used, so the custom of establishing ownership through tree planting has all but disappeared.
**Women and Tree Planting**

It is customary for men to plant trees and for older men in particular. The idea of women planting trees is inconceivable.

**The men say:**

1. Women have a short-term perspective and prefer crops that occupy the soil for a short time and produce something edible.

2. Women cannot forecast the utility and value of trees.

3. Women have no time for trees because of household chores, child rearing and cultivating food crops.

4. Women lack strength.

5. There is not enough land. Even though women want to plant trees on the fields they manage, the small size of the fields makes it impossible to plant even a single fruit tree because the competition with food crops would be too great.

**The women answer:**

1. Women have arms also.

2. Women can project the utility of trees in the future as well as men.

3. Women's responsibility for the family's food security is the main reason women should plant trees that produce fruit, condiments or species, because these trees help attain and increase food security.

The notion expressed by some men that women do not have time and prefer to use the land for short duration food crops was also not supported by women. Although one of the men explained his objections in very strong terms—....

Normally, the planting of trees requires a lot of strength, for example to dig the plant holes when the soil is hard or to transport 30-40 seedlings over a long distance from the nursery to the house. These activities, as well as others, demand a lot of effort that women are incapable of providing. On the other hand, Rwandan men cannot, for example, sweep the house, cook and wash the dishes other than in an emergency. However, as these activities are important, men want women to take care of these chores while the men take charge of the outside activities considered difficult for women, including tree planting. In my opinion, this is the reason why women do not plant trees.

....some shifts are occurring in traditional role patterns. Two persons (supported by several others) mentioned that nowadays husband and wife often help each other with various agricultural tasks on the farm, including tree planting and management.
Even though there is (no longer) a formal prohibition against women planting trees, women are not allowed to plant forest trees or trees that grow tall unless it is National Tree Planting Day, if they are widowed or divorced, or if their husbands are absent or sick. In effect, a woman without a husband is considered a man.

A number of people who were interviewed also stated that many species on the farm were planted by the husband at the suggestion of his wife because she felt it necessary to have certain species to maintain the health of the children and to diversify the food supply. But this was rarely admitted. In fact, it was said that "man appropriates all that is done by a woman".

**Tree planting possibilities in relation to farm size**

Farm size appears to be related to both number of trees and species diversity. During the community interviews, two questions were asked about the possibility of practising agroforestry in relation to farm size: (1) Is agroforestry possible for farmers who have little land? and (2) What will be the effect of decreasing farm sizes on tree planting in the future?

Participants in the meetings not only discussed the problem, but proposed several solutions ranging from simple (better arrangements for crop/tree integration) to radical (regroup people in villages and redistribute the freed land).

The majority of participants agreed that either food crops or trees can be planted on a small piece of land but not both. If the choice is between trees and crops, one woman explained, she would choose crops because you cannot feed trees to a hungry child. In her opinion, trees on small holdings may lead to chronic malnutrition. Almost everyone present agreed that it is not possible to plant trees on a small farm, as trees are incompatible with crops and damage the soil.' In the farmers' experience, once trees are introduced, crop yields will visibly decrease. Even bananas, a traditional staple widely cultivated, particularly for the brewing of banana beer (urwagwa), were mentioned as hindering the normal development of associated crops such as sorghum and beans. In the farmers' opinion, all trees damage the soil because all trees have roots and give shade. Damage to the soil refers primarily to trees' negative effects on soil fertility, even though some species (particularly mentioned were papaya, orange and guava) are less damaging than others.

A majority of farmers did not see the possibility for planting more trees on their farms, as most of their parcels are already very small and decrease with every generation. The following quote from one participant summarizes the opinions of many:

They have forced us to plant trees in our small holdings instead of planting them in uninhabited areas. My son has to have a piece of land as his inheritance and for his survival. Therefore, I do not see how this land can suffice for my son, his brother and myself if, in addition, we have to practice reforestation. We thought that you (the researcher) were going to redistribute the trees planted here and there. We do not see any other possibilities.

Others, primarily men, were more optimistic, and considered agroforestry the only way to have tree products in the future despite the negative effects of trees on their soils. Much depends, in their opinion, on the proper arrangements (the best place, according to the audience would be along the anti-erosion ditches) and choice of species with the least negative influence on soil and crop production. Wives were not so supportive of their
husbands' ideas for increasing the number of trees on the farm, since, in their opinion, agroforestry would only further decrease yields.

The future of farming and agroforestry: solutions proposed by the audience

Participants in the group interviews not only discussed the difficulty (if not impossibility) of practising agroforestry on small farms and the uncertain future of agroforestry because of diminishing farm sizes, but also offered both land-based and tree-based solutions.

Land-based solutions: Although the inheritance system and population growth were acknowledged as the primary forces behind decreasing farm sizes and farm fragmentation, the audience did not offer concrete suggestions of what to do about it. People with large farms were urged to reserve some land for a woodlot, while the State could redistribute the state and communal forests to provide families with small farms with small pieces of land for planting trees. Another suggestion was for the State to increase the land holdings of each family so that each family would have an equal piece of land. This would require reform of the land tenure system. But even if this could be done for the present generation of farmers, they had not thought how it would affect future generations as not all families have equal numbers of sons to inherit the land. Redistribution of land to provide equal amounts of land to each family would, therefore, only be a temporary cure.

The most radical solution proposed was for collective farming; making the State the sole land owner with a simultaneous regrouping of people to live on the least fertile places:

The State must look for means to house people on the least fertile areas and reserve the good land for agriculture and trees. We notice that the forest has been planted on the good soil and the farmers live on the crests of the hills. An example is the Nyarucyamu and Nyarurembo forests where the trees are planted on good soil. These forests have to be divided among the people to practise agriculture. Another forest can be planted on the crests of the mountains. Alas! The land where the forest of Rugarama is located could feed a thousand people!

Tree-based solutions: Solutions in this category stressed the importance of planting trees that are less competitive, do not damage the soil and can be grown together with crops so that the harvests will be sufficient to feed the family. Participants suggested limiting competition by planting trees on the home compound, along the anti-erosion ditches or as hedges around the property. It should be noted that some of these arrangements were already being used. One participant suggested that people could specialize; one farmer could grow trees, another bananas and other food crops, and subsequently they would exchange their harvests.

In each of the thirteen meetings, participants called on the government for more research on trees that do not destroy the soil and damage the crops. Some of the older farmers disagreed with this, saying that in the past farmers planted a number of species (such as Euphorbia tirucalli, Markhamia lutea, Ficus sp., and Cajanus cajan) that would be suitable as agroforestry species today. But farmers would like to increase their options, which means trees that are compatible and non-competitive with crops, do not provide too much shade, do not spread roots too far out into the soil, can also be used as live stakes for climbing beans, and produce fuelwood and fruit simultaneously.
Considering the small size of our properties, I have seen trees that resemble Sesbania. These trees grow like Sesbania, but do not have a long growing cycle and do not occupy our soil for a long time. One can plant them in a field of beans, and they can provide support to climbing beans. After the first bean harvest, we weed them and can plant another crop of beans. Normally, they are planted along the anti-erosion ditches. They do not give too much shade and do not damage the crops. They can also be used as fuelwood. They give an abundance of seeds, so that we can multiply the trees ourselves. Researchers must do everything they can in a search for trees which can provide fuelwood and fruit simultaneously on our small farms.

Potential locations of trees within the farm

The objective of this question was to learn more about land tenure and its effect on tree planting and agroforestry. However, participants also included soil and tree characteristics, crops to be grown and, in one case, aspect.

In general, farmers can plant trees on all land except land that is rented, borrowed or land which belongs to the extended family and is managed by its oldest male member; the latter can cultivate this land himself or can loan all or parts to other family members if they have a particular need for extra land. Planting trees on parents’ land is prohibited, even though it is known which piece of land will be inherited, because the land is not yet owned. Similarly, trees can only be planted on land obtained from the municipality if the municipality has given permanent usufruct rights.10 Within the household, women can only plant trees on the location(s) indicated by their husbands or, in case they are widows, by their sons. An exception is trees planted by women during National Tree Planting Day. Thus, even though women cultivate the land intensively, they do not accrue any decision-making rights over that land beyond those associated with seasonal crops.

In addition to tenure, farmers take a number of factors into account in deciding where to plant which species within the farm:

One cannot plant trees in all the fields one cultivates because there is a risk that the trees would compete with the crops. I cannot conceive of a field in which sorghum, Pennisetum, bananas, sweet potatoes, Ficus thonningii and Euphorbia tirucalli are mixed. A certain weighting is essential. For this reason, one uproots some bananas so that the sweet potatoes can grow well.

If there is enough land, separation of crops and trees is the preferred agroforestry arrangement. On large farms, trees are most often planted on infertile pieces of land unsuitable for crops, such as shallow soils, rock outcrops, gravelly soils or soils with a hardpan close to the surface. Small farmers also prefer to cultivate food crops and trees in separate fields but decreasing farm sizes make such separation increasingly impossible and new, more intimate arrangements of trees and crops are becoming necessary. How many trees can be planted in or around fields depends on the crop to be planted, the characteristics of the tree species, and the placement of the trees. Farmers will generally chose to plant trees so as to minimize completion such as planting along the field boundary, to protect against soil erosion such as planting along the contour or along anti-erosion ditches, or to produce a high value product such as fruit trees.
Species diversity in indigenous agroforestry systems

A total of 152 tree species was found on the farms of the 114 study participants. Including trees observed during visits and guided tours of farms undertaken during the ranking game, 193 species were found in the three study areas. This diversity of species is remarkable considering most farmers said that there were no or few trees on the land when they started farming, and there are many more trees now than when they were young. The only farm trees they remember were those planted on the home compound and between the bananas immediately surrounding the home compound, which means all species presently found on the farm have been purposely planted and managed by the farmers in the last two to three decades (most farmers in the samples started farming their land between 1960 and 1970). Many different tree species are planted and maintained to meet the diverse needs for such tree products as fuelwood, poles, lumber, food, fruit, stakes and medicines. While wood needs for fuel and timber can be satisfied with few species, it is necessary to plant many different species to treat the many diseases and parasites from which people and animals suffer. A complete list of all species encountered on consultants’ farms during the ten month research period, giving both the names in Kinyarwanda and their Latin equivalents, is found in the Appendix.

Farm size, species diversity and tree density

In addition to having larger average farm sizes, tree experts have both a greater variety of tree species (34.4 vs. 11.7 species) and a greater total number of trees (929 vs. 304 trees) than comparison farmers (see Table 8). Species diversity is particularly high on the food crop fields and the banana fields of the tree experts with an average of 16.8 and 15.5 species, respectively. However, in spite of a lower number of trees and species on comparison farmers’ land, tree density is more than twice the density found on tree experts’ farms: 1,683 trees.ha⁻¹ (ranging from 1,320 to 2,563) compared to 747 trees.ha⁻¹ (ranging from 632 to 1,407 trees.ha⁻¹). Thus, there seems to be an inverse correlation between land size and tree density. With declining farm sizes, farmers cultivate fewer trees of fewer species, although on small pieces of land, the systems become more complex with a higher degree of integration of trees and crops.

Thus, differentiation in both agroforestry systems and agroforestry knowledge can be observed between the two groups of farmers.
**TABLE 8: MEAN NUMBER OF TREES PER SPECIES, MEAN NUMBER OF SPECIES, AND MEAN NUMBER OF TREES PER FARM AND PER HECTARE**

<table>
<thead>
<tr>
<th></th>
<th><strong>Comparison farmers (no. = 70)</strong></th>
<th><strong>Tree experts (no. = 44)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RUGO</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean no. trees per species (sd)</td>
<td>15.0 (36)</td>
<td>10.0 (24)</td>
</tr>
<tr>
<td>Maximum no. of trees</td>
<td>300</td>
<td>210</td>
</tr>
<tr>
<td>No. farmers</td>
<td>65</td>
<td>44</td>
</tr>
<tr>
<td>Mean no. species on block</td>
<td>4.9</td>
<td>8.0</td>
</tr>
<tr>
<td><strong>FOOD CROP FIELDS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean no. trees per species (sd)</td>
<td>20.0 (48)</td>
<td>15.0 (36)</td>
</tr>
<tr>
<td>Maximum no. of trees</td>
<td>460</td>
<td>371</td>
</tr>
<tr>
<td>No. farmers</td>
<td>69</td>
<td>33</td>
</tr>
<tr>
<td>Mean no. species on block</td>
<td>6.0</td>
<td>15.8</td>
</tr>
<tr>
<td><strong>BANANA FIELDS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean no. trees per species (sd)</td>
<td>* * *</td>
<td>14.0 (30)</td>
</tr>
<tr>
<td>Maximum no. of trees</td>
<td>230</td>
<td></td>
</tr>
<tr>
<td>No. farmers</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>Mean no. species on block</td>
<td>15.5</td>
<td></td>
</tr>
<tr>
<td><strong>WOODLOTS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean no. trees per species (sd)</td>
<td>96.0 (208)</td>
<td>71 (184)</td>
</tr>
<tr>
<td>Maximum no. of trees</td>
<td>&gt;500</td>
<td>&gt;500</td>
</tr>
<tr>
<td>No. farmers</td>
<td>30</td>
<td>42</td>
</tr>
<tr>
<td>Mean no. species on block</td>
<td>2.9</td>
<td>8.9</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean no. tree per species (sd)</td>
<td>26.0 (86.0)</td>
<td>27.0 (98.0)</td>
</tr>
<tr>
<td>No. species conserved</td>
<td>816</td>
<td>1544</td>
</tr>
<tr>
<td>Mean no. species on farm (sd)</td>
<td>11.7 (5.6)</td>
<td>34.4 (16.0)</td>
</tr>
<tr>
<td>Mean no. of trees per farm</td>
<td>304</td>
<td>929</td>
</tr>
<tr>
<td>Mean farm size in hectare (sd)</td>
<td>0.18 (0.17)</td>
<td>1.27</td>
</tr>
<tr>
<td>Mean no. of trees per hectare (range)</td>
<td>1689.0-1329-2564</td>
<td>731.0-636-1408</td>
</tr>
</tbody>
</table>

**SOURCE:** den Biggelaar 1994
<table>
<thead>
<tr>
<th>Utilization</th>
<th>Total no. of species used</th>
<th>Most important species*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuelwood</td>
<td>60</td>
<td>Grevillea robusta, Eucalyptus sp., Vernonia amygdalina, Euphorbia tirucalli, Cupressus sp., Acanthus pubescens, Ficus thonningii</td>
</tr>
<tr>
<td>Construction poles</td>
<td>27</td>
<td>Eucalyptus sp., Grevillea robusta, Cupressus sp., Vernonia amygdalina</td>
</tr>
<tr>
<td>Timber ry</td>
<td>28</td>
<td>Grevillea robusta, Eucalyptus sp., Cupressus sp., Ficus thonningii, Euphorbia tirucalli</td>
</tr>
<tr>
<td>Woodworking</td>
<td>23</td>
<td>Ficus thonningii, Euphorbia tirucalli, Persea gratissima, Clerodendrum rotundifolium, Makhania tutea</td>
</tr>
<tr>
<td>Food, fruit, spices</td>
<td>32</td>
<td>Persea gratissima, Psidiumguajava, Coffea sp., Capsicum frutescens, Carica papaya</td>
</tr>
<tr>
<td>Mulch</td>
<td>30</td>
<td>Grevillea robusta, Eucalyptus sp., Pavetta ternifolia, Acanthus pubescens, Pinus sp.</td>
</tr>
<tr>
<td>Yeast for beer</td>
<td>13</td>
<td>Vernonia amygdaiina, Euphorbia tirucalli, Vernonia sp.</td>
</tr>
<tr>
<td>Fodder</td>
<td>32</td>
<td>Ficus thonningii, Vernonia amygdalina, Acanthus pubescens, Draceana afromontana, Leucaena leucocephela</td>
</tr>
<tr>
<td>Stakes</td>
<td>43</td>
<td>Grevillea robusta, Cupressus sp, Acanthus pubescens, Vernonia amygdalina, Eucalyptus sp, Clerodendrum johnstonii/fuscum</td>
</tr>
<tr>
<td>Medicines</td>
<td>106</td>
<td>Vernonia amygdalina, Euphorbia tirucalli, Tetradenia riparia, Synadenium grantii, Clerodendrum johnstonii/fuscum, Clerodendrum fuscum, Vernonia sp</td>
</tr>
<tr>
<td>Fencing</td>
<td>34</td>
<td>Euphorbia tirucalli, Dracaena afromontana, Ficus</td>
</tr>
</tbody>
</table>
thonningii, Vernonia amygdalina, Cupressus sp., Eucalyptus sp.,

<table>
<thead>
<tr>
<th>Shade</th>
<th>4</th>
<th>Persea gratissima, Acacia sieberiana, Manihot glaziovü, Ficus thonningii</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compost</td>
<td></td>
<td>Tephrosia vogelü, Crotalaria incana, Vernonia amygdalina, Cajanus calan</td>
</tr>
<tr>
<td>Rope</td>
<td>7</td>
<td>Ficus thonningii, Acacia mearnsii</td>
</tr>
<tr>
<td>Carpets/mats</td>
<td>1</td>
<td>Ficus thonningii</td>
</tr>
<tr>
<td>Other</td>
<td>38</td>
<td>Erythrina abyssinica, Ricinus communis</td>
</tr>
</tbody>
</table>

* Bold means species used by more than 50% of tree experts and comparison farmers combined.

**SOURCE:** den Biggelaar 1994

_ The tree experts had extensive experience cultivating a great diversity of tree species and thus were considered the most knowledgeable about trees and tree cultivation in the eyes of their fellow farmers. They followed a strategy in which trees were grown in less intimate associations with crops (most tree species were growing in woodlots), leading to highly diverse but low density agroforestry systems.

_ Comparison farmers had complex systems with low species diversity but a high degree of tree/crop integration in a small space. This demands a greater awareness and knowledge of component interactions and a higher level of management skills to balance the multiple requirements of the family for food and tree products.

In addition to the decreasing number of trees and species diversity with declining farm sizes, there was a shift in planting locations. The larger farms in Kibingo had large woodlots with a greater number of trees than the other two districts, but fewer trees on the home compound. The inverse relationship between number of trees in woodlots and the number of trees on the home compound was particularly noticeable in the comparison group. Overall, fewer than half the farmers in this group had a woodlot, and those who did have woodlots had an average of only three species. However, as woodlots were cleared for land to feed the family or to provide sons with their inheritance, more trees of various species were planted on the home compound where they would not compete with crops.

**Use of tree species**

Most trees are used according to their original intent (i.e. trees planted for fuelwood are used for fuelwood), but are also put to other uses. Some trees are planted for a very specific use, such as for a medicinal product. Even they, however, may be used for other uses. Use pressure increases and the necessity for multipurpose trees becomes more acute as farm sizes decrease. This does not mean that all uses have to be known or that the multipurpose character of a tree species has to be clearly established before it is introduced. Farmers are capable of adapting existing resources for new opportunities. For example, after the introduction of climbing beans in 1987, farmers showed great creativity in producing stakes from existing
tree species (especially from Grevillea robusta, but also from Cupressus lusitanica and Pinus sp.) (Twahirwa, 1992).

An overview of species actually used by farmers for various purposes is provided in Table 9. The table shows that two-thirds of the total number of species inventoried on consultants' farms are used for medicinal purposes (106 species out of a total of 152). The species most commonly used as medicine (Vernonia amygdalina and Euphorbia tirucalli) are also used as fuelwoods by a majority of consultants and, to a lesser extent, as yeasts for brewing beer, for fences and for a number of other purposes. Sixty species are used for fuelwood. By giving an indication of the multipurpose character of species, the table shows that people manage and use a much greater number of tree resources than commonly assumed. The diversity of species is not only the result of what is ecologically possible to produce on the farm with the available resources (many of the species found occupy spaces unsuitable for cultivation which would otherwise remain unused), but it is a deliberate strategy to spread risk in order to meet unexpected events (drought, flooding, hail storms, diseases, etc.) and economic uncertainties.

In Rwanda, as in much of Africa, the State is the sole land owner. Farmers (farm families) are given permanent usufruct rights which can be transferred from father to sons. In practice, farmers interpret the permanent usufruct rights as ownership.

Chapter 6

Farmer Experimentation: Building Knowledge

One of the premises of this case study is that experimentation is a knowledge-building process. It is not a process aimed at designing a specific agroforestry system. When an agroforestry system is created as the result of experimentation, it does not mean the process is completed. As stated in the introduction, agroforestry systems are dynamic and adapt to ecological, economic and social changes. This chapter looks at farmers’ experimental or knowledge-building activities, in terms of how farmers themselves define knowledge.

Previous chapters described how the combined efforts of farmers and outsiders have led to enormous changes in the landscape and created complex agroforestry systems. Farmers have evolved from being primarily exploiters of natural vegetation to active tree planters and managers. Simultaneously, their knowledge has expanded from knowing only the uses of trees to knowing about tree planting and management practices.

The second part of this chapter looks at farmer-based innovations in agroforestry related to these changes. Farmers use experimental methods resembling Western methods for food crops (Richards, 1986 and Box, 1988). But is this also the case for trees, which can take years to mature? Tree cultivation is so interwoven with agricultural production and daily activities that during the guided farm tours and ranking game discussions, consultants could not recall if
they had used a trial period before deciding to adopt a new species. This may have been because farmers had been obliged to adopt many agricultural technologies (i.e. anti-erosion ditches, the planting of Grevillea alongside these ditches, Eucalyptus woodlots and cassava cultivation).

Three processes can be identified through which farmers acquire agroforestry knowledge:

1. The generation of new knowledge through their own experimental efforts.

2. The adaptation of ideas (knowledge and/or technologies) from exogenous knowledge systems. This may or may not involve experimentation.

3. Wholesale adoption of exogenous knowledge and technologies without further adaptation.

There are a number of inter-related activities associated with these processes including decision-making about species choice, farm and field location and planting methods; implementation of a species trial; and evaluation and determination of suitability, usefulness and benefits.

The biographical information about the 44 tree experts was gathered during repeat visits which offered the opportunity to learn how tree cultivation and knowledge-building activities fit into the farmers' lives and which experimental methods they had used when trying new species or tree management practices. However, the case studies did not yield sufficient information about the specifics of farmers' experimentation with trees, so it was decided to set up a species trial in collaboration with the ICRAF/ISAR programme in Rwanda as part of the field research. The ICRAF/ISAR programme provided seedlings or seeds of 15 tree species; some were already widely cultivated in the research areas, and some had not yet been tested on-farm and were unknown to farmers. ICRAF also provided short descriptions in Kinyarwanda of each species and consultants were asked to choose the species they would like to try on their farm on the basis of these descriptions. During the focus group meetings, several questions were asked dealing with consultants' choices, risk associated with testing, experimental methods they intended to use, and evaluation criteria.

**What is knowledge and how is it obtained?**

Discussions identified four factors that have to be present for a person to be recognized as knowledgeable: intelligence, experience, communication and putting information in practice. Being knowledgeable about something means knowing its use, holding its secrets and showing a sustained interest in it. Some considered knowledge to be "natural" (i.e. a gift of God), some stated that it comes from experience, while others felt it comes from being well-informed and having gone to school (although they considered knowledge learned in school "artificial knowledge"). But, whatever the source, a person must use the information to be recognized as knowledgeable. For example in the case of medicine, a person will be recognized as a healer if he or she is capable of curing diseases. Thus, the knowledge of a healer is revealed through his or her actions as a healer. Or, a person who has planted many species of trees and then takes good care of them will be recognized as being knowledgeable about trees.
*Individual versus collective knowledge:* People in the meetings emphasized the differences in their knowledge. In the words of one participant:

> We have diverse knowledge because we do not have the time and place to exchange our knowledge. Having meetings where we could learn from each other would allow us to have collective knowledge.

While some collective knowledge is necessary for any society to function, the person who provided the above information probably referred to agroforestry knowledge in particular. In addition to meetings, another participant stated, "In general, collective knowledge is acquired in the classroom. Beyond that, each of us possesses skills we can exploit in our own individual ways." Based on this premise, there does not appear to be any collective agroforestry or tree knowledge, because such knowledge is not acquired in school.
Why does agroforestry knowledge differ?

Many explanations were given for the different levels of agroforestry knowledge, many of which are beyond the control of the farmers.

..It starts at birth because God does not equip everyone with equal intellectual abilities ... There is a difference in the knowledge passed on by ancestors... Whether someone becomes a carpenter, blacksmith, healer of cow diseases or a farmer depends on education and training provided by parents ... To be recognized as highly knowledgeable or as a specialist depends on how the initial information is used... People differ in character, interests and taste ... Some are more serious in their tree planting activities than others ... Some have a feeling for experimentation and research and are constantly tinkering in search of new knowledge and technologies, others are satisfied with what they have and know ... Economic circumstances affect knowledge ... A large farm offers more opportunity to experiment and acquire knowledge.

There is also the problem that there is not a regular, organized way for individual exchanges of information to take place, as this conversation between a female healer and the researcher demonstrates.

Q: Do you have a collective knowledge of trees, in other words, is your knowledge of trees similar to that of other people?

A: No, it is different. N. treats ifumbi from which his mother suffers. He has his own knowledge about the treatment of this disease and I have mine. But, now we have exchanged our knowledge and we have harmonized our treatment of ifumbi.

Q: But can you confirm to us: Do you know whether other healers treating ifumbi have the same knowledge that you have about ifumbi and its treatment?

A: No! We do not know what they know, as they also do not know what we (i.e. N. and I) know.

Agroforestry knowledge and gender

During the ranking game, an equal number of men and women were asked to rank the other farmers on their colline. The resulting scores of couples were combined because many informants stated that if wives are knowledgeable about trees, their husbands must also be knowledgeable. This may have been because of the traditional belief that women cannot admit they have more knowledge than their husbands (Bucyobukiro, personal communication). In addition, since knowledge was defined primarily as having species diversity on the farm which could only be possible through the efforts of the husband, he must also be knowledgeable about trees. Ranking game results also indicated that the nature of trees and agroforestry knowledge differs between men and women. To confirm this and to determine whether farmers consider men or women more knowledgeable about trees, a deliberately-ambiguous question was asked during the community interviews: "If tree knowledge differs between men and women (men know how to plant and manage trees, women can identify species and know uses of trees), who has the most knowledge of trees? Who are the real experts?". The subsequent discussions on this question were the most
animated and contentious in each of the thirteen community interviews. Table 10 provides an overview of the opinions expressed and the response frequency.

In spite of the fact that 286 men attended these interviews compared to 156 women, the majority said that women are more knowledgeable about trees. They also felt that men's and women's knowledge is not the same.

Men's knowledge relates to big trees (Eucalyptus, Grevillea, Markhamia, etc.), tree planting and management, the introduction of new species and/or varieties of trees, and the decision-making aspects of species choice, place, planting times and harvesting (i.e. cutting of the whole tree). Women's knowledge is confined to species identification, naming of species, and the use and harvesting of tree products such as yeasts for brewing beer, seasoning, medicine, fuelwood and love potions. As knowledge of the use of trees, particularly for medicinal purposes, is highly valued and as women are especially skilled in human healing practices, women were considered more knowledgeable about trees than men. However, there were men with extensive knowledge of healing plants and practices and there were women who knew nothing about them. Knowledge depends on intelligence obtained at birth, education, training by parents and interest in discovering and learning new things. Since these factors vary with individuals, regardless of gender, there are knowledgeable and non knowledgeable persons in each group.

Is knowledge about trees essential for tree planting and agroforestry activities?

Consultants were equally divided on the question of whether prior knowledge about a new species or practice is necessary to practice agroforestry. For traditional (i.e., indigenous) tree species cultivated by ancestors and inherited with the land, no additional knowledge is necessary as people observe them from early childhood. For newly-introduced, exotic trees, people need instruction because "you cannot plant a tree
### TABLE 10: FREQUENCY OF STATEMENTS ABOUT AGROFORESTRY KNOWLEDGE AND GENDER

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Statements about men being more knowledgeable</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Men (no further explanations given)</td>
</tr>
<tr>
<td>3</td>
<td>Men have more knowledge because of their more frequent travels from which they bring back new species</td>
</tr>
<tr>
<td>3</td>
<td>Men, because they dig the holes and do the planting</td>
</tr>
<tr>
<td>3</td>
<td>Men know more about tree planting, maintenance, etc.</td>
</tr>
<tr>
<td>2</td>
<td>Men know the different species better than women</td>
</tr>
<tr>
<td>1</td>
<td>Men are more important</td>
</tr>
<tr>
<td>1</td>
<td>Men have more knowledge of big trees</td>
</tr>
<tr>
<td>1</td>
<td>Men have more knowledge in general, but women know more about medicinal plants</td>
</tr>
<tr>
<td>1</td>
<td>Men plant trees without caring much about their utility</td>
</tr>
<tr>
<td>1</td>
<td>Men are more active in searching for new species</td>
</tr>
<tr>
<td>1</td>
<td>Men, as they are responsible for their land and what is planted on it</td>
</tr>
<tr>
<td>1</td>
<td>In Rwandan tradition, men take care of all aspects of tree cultivation</td>
</tr>
<tr>
<td>1</td>
<td>It is men who cut the trees, sell them and make objects from them</td>
</tr>
<tr>
<td>1</td>
<td>Those who plant the trees (i.e. men) know their utility better than women</td>
</tr>
<tr>
<td>24</td>
<td>Total number of statements favoring men</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Statements about women being more knowledgeable</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>Women have more knowledge of medicinal trees, their preparation and use</td>
</tr>
<tr>
<td>7</td>
<td>Women are the first to know the utility of trees, but men also have their knowledge</td>
</tr>
<tr>
<td>6</td>
<td>The general conclusion is that women have a greater knowledge of trees (including aroid trees) than men</td>
</tr>
<tr>
<td>3</td>
<td>Women know more about species identification and species names</td>
</tr>
<tr>
<td>3</td>
<td>Men only plant the trees, but women have more knowledge of them</td>
</tr>
<tr>
<td>3</td>
<td>Girls are trained from a young age in the healing arts by being asked to gather the necessary plants and by observing their preparation</td>
</tr>
<tr>
<td>2</td>
<td>Women (without further explanations)</td>
</tr>
<tr>
<td>2</td>
<td>Women have more knowledge about trees, more than men</td>
</tr>
<tr>
<td>2</td>
<td>Women know plants for yeast, seasoning, etc.</td>
</tr>
<tr>
<td>1</td>
<td>Women are normally the doctors, if they do not know the right medicine, they will ask other women</td>
</tr>
<tr>
<td>1</td>
<td>It is women who harvest the medicinal plants shown by other women</td>
</tr>
<tr>
<td>1</td>
<td>Women know more about the qualities of fuelwood</td>
</tr>
<tr>
<td>43</td>
<td>Total number of statements favoring women</td>
</tr>
</tbody>
</table>
which you have just seen for the first time”. Thus, with new species, farmers need information about (1) the utility of a species, (2) method of propagation and where and how to plant it and (3) where to obtain the necessary seeds, seedlings or cuttings. Other farmers, especially neighbours, were cited most frequently as information sources:

One plants a tree species because one has seen its utility for a neighbour. Until now, we have not planted trees without first learning about their utility. But there are recently-introduced species, such as Pinus and others, which we planted after we heard talks about their utility and the beauty of its lumber.

Farmers also become interested just by hearing about the benefits of certain new technologies. However, according to this Rwandan proverb:

A second group of consultants maintained that farmers can cultivate a new species without prior knowledge of its name, planting and management methods or its utility. The necessity of prior knowledge depends on personal preferences, individual spirit of research, the amount of risk s/he is willing to take, imagination of possible future benefits plus the aspect and physical form of the tree. This group of consultants was willing to take risks and look for new technologies that might contribute to a better livelihood. They all said that it was possible to discover the benefits of a species during growth or after its harvest. If the tree did not meet expectations, it could be cut and replaced with another species. It was also a source of pride to leave something new for posterity or to provide a showcase for neighbours who could try the innovations on their farms. For the majority of the population, observing what neighbours or friends have done and asking for information in order to follow their examples remains a powerful motivation to adopt new technologies:

If we notice a certain tree is useful for a neighbour, we introduce this tree on our own farms and then pass on the knowledge. This happened with the introduction of fruit trees, coffee, and eucalyptus in our region. Even before we had agricultural officers and extension workers to help us, we always followed examples.

The importance of neighbours and friends as a source of knowledge and new ideas is also expressed in the following Rwandan proverb:
Taking risks and learning

These three consultants offered anecdotes to illustrate why it is a good habit to take a risk and try new species without any prior knowledge in order to learn something new.

Consultant 1: One day I went to Butare. I stopped at Rwabuye to rest a bit when I saw a plant that I did not know but fell in love with. I uprooted it and the next day I planted it on my farm. I learned later that it was a guava tree which was not known in my region when I planted it. Therefore, it is possible to plant a tree without knowing its name or its utility.

Consultant 2: Walking in a forest, I came upon gapeli (Physalis peruviana) plants. I observed them with a lot of curiosity. One day, I bought their seeds from a boy for 15 ERw. I planted them among my coffee trees. After a while, I devoted a whole field to the young seedlings. This field enabled me to deliver fruits to KONFIGI for a total sum of 150,000 F.Rw. When one discovers a tree, one observes it. If one finds the tree can provide a benefit, one takes this tree home. This is true of medicinal plants. Their importance and utility are learned from neighbours who have used them. One does everything possible to introduce these plants within one's own fields.

Consultant 3: What I can add to the above is that in most cases the neighbour provides the information concerning planting such trees and yield. The person who introduced gapeli spread this species among us and we have cultivated this plant in our region for more than 15 years.

Farmer experimental practices

In each of the three processes of agroforestry knowledge-building (knowledge-generation/acquisition/adaptation), farmers need basic information about species choice, location for planting and method of planting (from seed, seedlings or cutting). How does the farmer determine if a new species is beneficial? How does s/he evaluate trials with new species?

Choice of species: A species is chosen because of its benefits and utility, because it has been seen on another farm, or it has been talked about, or because of tradition. In a few cases, consultants mentioned having no choice, because they were forced by the State to plant certain trees, for example Eucalyptus sp. during the Belgian colonial period, and Grevillea robusta as part of many tree planting drives by various rural development projects. Mostly, though, farmers planted trees because of their utility, even before the arrival of the "white people" and the establishment of nurseries. For example, a father would show his sons how to construct a home compound using such trees as Ficus thomningii, Euphorbia tirucalli, Vernonia amygdalina, Tetradenia riparia, Erythrina abyssinica. These traditional species, still used because they grow quickly and form a solid fence, can also be used as fodder (Ficus, Vernonia), medicine (Vernonia, Erythrina, Euphorbia, Tetradenia), or to protect the inhabitants and their possessions from unwanted visitors (Erythrina). Copying what other farmers have done is the most common way consultants choose a species to try. As was explained in one meeting, "Rwandans are imitators." Observing how the species developed and whether it was damaging to the soil and/or to associated food crops also helps determine if and where a species fits, i.e., if it conforms with other elements of the farming system (especially competition with crops), where it grows best (in the woodlot, fields or home...
compound) or its possible function (boundary marker, fence, food production, medicine, anti-erosion, etc).

Other criteria mentioned were availability, ease of planting and whether or not the species demands a lot of manure or fertile soils. One female consultant stated that it was a matter of chance; she planted many trees of various kinds because only some would survive. While most of the consultants chose their species carefully, they concluded that it is always good to try one or two trees to determine the results under the conditions of one's own farm.

**Species location within the farm:** There are no rules to govern where a species can be planted. Location depends on what the species produces or provides, its competitive and/or allelopathic effects, and its social benefits. For example, many smaller farmers plant fruit trees (particularly avocado) on the home compound, in order to free space in the banana fields for crops. In addition, Eucalyptus is often found on the home compounds of small farmers who can no longer afford to maintain woodlots.

### Species location in the fields

There are several rules of thumb that farmers follow when determining where a species should be located within a field.

| - Timber and fuelwood trees and those that are highly competitive and/or allelopathic will be planted in woodlots distant from crop fields (for example Eucalyptus, Cupressus, Pinus, Grevillea). | - Ficus was traditionally planted on the home compound to provide fodder but, as animal ownership has declined, many are presently found in the middle of the fields (remnants of former home compounds) where, according to the consultants, they contribute to soil fertility through leaf litter. |
| - Species that are good for holding the soil are planted along anti-erosion ditches or on terraces (Grevillea, Vernonia). | - Fruit and medicinal trees are grown in the fields closest to the home mostly for social reasons (fruit trees because of the risk of theft and medicinal trees in case of necessity). The exact location also depends on the farm's size. |

**How to plant species:** Discussions of planting methods included planting holes, use of manure, time of planting and type of propagation material necessary (seedlings, cuttings or seeds). Most consultants again emphasized they obtained much information about planting methods through observation of other farmers and by asking for additional instructions if necessary. The size of the plant hole depends on the species: timber trees need big holes, but small holes suffice for species used as vegetables or medicine. Consultants disagreed on the
necessity of adding manure. Some maintained that all trees need manure, just like crops. Others felt this wastes scarce manure because they believe manure is only necessary for fruit trees.

To produce high quality timber, it was considered best to plant seedlings. Cuttings grow faster and are best for making a fence around the compound. The consultants agreed it is important to plant all the desired species at the same time when building a home compound, so they develop together and make a strong, dense fence.

Consultants differed about the best time to plant trees. One group maintained that trees should be planted at the same time as other crops, i.e. at the beginning of the short rainy season in September. Another group said that the seedlings would dry out if planted that early and should be planted in late October-November, when rains are more plentiful, which is also the time to obtain seedlings from the nurseries. As each species has its own planting method, both groups could be right. Seedlings are generally planted in late October-November, but cuttings and seeds of some species are often planted earlier. They did agree that, in view of the uncertainties of rainfall, plant diseases, marauding goats, landslides or weeding accidents, it is often necessary to replant a species several times before it survives.

**Are the decision criteria regarding species, location and planting methods the same for all farmers?** A minority of the consultants responded that the criteria are the same for all farmers because they follow the example of their parents or imitate what neighbours have done. In some cases, extension workers, through the information they provide, push farmers to make uniform decisions. But, the majority of consultants said the criteria inevitably vary because farmers have different motivations and objectives.

Our criteria cannot be the same. Some people calculate the benefits they will obtain beforehand and plant few or many trees as a result. Other persons are more carefree.

Some can plant Vernonia amygdalina along the anti-erosion ditches. Others can plant it on their home compounds or even on the ditch, but in their own ways.

There are many variables to be taken into account in deciding about species, location and planting methods. The consultants said they consider such elements as utility, benefit, desired end product of the tree, farm size, soil conditions, slope, competition between trees and crops, allelopathy, preferences, motivation, interest or possibility of theft. And, because there are many species available, some of which provide the same or similar benefits, an almost unlimited number of variations in agroforestry systems is possible. This diversification of species within an increasingly-complex farming system shows a deliberate strategy used by the farmers to overcome ecologic and economic uncertainties. Thus, the tree experts who participated in the species trial preferred to try unknown species.

**The tree experts’ species trial: studying farmer experimentation in action**

A minority of the 44 tree experts chose to try species that they knew. One choose Grevillea, and less than five chose to try Leucaena leucocephela, Calliandra calothyrsus or Sesbania sesban. The remaining tree experts all rejected the tree species they already cultivated and provided a number of reasons for why they were interested in the new and unknown species. These reasons speak for themselves:
We walk forward for progress. We want to plant this tree for future generations who will discover that once upon a time this tree was introduced to the region by us.

We work for the Rwanda of tomorrow. We are preparing ourselves for times to come.

For us, it is a sign of development. Fairly recently, Eucalyptus was introduced in the same manner. Now, there are new species available to us. It is very important for us to have these new species, even if we will not obtain any benefits. Our descendants certainly will benefit from them.

Among these species, there is no doubt one that will be more important than the species we are used to. When we have passed away, the action of the father will be recognized by his descendants. The best informed persons will talk about their economic or medicinal importance and advise people not to cut these trees.

When Grevillea was introduced, we did not know its utility. The same for avocado. We only had heard talks about them. But, we planted them anyway. Now, we will plant this unknown species as part of the trial. Good or bad, we will plant it.

Once, many of us were adverse to eating avocado. But many people, especially older ones planted them and only later noticed that the children were eating them. Then everyone realized that its fruits were a new source of wealth. For this reason, we want to introduce these new species which will perhaps be edible or have other, similar importance.

This is to increase the number of tree species we have at our disposal, to have as many varieties (species) as possible.

Even if we do not know these trees yet, we want to discover if they have any use.

Later we will be able to determine their importance. It is possible that the new species will provide greater benefits than those we have cultivated until now.

From the above statements, several themes emerge, some of which were already mentioned in the discussion of the nature and distribution of knowledge. On one hand, these themes relate to individual characteristics of tree experts such as curiosity, desire for knowledge, an internal drive for discovery and the hope to leave a better world for children. On the other hand, consultants expressed strong feelings about the importance of experimentation with new technologies for development and progress. They felt that lack of experimentation would lead to stagnation and make an already precarious existence even worse, that constant adaptation increases subsistence security by providing a diversity of species for farmers to choose from, and that the benefits of these new technologies could exceed those of presently available species.

In a follow-up question, consultants were asked if it were possible for all farmers to plant and experiment with unknown species. The vast majority agreed that everybody needs trees and:

Every person has a need to develop and to know what he does not yet know.
Others talked about the benefits of planting unknown species, even though they may not always be obvious at planting:

Experience has shown that it is always beneficial to plant unknown trees, and everyone can do it. It was the same with Grevillea and cypress which are now found all over the area and with vetiver which we were sceptical about introducing.

One consultant stated that most farmers would be able to plant unknown species if they received sufficient information about the potential benefits, planting methods and best location for planting beforehand. Some qualified their answers by saying that the possibility of testing any new species depends on the size of one's farm:

Someone who has plenty of land can accept, but someone with a small farm cannot. It is too bad if you do not have a large enough farm for these trees.

The others plant new tree species, and you remain with empty hands.

Thus, in principle it is possible for everyone to try new technologies, but in practice not everyone will do so because of a lack of interest or curiosity or because of insufficient resources, especially land. For farmers who have little land, the risk associated with experimentation may be too great because they need all that land to produce sufficient food for their families.

How do farmers deal with risk associated with introducing new, perhaps unknown, technologies? Consultants were well aware of the risks in trying new technologies, especially if they had not been able to observe them somewhere else. But, such risks are also associated with well-accepted and common agricultural practices. For a farmer, it is impossible to escape risk:

Almost everything has negative aspects which one has to accept no matter what. When a cow gives a good milk yield but also attacks people, you do not sell it. Synadenium grantii, Euphorbia candelabrum and Euphorbia grantii have been cultivated for a long time in Rwanda. If one of these trees is close to the home compound, all the children are informed about the nature and poisonous character of these trees.

When one says to a child to be careful with this or that, he will do so. One teaches him continuously what is harmful and what is not.

Part of dealing with risk is accepting that it is there. Through education and training from a young age, farmers are made aware of the risks associated with cultivating some tree species. Consultants want prior information so they can deal with possible negative effects of new species. In addition to the inherent risks (i.e. toxicity, thorns, prickles, etc.), there may be negative effects on the soil or competition with crops or other tree species. If negative effects appear, the consultants can simply remove the species from the field, either by uprooting it or by replanting far from any food crops, preferably in a woodlot. If the species still shows promise and possible benefits to the farmers, the information gained from the experiment will be passed on to neighbours, friends and future generations.
Farmers' reactions to a new, unknown species: a hypothetical scenario

As an additional test of how they react to new technologies and how they would approach the incorporation of such technologies into their farming systems, the consultants were presented a hypothetical scenario. First, they were shown a seedling of a species they did not know, Chamaecytisus palmensis. This species had been tested for several years on the ISAR stations of Rwerere (Ruhengeri Prefecture) and Gakuta (Kibuye Prefecture) but none of the farmers in southern Rwanda had seen or heard of it. The seedling was passed around to the people at the meetings who sniffed its leaves, touched it, observed its stature and speculated about what it could be and how it could possibly be used. The following dialogue illustrates the initial reactions of the farmer-consultants when asked whether or not they knew the species.

No. This is the first time that we have seen it [this species].

Is it umuruku (Tephrosia vogelii)? Me, I do not know it.

This tree does not yet exist in our region. It is umunvegenyege (Sesbania sesban). No, no, ...

It is umuruku.

We do not really know.

After this introduction, the name of the species was given (farmers who had tested it around Rwerere had tentatively baptized it ‘umuvumbuka’) but no additional information about its potential benefits. Consultants were asked what they would do if they were given 500 seedlings of this species. This high number was chosen deliberately to provoke audience reactions. The tree experts at these meetings were interested in testing new species and would very likely have accepted any proposition involving only a small number of seedlings. But the idea of 500 seedlings took them aback.

You are imposing these 500 trees upon us. You insist too much on this! Keep our small farm sizes in mind! Are you going to plant these 500 trees of which you do not know their utility on a property of 20 meters? If I plant them in the area where I wanted to plant another crop, what will I do? Would I plant these trees if I do not know whether they are going to produce fruit or help my son?

A number of consultants emphasized that it is important to get some information about the species before any decision is made about planting 500 seedlings:

Thank you! If you proceed like that, you are only complicating my life.

Without explanations regarding the utility of these trees for my son, well, without explanation on how I am going to be able to follow their growth, I tell you I will not accept these trees.

Although most consultants felt it would be difficult to plant 500 seedlings of a species without knowing their utility, they did not completely reject the offer. One consultant stated that he
would accept all 500 seedlings, but instead of planting them all on his own farm he would distribute 2-3 seedlings to each farmer in the cellule. Most consultants would accept from 2-4 seedlings so they could test performance and find out more about the utility of the species. If the seedling showed positive aspects such as fast growth, potential for profit, non-competitive behaviour and provided useful products, the consultants would increase the number of trees. In one meeting, consultants accepted much higher numbers of seedlings (100 to 200) after one consultant speculated out loud that, since umuvumbuka resembled a Crotolaria species, he could plant all 500 seedlings because, just like Crotolaria, it probably would fertilize the soil. Following are comments regarding the consultants' plan for testing the umuvumbuka seedlings.

A farmer in Karama pointing his climbing bean stakes. A total of 16 species were observed in this pile: Eucalyptus and Grevillea were the most durable (lasting six seasons), while Pennisetum and Vernonia were the least durable (lasting only one season).

One starts with a small number to determine the way in which they grow and their utility.

Me, I will accept four seedlings which I will plant close to the home compound. But if they do not provide anything for my son to eat, I will get rid of them.

Give me my two seedlings as I have a small farm. If these are profitable, I will ask you for additional ones.
After I have discovered their utility, I can look for places to plant additional trees/species you give me by eliminating and replacing some trees I already have.

I cannot plant more than 10 seedlings in the beginning. I start with a trial. If the results are positive, I can plant up to 1000. If the trial is not successful, I will eliminate them and will leave two trees only.

**Farmers' approach to testing and evaluating tree species experiments**

As mentioned previously, the species trial began at the end of the field research period in Rwanda. The following discussion is, therefore, not based on observations of what consultants actually did with the species they were given, but on interactions during the focus group meetings. Consultants used the Kinyarwanda word for experimentation, igerageza, when talking about this species trial, which is quite different from the connotation of researchers trained in the scientific tradition. It is derived from the verb kugerageza, meaning to submit to a test. For trees, there does not appear to be any specific research method and tree experiments are not done on a separate piece of land. In contrast, farmers do something resembling a scientific experiment when testing new food crop varieties. For example, to test new bean cultivars, women use small plots of land to plant beans first in pure and later in various mixes of cultivars repeated over several seasons on different locations and soils (Sperling, 1992; Sperling et al, 1993; Sperling, personal communication). As trees take several years to mature or to yield any usable parts, most farmers cannot afford to tie up even a small piece of land for several years just to test out one particular tree species.

When farmers test a new tree species, they observe and evaluate it over a certain number of years in order to determine whether it meets their goals and expectations. They also study whether these new species will provide more benefits than the trees they already have. Most consultants are concerned with an end product: timber, fuelwood, construction poles, stakes, etc. If the species produces the desired product within the predetermined time frame, the trial is considered a success and the farmer may decide to plant additional trees of the species:

If I discover that a certain species only provides fuelwood, I will not ask for additional trees of this species. But if I discover that the species will yield timber, I will ask for many seedlings from the ICRAF project.

Consultants less fixed on a particular goal stated that other products or benefits may be obtained from the species being tested that may not be known at the onset of the trial:

Among these species, those that yield timber will also be useful for other purposes. We all know very well that guava, in addition to its fruits, provide a medicine against diarrhoea. Rwandans themselves do their little research.

If it is a species that provides timber, we are going to saw it for boards. If it is a fruit tree, we will consider it as that. If this species can be worked to provide utensils, we will also discover this. In brief, we will discover the utility of these trees afterwards.

A consultant in Maraba told of planting one Trema orientalis to test it for timber production. He was not able to explain what had happened, but the tree turned out to be a very bushy
shrub. He realized that this shrub would never yield any timber and the experiment as such had failed. He was, therefore, not interested in planting additional Trema trees but kept the one he had so he could at least harvest some fuelwood from it. These examples also explain why the few farmers who had planted Calliandra calothyrsus had done so primarily to produce timber, not fodder, stakes or green manure. As can be seen from these examples, fuelwood is often not a major objective for planting trees. Farmers experiment primarily to discover the utility of a new species and to determine whether the species provides more benefits than those they already cultivate:

We are going to consider these species, and we will demand others of those that prove useful to us. Or, we can even ask you for other tree species that we do not yet know to enrich ourselves.

**How do consultants evaluate their experiments and determine whether the new species will be of interest to them?** Consultants evaluate new species by size, form, amount of growth per year, diameter, health and the effects on crops and soils:

To observe the growth of these trees, we observe if the tree is hard or pliable. If the latter is the case, we replace it with another one or provide a support. We also observe if the tree grows straight, its diameter and its age. If the tree does not grow, we will uproot it. We also observe if the tree yields cuttings or seeds to distribute to other farmers.

Almost all consultants talked about distributing plant material of the new species they would be testing to their friends and neighbours. Such extension appears to be an important part of the evaluation and validation of the success of these new technologies.

We are going to do a common experiment. If it proves useful, everyone will benefit. If it fails, we will still be together. If we spot a tree that does not grow as it should, we move it to another area, or we isolate it so that it no longer harms other trees.

If this species does not harm my crops, I will introduce it in my farm and take care of it. If it gives seedlings, I will plant two myself and give a third to my neighbour. I will do the same if the species gives seeds. I will harvest them and share some with the neighbour.

In any case, this sharing depends on whether the species produces well or not. But if it grows well, it will get the attention of the neighbour by itself.

If these species do not reproduce, the neighbours will have nothing as a consequence.

This emphasis on extension of information and knowledge gained from consultants' experimentation should not be a surprise, since communication of knowledge is a major part of being recognized as an expert on trees and tree cultivation. In the consultants' opinions, agroforestry knowledge is largely individual; collective agroforestry knowledge is built by sharing technologies and knowledge gained through trials. However, there is no central depository for this knowledge and this knowledge is not recorded in any written form, so any collective knowledge remains stored in the wisdom of many individuals.
Chapter 7

Building Knowledge Through Information Gathering and Sharing

Introduction

Farmers acquire new knowledge and technologies from a variety of sources, but not all farmers have equal access to nor are they equally active in seeking new information, discussing problems or sharing experiences. This chapter sheds more light on differences in knowledge acquisition and sharing between the two sample groups of farmers, based on questions in the socio-economic survey on farmers' access to information about tree species, tree management methods and new cropping and livestock rearing practices. Questions are divided in three categories: active seeking of new species and ideas during travel, passive acquisition of new species and ideas from visitors to the farm (researchers, extensionists, friends, etc), and cooperation with development projects or the agricultural extension service for on-farm testing of new practices.

Active searches for new information: travel to other places

This chapter also looks at farmers' informal communications networks, how they share experiences with new technologies and methods, and the accessibility of extension or specialists. Chapter III referred to demographic and socio-economic characteristics of tree experts and comparison farmers and to differences in their resources. This section looks at the knowledge flow among those involved in an agricultural knowledge system and helps explain why tree experts are called "experts."

In spite of poor transportation, people do travel in search of work, to visit relatives or to attend ceremonies (marriages, funerals, baptisms, etc.). Eighty-nine percent of the tree experts had travelled compared to 54 percent of the comparison farmers. While travel destinations are varied, the data showed that the majority of comparison farmers (60.5 percent) travelled only short distances, either to other districts within their municipality or to neighbouring municipalities. Only in Simbi had the comparison farmers who had travelled ventured as far as other prefectures or other countries. In the tree expert group, not only had a larger percentage of consultants travelled, they had travelled much further. More than half had travelled to other prefectures and onethird had travelled to other countries, or to the city (meaning Butare or Kigali).

Travel does not automatically lead to knowledge, but travel offers the opportunity to increase experiences, to obtain new crop varieties and tree species and to observe new tree management methods. Of the 38 comparison farmers who had travelled, only six (15.8
percent) had brought back seeds or seedlings of new tree species. All six had planted their new seeds or seedlings to determine their suitability under their own farm's conditions. A much higher percentage of tree experts (48.7 percent) had brought back and planted new species.

When asked if they had observed new methods of managing trees (pruning, coppicing, planting, fertilizing), the answer from both groups was a resounding "No." This could be because farmers are not interested in different tree management methods or these methods were not significantly different from what they were already doing. Farmers do not have a fixed set of management practices for each species, but use a range of practices according to their circumstances, objectives, needs and desires. Tree management also varies with the location of the species on the farm. For example, cypress located on the home compound will be managed intensively to form a dense hedge, those planted as a windbreak along the fields may be managed for stakes while those planted in a woodlot are managed for timber.

**Passive acquisition of new ideas from farm visitors**

Farmers rarely receive visitors to discuss agricultural problems in general and agroforestry practices in particular. Only six comparison farmers (8.6 percent) had received visitors who brought them seeds of new tree species, while three persons (4.3 percent) indicated that visitors had shown them new tree management practices. In the tree expert group, the situation was similar. Of the tree experts, 15.9 percent (all of them living in Kibingo) had received visitors who brought them tree seeds or seedlings, while three persons (6.8 percent) had received visitors who described new tree management methods (two in Kibingo and one in Maraba). The higher number of farm visits in Kibingo can be ascribed to the presence of two agroforestry projects (Projet Agropastoral de Nyabisindu and the Projet Agricole de Karama) in Karama. All but one comparison farmer and all tree experts had tried the new tree species. The reaction to the new management practices was more favourable than those that people observed during their travels, with two out of three persons in each group trying them.

In the comparison group, visitors were predominantly local (parents, municipal agricultural officer, municipal counsellor or burgomaster). One person mentioned a visit by an ISAR researcher with whom she was collaborating for an on-farm trial. As extension workers had poor training and few improved technologies to offer farmers, the influx of new ideas and information was all but non-existent. In the expert group, the visitors who provided tree seeds were predominantly outsiders (ISAR researchers and agronomists of the PAP and PAK projects). Only one person mentioned that the visitor who brought seeds was the municipal agricultural officer. The municipal agricultural officer was the only visitor mentioned who showed farmers new tree management methods. It appears, therefore, that the collaboration with ISAR and the agroforestry projects in Kibingo is limited to the provision of tree seeds or seedlings and that farmers are not given advice on their maintenance and management. The low number of farm visits reported (particularly by extension workers), even in the tree expert group, is testimony to the low level of activity of the agricultural extension services, even those supported by development projects as was the case in Karama. Even when extensionists and researchers did visit farms in Karama, it was often only to visit project participants. The vast majority of farmers in the community were ignored.
Sharing information and experiences about new technologies and farm problems

Sharing experiences with new tree species and management methods: More than 80 percent of the comparison farmers said they never discussed their experiences with new tree species or management methods with others, compared to only half of the tree experts. The remainder of the farmers discussed their experiences from time to time. The percentage who shared their experiences with new technologies was lowest in Kibingo in both groups in spite of the two rural development projects and the government extension agents working in the area. This is an indication that technology dissemination through pilot farmers may not be the most appropriate operation, since they appear to keep their new information mostly to themselves.

As in the case of farm visitors, comparison farmers share their knowledge and experiences in their immediate surroundings. Of the comparison farmers who discussed their experiences with others, neighbours, friends and family were the most frequently mentioned (63.6 percent), followed by municipal agricultural officers (36.4 percent). Only one consultant had discussed experiences with ISAR researchers. In the tree expert group, experiences were most frequently shared with municipal agricultural officers (63.6 percent), followed by neighbours and friends (40.9 percent).

Seeking solutions to farm problems: Almost one-third of comparison farmers and two-thirds of tree experts said they discussed farm problems with others in order to get advice or seek solutions. Almost all consultants mentioned discussing farm problems with others, namely the municipal agricultural officer (60.9 percent of comparison farmers and 71.4 percent of tree experts), followed by "other" (34.8 percent and 64.3 percent respectively). "Other" in most cases referred to the veterinary assistant. Since comparison farmers have fewer animals, it is logical that they have less need for consultations with this person than tree experts. Consultants also discussed farm problems with neighbours and friends, ISAR researchers and project agronomists.

Consultants in Maraba and Simbi appeared to be much more active in discussing problems and experiences than their counterparts in Kibingo, in spite of the development assistance provided to farmers in Karama. This could be due to the fact that these projects worked with a few pilot farmers to the exclusion and neglect of the general farm population, creating a small, select group of elite farmers on whom resources and efforts were concentrated. Most farmers, therefore, felt by-passed and were of the opinion that agricultural services were neither targeted at nor accessible to them. This situation was made worse by the fact that pilot farmers received improved seeds, fertilizer, tools, training and advice free of charge, something not available to noncooperating farmers. The absence of projects in Maraba and Simbi made farmers operate on a more equal basis and more open and willing to sharing ideas and experiences. The market on the border between Maraba and Simbi also contributed to the greater openness of farmers in both Maraba and Simbi by providing an opportunity to meet other farmers, the local extension workers, local and distant functionaries, and traders (buyers of coffee, fruits, surplus crops and animals and sellers of farm inputs and consumer goods).
Relationships with research, extension and development agencies: access to and on-farm testing of new technologies

For a more concrete look at farmer-consultants' contacts with research, extension, development projects, etc., we asked farmer-consultants if they had cooperated with agricultural extension or project personnel to test new cropping practices, improved crop seeds, new tree species, new tree management methods, fertilizers, lime or terracing. In the comparison group, a higher percentage of farmers in Maraba and Simbi indicated that they had done so than farmers in Kibingo (see Table 11). In the tree expert group, a higher percentage of consultants in Maraba and Simbi cooperated with the extension service to test new cropping methods, improved seeds, fertilizers and lime. For the other technologies, new tree species, new tree management methods and terracing, the percentage of farmers in Kibingo was greater, which is not surprising as they were the main technologies being promoted by both PAP and PAK. Particularly noticeable is the high percentage of tree experts in Maraba and Simbi who cooperated to test fertilizers (90.9 percent), improved seeds (72.2 percent) and new cropping practices (72.7 percent and 63.6 percent in Maraba and Simbi respectively). Of all the technologies mentioned, the lowest percentage was found in new tree management methods in both groups of consultants, confirming earlier observations of low interests in such methods.

Overall, tree experts had more access to new technologies than the comparison farmers. However, this may be due to the fact that they were more actively seeking new ideas and technologies. Again, the situation in Maraba and Simbi appeared to be more egalitarian than in Kibingo. A higher percentage of comparison farmers in Maraba and Simbi had tested one or more of the technologies than in Kibingo. In general, though, access to these new technologies was gained only if farmers (be they tree experts or not) actively sought them by going to the extension offices to ask for them. As was discussed earlier, waiting for extension workers, ISAR researchers or project agronomists to visit was an exercise in futility.
### TABLE 11: NUMBER AND PERCENTAGE OF CONSULTANTS WHO HAVE COOPERAED WITH PROJECTS OR EXTENSION TO TEST NEW AGRICULTURAL/AGROFORESTRY TECHNOLOGIES

<table>
<thead>
<tr>
<th></th>
<th>Comparison farmers</th>
<th>Tree experts</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>KIBOVO</td>
<td>MAPAFA</td>
<td>SIMBI</td>
</tr>
<tr>
<td><strong>NEW CULTURAL METHODS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>no.</td>
<td>3</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Count in percent</td>
<td>86%</td>
<td>17.5%</td>
<td>22.2%</td>
</tr>
<tr>
<td><strong>IMPROVED SEEDS</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>no.</td>
<td>3</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Count in percent</td>
<td>86%</td>
<td>35.3%</td>
<td>33.3%</td>
</tr>
<tr>
<td><strong>NEW TREE SPECIES</strong></td>
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<td></td>
</tr>
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<td>no.</td>
<td>2</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Count in percent</td>
<td>5.7%</td>
<td>23.5%</td>
<td>22.2%</td>
</tr>
<tr>
<td><strong>NEW TREE MGT. METHODS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>no.</td>
<td>-</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Count in percent</td>
<td>5.9%</td>
<td>-</td>
<td>1.4%</td>
</tr>
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<td><strong>FERTILIZERS</strong></td>
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<td></td>
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<td>no.</td>
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<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Count in percent</td>
<td>86%</td>
<td>41.2%</td>
<td>22.2%</td>
</tr>
<tr>
<td><strong>LIME APPLICATIONS</strong></td>
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<td></td>
</tr>
<tr>
<td>no.</td>
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<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Count in percent</td>
<td>5.7%</td>
<td>11.8%</td>
<td>11.1%</td>
</tr>
<tr>
<td><strong>TERRACES</strong></td>
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<td></td>
</tr>
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<td>-</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Count in percent</td>
<td>2.9%</td>
<td>5.9%</td>
<td>-</td>
</tr>
</tbody>
</table>

**SOURCE:** den Biggelaar 1994

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11 Since more than one destination could be mentioned, percentages may add to more than 100 percent.

12 "New" does not necessarily mean that the species is exotic to the area. It refers to being new to the respondent’s farm, where it previously was not found. Thus a new species could be either an exotic or an indigenous species.

13 During the focus group meetings, they did admit that Rwandan farmers are imitators, and that "seeing is believing." In general, they admitted that they do copy practices from their
friends and neighbours, but when asked directly about it, they would either deny that they did so or said that they could not remember where they saw or learned a certain practice.

Chapter 8

Summary, Conclusions and Recommendations

The goal of this case study was to survey and understand the historical and contemporary processes involved in the generation and adaptation of knowledge and technology of trees and tree cultivation by Rwandan farmers. In particular, this study focused on: (1) the dynamic aspects of Rwandan agroforestry systems, i.e. how and why these systems came into being and evolved over time, (2) the active role of farmers in the development of the agroforestry systems, and (3) agroforestry knowledge/technology production processes (i.e. processes of acquisition/adaptation of knowledge/technology from elsewhere, and generation of completely new knowledge/technologies based on farmers' own ideas and efforts).

The primary aim of this study was not to describe the agroforestry systems in the study areas. Agroforestry was used as the medium to understand the socially-constructed nature of the knowledge upon which these systems are based. The visual artefacts (i.e. the things we see in and on farmers' fields) are but the outcome, a reflection of farmer knowledge. Contrary to common assumptions, this knowledge is not static but changes each growing season with the implementation and maintenance of these artefacts. As we saw in the discussions in Chapter VI, putting ideas into practice in order to gain experience with and from them is an important aspect of "gaining knowledge" and of being recognized as "being knowledgeable" about something, be it crop cultivation, livestock rearing, blacksmithing, carpentry or healing practices. Within agroforestry, there are extensive interactions between agroforestry knowledge production and actual tree/crop/animal production activities (the agroforestry systems) on the farm. Often, the two activities are so thoroughly interwoven that it is hard to distinguish experimental practices from everyday practices. This is reinforced by the fact that most (new) knowledge generated through farmers' own efforts does not concern major changes in the systems or in species composition, but consists of serendipitous, seemingly-innocuous innovations involving a better or new use of existing resources. By consequence, to study knowledge production, one must also study the physical, observable artefacts constituting "normal" agroforestry systems and practices. The brief descriptions of particular agroforestry practices given in the main text of this case study provide a context to understand the nature and content of endogenous agroforestry knowledge and the processes involved in producing this knowledge.

This chapter provides a summary of the main findings and recommendations that can be formulated on the basis of these findings. The chapter is divided in four sections: (1) Methodological issues related to the identification of local tree experts; (2) Farmers' perspectives on agroforestry and tree planting practices; (3) Farmer experimentation: A comparison of methods and procedures with scientific research; and (4) Enhancing local
communication networks: The key for advancing agroforestry knowledge production and farmer experimental practices.

At this point, there is a note of caution concerning the formulation of recommendations for various outside agents (FAO, CGIAR centres, NGO’s, and national research and extension organizations) that aim to strengthen endogenous knowledge production and extension processes. It should be noted that farmer research and extension are, above all, activities of, by and for the farmers. For this reason, any efforts to enhance farmer R&E should be based on their suggestions and be implemented by and in consultation with the farmers. Studies of endogenous knowledge systems and farmer experimentation might not only preserve knowledge itself, but, more importantly, preserve the way in which it has been generated (and continues to be generated) for future generations. The importance of this is all too clear in view of the events of 1994 in Rwanda. But, when outside agents (i.e. people who are not part of an endogenous knowledge system and actively engaged in its reproduction) try to strengthen local knowledge production and diffusion processes, they must be careful not to co-opt and formalize farmer practices and methods, which could harm the system they want to help. The recommendations that are made in this chapter are (with the exception of those related to methodological issues) largely based on ideas and suggestions made by the farmers themselves. The researcher has developed logical extensions and inferences to translate the farmers’ words into feasible and practical guidelines for rural development agencies.

**Methodological issues related to the identification of local tree experts**

**Identification and characterization of tree experts:** According to the philosophical definition provided by Kagame (1958), knowledge (ubumenyi) implies knowing a plurality of objects or notions. Farmers concurred with Kagame. They equated knowledge of agroforestry with experience in the cultivation and/or use of many different tree species. Thus, the tree experts, as identified through a ranking procedure and community interviews, were all farmers who cultivated many trees of a large species diversity on their land. During the ranking game, informants explained that the larger number of trees and species diversity was possible because experts had more land, more animals and manure, better soils, greater wealth and were more active in tree planting activities.

The differences between tree experts and comparison farmers (the non-experts in this study representing the general farm population) were subsequently confirmed by a socio-economic survey. The survey results showed that tree experts were older, more experienced and further advanced in the family life cycle. They had greater resources (land, labour, animals, manure) and therefore could better absorb risks associated with experimentation. Tree experts were also better informed through travel and more observant of =yew species and practices during travel. In addition, they were more aggressive in seeking help and advice from extension workers, neighbours and/or veterinary assistants, and in pursuing extension and projects to gain access to new technologies, such as improved seeds, tree seedlings, fertilizer, lime, management practices of trees and crops. Although not all variables included in the tranal survey were mentioned as criteria by informants for the knowledge ranking exercise, the results indicate that informants were able to accurately distinguish groups of farmers within the population on key variables such as resources, wealth and tree species diversity, even if only on a relative scale. The ranking game data and observations made during game implementation provided valuable contextual information about agroforestry practices which proved invaluable in interpreting the overall results of the
study. This information could not have been obtained by relying exclusively on the formal socio-economic survey.

It would be wrong to say that comparison farmers did not have any knowledge about trees and tree cultivation, nor understand the need for and importance of trees. They had little land and resources which made their choice of species and species location more critical. The smaller the farm, the more farmers in this group concentrated their efforts on fewer, less-competitive species, resulting in complex systems of low diversity with a high degree of integration of trees and crops. The agroforestry knowledge of tree experts and comparison farmers may, therefore, indeed be different, confirming the initial conclusions of the knowledge ranking exercise. Low diversity/high tree density systems require farmers to have higher levels of management skills and greater knowledge of the various components and their interactions. As agroforestry research in particular concerns the study of the integration and interaction of trees, crops and/or animals, the agroforestry systems of the comparison farmers would make a more appropriate object of study to learn about endogenous agroforestry knowledge and the logic behind these systems.

Beans and bananas are commonly intercropped. Above 1800 metres bananas do not grow well and look scrawny, as in this photograph. Here, the land is being prepared before sowing of beans. The soil is often hoed twice to remove the stoloniferous roots of Eragrostis grass, a major weed. The roots are piled together to dry and are then burned. Photo: JM Olson

This study thus observed a difference in both agroforestry systems and agroforestry knowledge among individuals and groups of individuals. It confirmed observations by Scoones and Thompson (1994) that contrary to scientific knowledge, endogenous knowledge is manifold, discontinuous and dispersed, not singular, cohesive and systematized. As a result of "development" and other political, socio-economic and demographic processes of change, the definition of knowledge defined by a society once largely dependent upon gathering its tree products (i.e. having experience with a variety of tree species particularly concerning
their utilitarian aspects) no longer appears applicable to today's situation in which people actively plant and manage trees on their own land. A more extensive kind of "knowledge of trees" is developing which includes knowledge about the planting and management of trees, their integration and interaction with crops and/or animals, as well as knowledge of their utility. It is therefore recommended that:

Future studies of endogenous knowledge of agroforestry combine qualitative and quantitative, participatory and formal data collection methods to provide both complementary and supplementary perspectives on a complex reality (den Biggelaar, 1995).

For this research, it was deemed important, in order to study the various processes involved, to find and interact with the farmers most actively engaged in agroforestry knowledge production. The basic assumptions of this research (that individual knowledge of agroforestry varies because of differences in socio-economic and political position within the community and because of varying biophysical conditions on the farm; and that not all farmers would be equally active in knowledge generation due to different interests, motivations, propensities and abilities towards experimentation) proved to be correct. However, as the nature and content of agroforestry knowledge varies between (groups of) individuals, it was wrong to assume that only some farmers (in this study, those perceived by their fellow farmers to be the most knowledgeable about trees and tree cultivation) would engage in experimentation for knowledge production. In reality, farmers in each of the various "knowledge groups" created by the ranking game informants were engaged in the generation of their own particular kind of knowledge of trees and tree cultivation, although not all farmers were equally active experimenters.

Relying solely on local perceptions of the persons most knowledgeable about trees and tree cultivation to identify experimenting tree farmers (as was done in this research) may, therefore, not provide satisfactory results. As was shown in this study, there are multiple ways of knowing about trees and tree cultivation, and each is based on and evolves from its own forms of knowledge production. It is therefore recommended that:

Future in-depth studies of farmers' experimental activities and knowledge production processes should not rely exclusively on the farmers identified by other community members as the most knowledgeable about agroforestry. A sample of farmers stratified into different "knowledge groups" created by ranking game informants may better cover the wide range of agroforestry knowledge and associated knowledge production processes present among (groups of) individuals.

Farmers' perspectives of agroforestry and tree planting practices

Agroforestry: historical aspects: Discussion with individuals and groups of individuals revealed that Rwandan farmers traditionally did not practice agroforestry. Farmers satisfied the household needs for tree products by exploiting the natural vegetation on the hills and along valley bottoms. In addition, they practised "passive agroforestry", an agroforestry where naturally-seeded trees were purposefully maintained on the land. Active tree planting only involved planting of cuttings of Euphorbia tirucalli, Vernonia amygdalina and Ficus sp. as live fences around the compound. With increasing population, more land was needed for the cultivation of food crops, leading to the virtual disappearance of forests and forest galleries from the landscape, and making it less and less possible to depend on natural vegetation to
secure the necessary tree products. Since people did recognize the need for tree products and the benefits trees provide, they became more active in planting trees on their own land. Over the years, many indigenous and exotic species have been incorporated into the agricultural systems, facilitated by the overthrow of the kingdom in 1959 and the abolition of traditional chief-client relationships based on cattle ownership and the necessity of keeping land in pasture free of trees. In addition, research on suitable (exotic) trees and reforestation efforts, started by the Belgians in the 1930s, and by various development programmes since Independence, have helped provide suitable technologies to the farmers to encourage them in their own tree planting activities.

**Agroforestry: present situation:** This research found that in 1992, almost all farmers in the three study areas practised agroforestry. However, no two farms had a similar agroforestry system because farmers design individual systems that best meet their multiple needs given their resources. This individuality is reinforced by a large species diversity (as was seen in Chapter V, 193 species were found in the study zones), the multiple reasons for planting trees and the multiple uses farmers make of trees. These factors have led to agroforestry systems with very complex arrangements of species over space and/or time.

Tree inventories from previous studies of agroforestry in Rwanda diverge greatly from the results of the present research because they used a different definition of "tree."

Previous studies inventoried woody species (trees and shrubs) defined from a Western conception. Farmers in this research talked about trees using the definition given by Kagame (1958): "Trees are all plants that are not grasses". Thus, the plants found in the indigenous agroforestry systems that correspond to this term for "tree" included not only trees and shrubs (as defined in the Western world), but also annuals and perennials. This contributed to the species diversity found in the study areas and gave an additional layer of complexity to the indigenous systems. However, these "nontrees" (from a Western perspective) should not be ignored as they provide significant benefits to the farmers and often are grown in specific niches not usable for crops or trees. **It is therefore recommended that:**

Future studies of agroforestry follow the farmers' definition of trees and should not assume that these "non-trees" are weeds of no value..

Farmer-consultants were well aware of, and sensitive to, the biological interactions between trees, crops and soils. These interactions were the main criteria used in decisions about where to plant a certain species within the farm and/or the field, and to evaluate its performance. However, utility and other tangible benefits were cited as the primary reasons behind farmers’ choices of certain species. As many species meet the diverse needs of farmers, which species actually are planted depends on gender, farm size, personal interests, motivation, preferences for certain species and the initiative of each person. Women were primarily interested in trees producing food (fruit, spices, seasonings, yeasts, etc.) and medicines, whereas men preferred lumber trees and those producing construction poles. Neither gender expressed much interest in fuelwood trees, and fuelwood did not appear high on the list of farmer priorities to be addressed by agroforestry research.

During many meetings with farmers, it was repeatedly stated that it was imperative to find species and arrangements with the least negative influence on crops and soils in order to further agroforestry practices. In the opinion of farmer-consultants, all trees are competitive and damage the soil, although they stated that all traditional (i.e. indigenous) trees can be used
for agroforestry as they do not exhibit these characteristics. This seeming contradiction may be a reflection of their long observation of and experience with planting and managing a variety of indigenous tree species. The passive agroforestry practices of the past may, in fact, have been less passive than assumed or admitted, as farmers may have eliminated trees that did not provide direct benefits, were too competitive or had the wrong form and shape. The "all" in the above statement may indicate that useless and/or competitive indigenous trees have been eliminated over time, leaving only those that are compatible with crops and provide direct, tangible benefits. While farmers consulted in the study were not able to verbalize whether or not they had engaged in experimental practices related to this selection process in the past, it is obvious that these past experiences were and are being used in designing the agroforestry systems found in the study areas at present.

Farmer-consultants indicated that they value knowledge about the uses and benefits of trees, especially for medicinal purposes, more than knowledge of tree planting and cultivation. This is not surprising as people have been using trees for various purposes for centuries, but the intentional planting and management (outside the home compound) is a relatively recent phenomenon. As women were better in identifying trees and more skilled in treating everyday ailments using a wide variety of trees, they were considered more knowledgeable about trees and tree cultivation practices. As utility and tangible benefits were the primary reasons behind farmers’ choices of certain species; and as women were deemed more knowledgeable about tree uses and benefits; and as men were said to be more knowledgeable about, and had the responsibility for, tree planting and management. It is recommended that:

_Extension workers initially focus on women farmers to convince them of the benefits of new tree species and other agroforestry technologies, and subsequently explain to the men how to go about putting these improved technologies into practice on their own farm. As many species (especially medicinals and fruit trees) were planted by the men on the suggestion of their wives, this would not involve a major change in practices for the farmers. It would, however, involve a change in the habits of extension workers who primarily talk to men. Involving both men and women in the decision-making process about new species, where and how to plant and manage them would ensure that new agroforestry technologies will be more acceptable to, and adoptable by, a wider range of farmers._

**Agroforestry: future perspectives:** Although farms in the three study areas were already very small and continue to diminish in size every generation, farmers considered agroforestry the only solution to obtaining tree products in the future. With the increasing competition between trees and crops for a limited land base, farmers recognized that decisions concerning species selection and arrangements were becoming more and more difficult. The present differentiation of agroforestry systems will, therefore, become even more pronounced in the future with increasing fragmentation of farms. **It is therefore recommended that:**

Researchers and extensionists take the multiple goals and needs of farmers, and differences in availability of and access to resources, into account in the search for new species and intercropping arrangements of trees and crops.

Agroforestry development efforts in Rwanda in the late 1980s and early 1990s were often narrowly focused to address a limited number of problems defined by outsiders (for most projects, these problems were fuelwood, green manure and mulch to combat declining soil fertility, and erosion control). Most projects came up with one (standard) solution, ignoring
differences in resource availability, goals and needs of farmers. There are two problems related to such narrow focus. First, new technologies proposed may not be perceived as a solution by the farmers. For example, in the case of green manure for soil fertility improvement, farmers believed that plants by themselves could not add anything more to the soil than what they took up to grow, so how could they improve the soil? Second, some farmers’ needs may not be identified as major problems in a diagnostic exercise but researchers and extensionists should not assume that these other needs (for medicines, spices, fruit, twine, etc.) are already being met or will automatically be met if farmers adopt new agroforestry technologies. In this regard, it is important to keep differences in agroforestry practices and tree planting objectives in mind, particularly as they relate to gender and farm size. For example, the results of this study indicate that women and micro-holders were primarily interested in planting trees that contribute to the family food supply, whereas men and larger land owners preferred to plant trees for timber and construction poles. Women on both small and large farms also expressed great interests in planting medicinal trees.

As these differences in objectives and context indicate, collaboration between farmer and researcher to identify problems and opportunities, and to look for solutions, helps develop a range of technologies that reflect these differences. In all cases, existing agroforestry knowledge and practices should form the starting point from which to move towards solutions. To help bring this about, it is recommended that:

With the help of participatory approaches, local people and communities identify, implement and evaluate their own priorities for tree growing, as this will generate more reliable research and extension agendas than top-down approaches (adapted from Scherr, 1992).

The farmer-consultants themselves made research and extension recommendations, which they felt would best support their efforts in advancing agroforestry practices. They recommended that:

- There should be more research on suitable species to increase the number of options available to farmers. Farmers do not want to be constrained in their choices and put into a straitjacket by research and extension which offers them standardized solutions to the very diverse conditions of their farms. They demand a cafeteria system of new species' and technologies suitable for a range of biophysical and socio-economic conditions from which they can choose according to their own needs, goals and resources. They stressed that the availability of a variety of tree species (both indigenous and exotic) and tree management options was important to enhance their traditional strategy of diversification to overcome economic and ecologic uncertainties.

- New tree species to be introduced should be compatible and noncompetitive with crops, non-shading, have tap roots and the ability to be used as live stakes. Ideally, and this was suggested in particular by many of the very small farmers, research should introduce trees that produce fruit and (fuel)wood simultaneously.

- Research and extension should ensure that new technologies (species) are made more accessible to farmers.
Farmer experimentation: a comparison of methods and procedures with scientific research

Identification of specific shortcomings, instead of the wholesale dismissal of local technologies as inadequate, can be an important mechanism to generate knowledge: it can be one of the means with which local knowledge can be developed in a fertile interaction with other knowledge. In this way, specific areas of local technology can be improved so that existing shortcomings are eliminated and a solution will be found with greater local relevance than whichever ‘external’ technology (van der Ploeg, 1991).

Many farmers intuitively followed this advice. It was their strategy to solve particular problems and shortcomings by borrowing from any sources available (other endogenous knowledge systems, research and extension, etc.) to arrive at workable and profitable solutions for their conditions. It was, however, difficult to distinguish new from existing practices or to differentiate experiment from normal practice. For farmers, each season is an "experiment" in which new knowledge is obtained and new ideas are generated. The tree experts consulted in this study, therefore, described knowledge production through experimentation (igerageza) as an activity interwoven with everyday agricultural activities, not separated from them as is the case in the scientific knowledge system. These findings confirm the results of Box (1988) with cassava experimenters in the Dominican Republic, in which one of his research subjects explained that experimentation can only be understood if it is grounded within everyday life experiences and activities.

Although Plumeria alba is known to botanists as an ornamental shrub with sweet smelling flowers, farmers in Maraba regard it as a medicinal plant and call it umudwedwe. Women use its sap to increase lactation and it is given to cows for the same reason. Interestingly, neither its local name, nor its medicinal uses were known to botanists and foresters. The tree was not found in Karama and farmers in that area knew nothing about the tree or its medicinal properties.
However, in spite of the interweaving of experimentation and normal production practices, experimentation was a conscious effort on the part of the farmers to build upon the body of endogenous agroforestry knowledge. The diversification of species and its resulting increase in complexity of land use systems resulting from farmers’ experimental efforts were a deliberate strategy used by the farmers to overcome ecologic and economic uncertainties, and approach a better and more secure livelihood. Their experimentation with new agroforestry technologies was considered necessary to discover benefits not available from existing species and practices, or to determine whether they could get similar benefits more quickly and efficiently. Thus, although farmers were reluctant to try new technologies without having seen them in practice or use somewhere else, the majority of tree experts chose to try species with which they were unfamiliar in the species trial set up as part of this study (see Chapter VI). Farmer-consultants justified their choice by stressing the importance of experimenting with new ideas and technologies for development and progress. Within the group of tree experts, this was expressed as a greater sense of curiosity, a desire for knowledge, an internal drive for discovery and recognition for leaving descendants a better world. There was an implicit understanding that not experimenting would lead to stagnation and compromise an already precarious existence.

A fundamental problem facing experimenting farmers was the supply of new technologies to test on their farms. They identified the availability and accessibility of a range of options as necessary for their experimentation and system development. However, the options to be offered to farmers do not have to originate from scientific research. They can also come from other endogenous knowledge systems around the world. Farmers are able to make qualified assessments of what can (potentially) work in their own situation, but they are obviously limited to their immediate surroundings for information and ideas. An important role can be played by FAO, ICRAF, and other CGIAR centres to fill the gap. It would be ideal to take farmers on guided farm tours in different regions and countries to see new technologies in practice and to talk with their colleagues directly, but this is often impossible due to costs and restrictions on travel (especially across borders). Modern technology (video, cdrom, 3-D computer programmes) could provide an answer by taking farmers on "virtual" farm tours to expose them to new species, practices and systems from around to world. These media could show how farmers in other countries or regions have dealt with (similar) problems and what solutions they have devised to solve these problems. These media should be visually oriented, as farmers stressed the importance of seeing technologies in action in order to determine their suitability for their own situation. It would not be necessary to provide specific solutions, particularly not for the experimenting farmers. A glimpse of what other farmers have developed could provide ideas to push experimental activities in new directions. As FAO, ICRAF and other CGIAR centres have a global presence; and as they have collected and documented extensive information on agricultural and agroforestry systems from many different countries and/or indigenous peoples. It is recommended that:

- The multinational organizations and international research centres develop and distribute visual documentation (video, film, cd-rom, etc.) of indigenous agroforestry systems and practices, and farmers experimental methods and procedures related to the development of same. They also should assure their availability and accessibility to NGO's, farmer organizations, extension services and other persons and institutions interested in furthering farmer research and extension practices.

Such virtual farm tours need to be carefully conceived to guarantee that farmers receive the right message. Anthropological studies of farmer perceptions of messages from televised
media show that there are fundamental differences in how people from different cultures perceive the images they see (Crowley, personal communication). The following suggestions are made to take such differences in perceptions into account:

- Involve farmers in the script writing for these virtual tours, perhaps first producing a tour of their own agroforestry systems and experimental activities for outsiders. This will ensure that specific factors and aspects that farmers deem important are included.

- Have farmers produce their own video, photo and text materials necessary for producing a virtual reality tour. Most modern video and camera equipment is easy to operate. However, some basic training will be needed on camera operation, framing and presentation.

- With the help of visual, object-based computer programming, the practices and systems depicted should focus on a single idea, practice, method, etc. The users of these programmes (for example, extension services, NGO's or other organizations) can subsequently create the appropriate tour for their audiences.

- Simultaneously, there should be more in-depth studies of the logic and reasons behind specific agroforestry systems and practices and of the methods and evaluation factors of farmers' experimental activities. These studies will provide the necessary background information for the visual material.
Traditional healing practices are still widespread. This woman, one of the tree experts consulted in the case study, specializes in treating ringworm in children. The oval balls drying on banana leaves are made of clay mixed with leaves from various trees and plants. The clay preserves the healing powers of the leaves and masks their identity. It also facilitates application.

Experimental methods and procedures: The processes by which knowledge is added, used and lost to the stock of knowledge of a social group are similar in both the endogenous knowledge system and the scientific knowledge system. In both systems, we find a certain specialization and differentiation between a small group of knowledge producers (generators, adapters, acquirers) and a large group of knowledge users. But there are also fundamental differences in the way knowledge and technology are produced and validated.

The tree experts did not use specific research methods and procedures for tree and tree cultivation experiments. Trees take several years to mature or to yield usable parts, so most farmers (even the large ones) could not afford to tie up land for several years to experiment with new tree species or arrangements. Thus, tests of new tree species or tree cultivation methods took place within existing fields and crops, which explains the interweaving of experimental and everyday agricultural activities talked about earlier in this section. The topic (most often a new species) and objectives of experimenting and the methods to be used depend on:

- Resources (farm size, labour, animals, manure);
- Location within the farm (slope, soils, crops, distance from the home compound);
- Gender; and
- Personal interests, motivation, initiative and preferences.

While there is no uniform method for testing new agroforestry technologies, farmer tree experts did adhere to more or less standard variables to evaluate the experiment:

- Will the species meet the objectives for which it was planted? (fuelwood, timber, stakes, etc.);
- Intercropping ability (i.e., allelopathic effects, competition with crops and/or other trees, shade);
- Effects on the soil (excessive water use and nutrient uptake);
- Growth (primarily height);
- Disease and pest problems (in particular, termite and ant attacks); and
- Other possible uses or benefits not initially intended or envisaged.

Risks associated with experimental methods: The tree experts were well aware of the risks in trying new, untested technologies as can be seen from the above list of evaluation criteria. However, they stated that such risks were also associated with normal production practices; weather, pest and disease outbreaks, and market conditions cannot be predicted. The emphasis on observing (new) species and practices on other farms (to study their stature, growth pattern and possible negative effects on soil, crops and other trees) aimed at minimizing risks, since knowing potential risks helps in dealing with them. However, risks would not automatically preclude them from trying new technologies, especially if the utility and benefits were perceived to be greater than the risks.
Validation of experiment results: The major difference in knowledge production between experimenting farmers and scientists is not found in experimental procedures or trial evaluations, but in the way new knowledge and technologies are validated. In the scientific knowledge system, the primary aim of experimentation is the advancement of knowledge. There is an active communication of experimental results (in journals, conferences, seminars, etc.) among scientists and researchers. By contrast, knowledge production in the endogenous agroforestry system is primarily use- and user-oriented. Consultants consider communication of experimental results an important aspect of being recognized as "being knowledgeable", but there was not much apparent effort to share new knowledge. Validation of new ideas/ knowledge comes when efforts are imitated by other farmers (neighbours and friends), in other words by the final technology users, not by fellow experts engaged in knowledge/technology production. It is therefore recommended that:

- Knowledge sharing and extension of the results of farmer experiments (i.e., experimental outputs) were beyond the scope of this study. This research was concerned with the sharing of ideas as inputs for farmers' experimental activities. However, farmer-to-farmer communication of experimental results is important to enhance indigenous agroforestry practices and will make a fruitful area of research. Some topics that should be addressed in studies of informal extension networks have been provided in the section "Research questions requiring future investigation" below.

Enhancing local communication networks: the key for advancing agroforestry knowledge production and farmer experimental practices

While the two knowledge traditions vary in the nature and the content of their knowledge, the primary difference is in the distribution of that knowledge. Communication networks for knowledge sharing and distribution among tree experts or between tree experts and other farmers, were neither very extensive nor very well organized. Farmer consultants identified this virtual absence of local communication and information exchange networks as a major barrier to agricultural and agroforestry development. To enhance communication among farmers in general. It is therefore recommended that:

- Mechanisms for local and regional information exchange be created to facilitate communication among farmers and advance the knowledge of both exogenous and endogenous agroforestry technologies. Possible means to accomplish this are guided farm visits and community and/or focus group discussions such as undertaken in this research. To implement such a strategy, there is a need for persons with both endogenous and Western knowledge of agroforestry systems find new methods to share information with farmers in an informative, non-prescriptive manner, that treats farmers and their knowledge with respect.
Better communication is needed among farmer-experimenters to enhance endogenous agroforestry knowledge production through the sharing of methods, procedures and results. Opportunities exist for research, extension and NGO’s to identify (potential) farmer-experimenters and organize them around particular problems to be solved or technologies (species, practices or arrangements) to be tested. A fixed group of so-called "pilot farmers" involved in pretesting and/or demonstrating all new technologies offered by a project or research (as was used by PAP-Nyabisindu in Kibingo) is not recommended, as, for various reasons, few technologies spread beyond the group of pilot farmers to other members of the community. Additionally, it limits farmers' own experimental practices and "technology development from within." As interests and resources vary among farmers, different farmers or groups of farmers may be involved in experimenting with different technologies (for example, Chamaecytisus palmensis for stake production or Euphorbia tirucalli for erosion control), and multiple networks may be in operation simultaneously. It is therefore recommended that:

- Research, extension, and NGO's stimulate the formation of groups and/or networks of experimenting farmers which may or may not be technology and problem specific. These could take the form of study clubs in which farmers discuss specific problems they want to solve and work out solutions together. Subsequently, the group or club members can test the solutions on their own farms using their own experimental methods in order to determine the best solutions for various situations and conditions before communicating their results to the larger community. Researchers, extensionists and NGO personnel should, however, not be the main organizers of such groups, but only act as facilitators and resource persons.

These farmer study clubs should be organized, run and (if possible) financed by the farmers themselves in order to ensure their independence and sustainability. In addition, independence will ensure that problems addressed and solutions devised will be truly based on farmers' own beliefs, values, norms and experimental activities, even though they may decide to borrow ideas and technologies from elsewhere. As it will be difficult, if not impossible, to organize and run such clubs with farmers scattered in a wide geographic area, the clubs will be of a local nature. By consequence, the problems they will address and solutions to these problems will be of a local nature. Research, extension and NGO's may, however, help facilitate information exchanges between or periodic meetings of study clubs in different villages, regions, countries or even continents, especially for clubs struggling with similar problems.

NGO's, for example, could provide information exchange services through newsletters that include lists of problems the study clubs are addressing and stories about specific solutions devised. Information exchanges between clubs in different countries and continents could be made possible through, for example, the Ecovolunteer Programme of the Environment Liaison Centre - International (ELCI) in Nairobi, Kenya. This programme at present links more than one hundred NGO's across the globe through the Internet precisely for this purpose.

**Research questions requiring future investigation**

More in-depth research is needed to study pathways of agroforestry development and agroforestry knowledge generation. Research should be directed to investigate intensification-extensification processes of agroforestry systems across agro-ecological zones, land use systems and/or countries resulting from farm fragmentation and declining farm sizes.
The basic assumption of this study was that not every farmer would have the same knowledge of agroforestry nor be equally engaged in agroforestry knowledge production. Thus, a large part of the study was devoted to identifying the farmers most knowledgeable about trees and tree cultivation and most active in creating new knowledge about the subject. These farmers were then surveyed in detail about their knowledge and experimental practices. However, due to differing pathways of agroforestry intensification (high diversity/low density vs. low diversity/high density) both agroforestry systems and agroforestry knowledge differ among (groups of) individual farmers. A logical extension of this finding is that the kind of knowledge produced, and, by consequence, the processes by which this knowledge is produced may vary among (groups of) individuals as well. As this study focused primarily on the group of locally-identified tree experts, a future study aimed at the group of comparison farmers (or, even better, aimed at both groups) would be a welcome addition to the topic of farmer research and extension. Such a study should look into the question of differences in topics, objectives, methods, and evaluation criteria used by experimenting farmers who follow different strategies in agroforestry development.

An interview being conducted with a tree expert about the history and management of his woodlot.

A topic that has not been dealt with in great detail in this study is the informal extension of ideas, technologies and practices developed through farmer experimentation. This research only touched on the subject as far as it concerned the input of ideas for farmer experimental practices, but did not look at how results (the output) of these experiments diffuse through the community. Farmers did consider communication of their experimental results an important (if not the most important) aspect of their being considered "knowledgeable about trees and tree cultivation," but they did not appear to make an active effort to spread the results of their research efforts. This seeming contradiction calls up many questions and would make an interesting topic for study:

- Why do farmers remain so passive in communicating results of their experiments?
Is the passivity due to a lack of an enabling environment? Some of the things that come to mind here are: fear of government authority which monopolizes "invention" and diffusion and does not allow deviation from their recommendations; no return on investment in experimental activities if results are shared with a large public without compensation; lack of legal, financial or witchcraft protection if the technologies they "invented" do not turn out the way they should at others' farms.

- What are the farmers' own ideas and suggestions to create a more enabling environment for informal extension of the results of their research?
- How can these ideas and suggestions subsequently be translated into practical and doable plans of actions for governments, official research and extension organizations, NGO's, CGIAR centres and others without destroying the informal extension practices in the process?

**Conclusion**

Endogenous agroforestry knowledge is neither stagnant nor inherently "worse" than scientific agroforestry knowledge. One can study and compare the two knowledge traditions, but one cannot, and should not, judge them by each other's standards. Science-derived agroforestry knowledge and technologies now dominate (or appear to do so) because their adherents (researchers and extensionists) are more efficient in distributing information on a large scale, not necessarily because their products are inherently better. In reality, both the scientific and endogenous knowledge system are hybrid systems that have incorporated each others' technologies and ideas, even though researchers and extensionists do or may not want to recognize this. On the other hand, the farmer-consultants in this study did recognize the value of agricultural research, since without research they would never have been able to obtain tree species such as Grevillea, Eucalyptus, avocado, coffee, cypress and pine, and crops such as cassava, potatoes, wheat and climbing beans that now dominate the rural landscape in the study areas. Both farmer-derived and researcher-derived agroforestry knowledge and technologies have their strengths and weaknesses and both have a role in developing and furthering agroforestry technologies and practices. The major strategy to enhance farmer research will, therefore, be a synthesis of the two knowledge systems (den Biggelaar, 1991) taking the strengths and weaknesses of each into account.

The greatest strength of formal (Western scientific) research is that it can access information, ideas, and technologies from a much greater number of sources and a wider geographical area than farmers can. Formal research, therefore, has an important role in agroforestry development, not so much to design specific agroforestry systems but to increase the number of options (species, management practices) available to the farmers. The design of specific agroforestry systems is better left to the farmers, as they are much better skilled in incorporating technologies generated by each of the knowledge traditions in ways that are locally applicable and beneficial.

For this to happen, an understanding of the processes of knowledge production is of major importance. Future studies of endogenous knowledge systems should, therefore, put greater emphasis on process-oriented research. However, most research on endogenous knowledge to date has been aimed at collecting specific facts (soil classifications, tree uses, indigenous medical or veterinary practice, etc.) that sit on dusty bookshelves because no one knows what to do with the collected facts. They become dead, static representations of ever-evolving, dynamic knowledge systems. This study has been interested primarily in knowledge generation processes. For this reason, it has been short on specific details about particular
agroforestry systems, tree arrangements or species uses. The latter are only facts to help understand the logic of what farmers do and the reason behind it. By themselves, facts are meaningless; it is people who give meaning to them. This is perhaps best stated in the following quote from Jahn (1990): "... Kuntu [modality, determination of a 'thing'] is of higher value than Kintu [being without intelligence or thing; in Rwandan philosophy, these include minerals, plants, animals, objects, material goods, etc.] and so they gladly alter things and their organization yet keep their own style.

Two research assistants conduct a ranking game with a farmer and son, who were herding their cattle in a pasture in Karama.

They [the Africans] are convinced that it is not the thing which determines the style and the person, but that man through his style can and must give the thing a meaning, that the dignity and force of man lie in his capacity to give meaning to things, even when the things themselves were made for a explicit purpose" (text in '[]' added by this author). For example, a diagnostic study of agroforestry systems in Burundi contains a number of diagrams of farms showing tree locations, but this does not contribute to an understanding of how the system functions, why it was put together, how it evolves over time and which forces influence these changes. The drawings are but Bintu (things), they have no meaning. This case study has moved beyond this, not to show the Bintu (specific agroforestry systems and practices found in the study areas) but Kuntu (the modality and determination of the systems and practices) as indicated in the subtitle: "A case study of the dynamics of agroforestry systems and agroforestry knowledge".

The development of a synthesis among knowledge systems will increase the effectiveness of ongoing scientific agroforestry research and development as well as empower, legitimize and enhance the existing endogenous capacities for identifying problems and developing solutions (den Biggelaar, 1991). Farmers seem to have an intuitive sense of the importance of such a synthesis between the endogenous and exogenous knowledge systems. The major challenge
will, therefore, be to convince researchers, extensionists and policymakers of the necessity and benefits of such a synthesis. This synthesis should not lead to a formalization of farmer experimental methods nor to a relaxation of the rigor of scientific research. The goal of the synthesis is to build upon the comparative advantages of each knowledge tradition, leading to a participatory and collaborative strategy for agroforestry technology development and assuring that technologies are client-oriented and grounded in local dynamics of socio-economic and agroforestry development (Scherr, 1993).

Appendix

LIST OF ALL TREE (IBITI) AND OTHER PLANT SPECIES CULTIVATED ON THE SAMPLE FARMS IN THE COMMUNES OF KARAMA AND MARABA

EXOTIC TREE AND OTHER PLANT SPECIES

<table>
<thead>
<tr>
<th>LOCAL NAME</th>
<th>SCIENTIFIC NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Euphorbia cotinifolia</td>
<td></td>
</tr>
<tr>
<td>2. Acrocarpus fraxinifolius</td>
<td></td>
</tr>
<tr>
<td>3. Prunus salicifolia</td>
<td></td>
</tr>
<tr>
<td>4. Amacunga</td>
<td>Citrus sinensis/ C. aurantium vulgare</td>
</tr>
<tr>
<td>5. Amapera</td>
<td>Psidium guajava</td>
</tr>
<tr>
<td>6. Avoka</td>
<td>Persea gratissima</td>
</tr>
<tr>
<td>7. Calliandra</td>
<td>Calliandra calothyrsus</td>
</tr>
<tr>
<td>8. Callitrisi</td>
<td>Callitris sp.</td>
</tr>
<tr>
<td>9. Cassiya</td>
<td>Cassia spectabilis</td>
</tr>
<tr>
<td>10. Casuarina/umubunda</td>
<td>Casuarina cunninghamia</td>
</tr>
<tr>
<td>11. Gereverya</td>
<td>Grevillea robusta</td>
</tr>
<tr>
<td>12. Icyayi</td>
<td>Camellia thea</td>
</tr>
<tr>
<td>13. Igifenesi (jacquier)</td>
<td>Artocarpus integrifolia</td>
</tr>
<tr>
<td>14. I kawa</td>
<td>Coffea arabica</td>
</tr>
<tr>
<td>15. Ikinyomoro/itunda</td>
<td>Cyphomandra betacea</td>
</tr>
<tr>
<td>16. Indimu</td>
<td>Citrus limon</td>
</tr>
<tr>
<td>17. Inturusu/intusı</td>
<td>Eucalyptus sp.</td>
</tr>
<tr>
<td>18. Ipapaya</td>
<td>Carica papaya</td>
</tr>
<tr>
<td>19. Ipapaya y'umusozi</td>
<td>Carica cundinamarcensis</td>
</tr>
<tr>
<td>20. Isederera</td>
<td>Cedrela serrata</td>
</tr>
<tr>
<td>21. Jacaranda</td>
<td>Jacaranda mimosifolia</td>
</tr>
<tr>
<td>22. Lesena</td>
<td>Leucaena leucocephala/L. diversifolia</td>
</tr>
<tr>
<td>23. Mandarine</td>
<td>Carica reticulata</td>
</tr>
<tr>
<td>24. Pinusi/umubunda</td>
<td>Pinus sp.</td>
</tr>
<tr>
<td>LOCAL NAME</td>
<td>SCIENTIFIC NAME</td>
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<tr>
<td>-----------------------------</td>
<td>--------------------------------------</td>
</tr>
<tr>
<td>25. Seremoliya</td>
<td>Annona cherimola</td>
</tr>
<tr>
<td>26. Umudwedwe</td>
<td>Plumeria alba</td>
</tr>
<tr>
<td>27. Umukunde/Itenderwa</td>
<td>Cajanus cajan, c. indicus</td>
</tr>
<tr>
<td>28. Umunoferiya</td>
<td>Eriobotrya japonica</td>
</tr>
<tr>
<td>29. Umutima w'imfizi</td>
<td>Annona reticulata</td>
</tr>
<tr>
<td>30. Umuzonibari</td>
<td>Cupressus/usitanica</td>
</tr>
<tr>
<td>31. Umwembe</td>
<td>Mangifera indica</td>
</tr>
<tr>
<td>32.</td>
<td>Dovyalis caffra</td>
</tr>
<tr>
<td>33. Akaziraruguma</td>
<td>Begonia meyeri johanni</td>
</tr>
<tr>
<td>34. Amadwedwe</td>
<td>Euphorbia grantii</td>
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<tr>
<td>35. Bambuwa</td>
<td>Coryza sumatrensis</td>
</tr>
<tr>
<td>36. Barakatsi</td>
<td>Acacia mearnsii</td>
</tr>
<tr>
<td>37. Bugangabukare</td>
<td>Hygrophila auriculata</td>
</tr>
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<td>38. Iboeri</td>
<td>Morus alba</td>
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<tr>
<td>39. Icyicamahirwe</td>
<td>Tithonia sp.</td>
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<tr>
<td>40. Icyuyyu</td>
<td>Pavonia urens</td>
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<tr>
<td>41. Icyumwa</td>
<td>Trichodesma zeylanicum</td>
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<tr>
<td>42. Idaforoma</td>
<td>Vinca rosea</td>
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<tr>
<td>43. Idoma</td>
<td>Vernonia aenulans</td>
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<tr>
<td>44. Igicucu</td>
<td>Manihot glaziovii</td>
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<td>45. Igicumucum</td>
<td>Botriocline ugandensis</td>
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<td>46. Igicunshu</td>
<td>Coleus kilimandschari</td>
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<tr>
<td>47. Igihungeri</td>
<td>Protea madiensis</td>
</tr>
<tr>
<td>48. Ighondohondo</td>
<td>Dracaena steudneri</td>
</tr>
<tr>
<td>49. Igikakarubamba</td>
<td>Aloe dawei</td>
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<tr>
<td>50. Igikakarubamba kizungu/taburini</td>
<td>Aloe sp.</td>
</tr>
<tr>
<td>51. Igikamba/itabi</td>
<td>Nicotianum tabacum</td>
</tr>
<tr>
<td>52. Igisura</td>
<td>Urtica dioica</td>
</tr>
<tr>
<td>53. Igitabitabi</td>
<td>Nicotianum tabacum (wild tobacco)</td>
</tr>
<tr>
<td>54. Igitenetene</td>
<td>Kalanchoe sp.</td>
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<tr>
<td>55. Igitoborwa</td>
<td>Solanum capsicoides</td>
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<tr>
<td>56. Igitotsi</td>
<td>Blumea alata (syn lagera)</td>
</tr>
<tr>
<td>57. Igiturabuguma</td>
<td>Hibiscus diversifolius</td>
</tr>
<tr>
<td>58. Igitovu</td>
<td>Acanthus pubescens</td>
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<tr>
<td>59. Ikarambwe</td>
<td>Rubia cordifolia</td>
</tr>
<tr>
<td>60. Ikegera</td>
<td>Senecio ladiensis</td>
</tr>
<tr>
<td>61. Ikibonobono</td>
<td>Ricinus communus</td>
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</tbody>
</table>
62. Ikibonobono | Psychotria sp.
63. Ikiwarara | Berkheya spekeana
64. Ikiha/umuduha | Euphorbia candelabrum
65. Kimungu | Opuntia vulgaris/O. ficus indica
66. Ikinvankurwe | Clerodendrum fuscum/johnstonii
67. Inkinyononyondo | Kalanchoe sp.
68. Ikizimyamuliro | Guizotia scabra
69. Ikiziranyenzi | Clerodendrum rotundifolium
70. Ikura | unidentified sp.
71. Imbabazi | Microg/ossa pyrifolia
72. Indarama | unidentified sp.
73. Inkeli/umukeli | Rubus rigidus
74. Intobo | Solanum aculeastrum
75. Intoryi | Solanum melongena
76. Inyabarasa | Bidens pilosa
77. Inzirane | Cassia floribunda
78. Iralire | Senecio stuhlmannii (syn. cydonifolia)
79. Ireke/Iginetenete | Kalanchoe beniensis
80. Isonga | Ocimum americanum
81. Kamenamaseke | Polygala luteo-viridis
82. Kavunjahomo/akavunjahoma | Chenopodium ambrosioides
83. Mahuru | Leptactina platyphilla
84. Magaru | Hypoestes verticillaris
85. Nyirakayenzi | unidentified sp.
86. Quinquina | Cinchona sp.
87. Rubamba | Sanseveria sp.
88. Rubilika | unidentified sp.
89. Ubuhandanzovu | Tribulus terrestris
90. Ubutwiko | Helichrysum fruticosum
91. Umubazi | Monechma subsessile (epiphyte)
92. Umubili | Vernonia amygdalina
93. Umubogora | Cissus quadrangularis
94. Umucaca | Cynodon aethiopicus/C. ulemfuensis
95. Umucucu | Solanum incanum
96. Umucundura | Triumfetta sp.
97. Umucyuro | Cassia didymobotrya
98. Umufatangwe | Celaspinia decapetala
99. Umufumba | Ekebergia capensis
100. Umufumbageshi | Balthasaria schlebenüvar. intermedia
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<th>Number</th>
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<th>Name 2</th>
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<td>101</td>
<td>Umuganashya</td>
<td>Cussonia ho/stii</td>
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<td>102</td>
<td>Umugasa</td>
<td>Toddalia asiatica</td>
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<td>103</td>
<td>Umugano</td>
<td>Arundinaria alpina</td>
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<td>Umugombe</td>
<td>Chenopodium ugandae</td>
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<td>Umugote</td>
<td>Syzygium parviflorum</td>
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<td>106</td>
<td>Umugwamporo</td>
<td>Trema orientalis</td>
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<td>Umuhanga</td>
<td>Maesa lanceolata</td>
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<td>Umuharakuku</td>
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<td>Umuhati</td>
<td>Dracaena afromontana</td>
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<tr>
<td>111</td>
<td>Umuhati kizungu (has red leaves)</td>
<td>Dracaena afromontana?</td>
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<td>Umuhatu</td>
<td>Pavonia patens</td>
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<td>Umue</td>
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<td>Umuhengeli</td>
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<td>Umuhokoro</td>
<td>Mikaniopsis tedlei</td>
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<td>117</td>
<td>Umuhombo</td>
<td>Ficalhoa laurifolia</td>
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<td>118</td>
<td>Umuhuhu</td>
<td>Physalis peruviana</td>
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<td>119</td>
<td>Umuhuhwe</td>
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<td>Umuhumuro</td>
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<td>123</td>
<td>Umukiryi</td>
<td>Virectaria major</td>
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<td>124</td>
<td>Umuko</td>
<td>Erythrina abyssinica</td>
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<tr>
<td>125</td>
<td>Umukobe</td>
<td>Ficus sp.</td>
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<tr>
<td>126</td>
<td>Umukoni</td>
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<td>127</td>
<td>Umukoni kizungu (has red leaves)</td>
<td>Synadenium compactum</td>
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<td>Umukonora</td>
<td>Gloriosa simplex</td>
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<td>129</td>
<td>Umukorokombe</td>
<td>Grewia similis</td>
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<td>Verbena officinalis</td>
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<td>131</td>
<td>Umukubayoka</td>
<td>Cassia floribunda</td>
</tr>
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<td>132</td>
<td>Umukumbuguru</td>
<td>Clerodendrum buchholzii</td>
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<td>133</td>
<td>Umukurazo</td>
<td>Vernonia hochstetteri</td>
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<td>Umukuzanyana</td>
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<td>Umumenamabuye</td>
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<td>Umumeya</td>
<td>Albertisia exelliana</td>
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<td>Umunanira</td>
<td>Rhamnus prinoides</td>
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<td>139</td>
<td>Umunkamba</td>
<td>Clematis sinensis/C. hirsuta</td>
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<tr>
<td>140</td>
<td>Umuno</td>
<td>Clausena anisata</td>
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<tr>
<td>141</td>
<td>Umunyegenyege</td>
<td>Sesbania sesban/S. macrantha</td>
</tr>
</tbody>
</table>
142. Umunyinya: Acacia sieberiana
143. Umuravumba: Tetradenia riparia
144. Umurehe: Ficus vallis-choudae
145. Umurerabana: Vernonia adoensis
146. Umuretezo: Anisopappus africanus
147. Umurogora/umukaka: Bersama abyssinica
148. Umuryogera: Crotalaria recta
149. Umuruku: Tephrosia vogelii.
150. Umusagara: Rhus vulgaris
151. Umusange: Entada abyssinica
152. Umusarenda: Trumfetta cordifolia
153. Umusasa: Sapium ellipticum
154. Umusave: Markhamia lutea
155. Umusebe: Cassia floribunda
156. Umusebeya: Albizia sp.
157. Umusekera: Macaranga neomilbreadiana
158. Umusena/umuseno: Ficus asperifolia
159. Umusene: Dasylepis racemosa
160. Umushubi': Maytenus sp./Dovyalis sp.
161. Umushunshu: Solanum incanum
162. Umusororo: Indigofera erecta
163. Umutagara: Senecio mannii
164. Umutagarasoryo: Solanum anguivi/S. indicum
165. Umutakaforo: unidentified sp.
166. Umutarishonga: Cluytia abyssinica
167. Umutinsyi: Erytroccoca bongensis
168. Umutobotobo: Solanum aculeastrum
169. Umutozo: Hibiscus fuscus
170. Umuturirwa: Waltheria indica
171. Umuturuturu: Schefflera goetzenii
172. Umuvumo: Vernonia sp.
173. Umuvumu/gasuru: Ficus thonningii
174. Umuyenzi: Euphorbia tirucalli
175. Umuyogera/kayogera: Crotalaria incana sp. purpurescens
176. Umuyogoro: Millettia dura
177. Umuyoka: Cassia occidentalis
178. Umuzabibu: unidentified sp. [raisin]
179. Umuzibaziba: Mitragyne rubrostipulata
180. Umwamira: Terminalia mollis?
181. Umwange: Senecio angulatus
182. Umwanzuranya: Vernonia smithiana
183. Umwenya Ocimum suave
184. Umwisheke Chenopodium ambrosoïdes
185. Umwumba Prunus africana
186. Umwungo Polyscias fulva
187. Uruberwa Hibiscus cannabinus
188. Urubingo Pennisetum purpureum
189. Uruhehe Botriocline longipes
190. Uruheza Phyllanthus niruri
191. Urukwamo Pennisetum sp.
192. Urusayura Thunbergia alata
193. Urusenda Capsicum frutescens

**Glossary**

**French words**
- Agronome de commune: municipal agricultural officer
- Banque Populaire: workers bank
- Cellule: neighbourhood
- Colline: hill
- Commune: municipality
- Conseiller: municipal counsellor, alderman
- Foyer Social: Social Centre
- Jeunesse Ouvrière Chrétienne: Young Christian Workers (Catholic youth organization)
- Préfecture: prefecture, province
- Secteur: district

**Kinyarwanda words**
- Amashyamba: woodlots
- Bintu: things
- Kintu: being without intelligence; thing
- Ibiti: trees
- Igerageza: experiment
- Igishonyi: light coloured chalk soils mixed with mica
- Igiti: tree
- Imirima: crop fields
- Ingo: home compounds
- Intoki: banana plantations
- Ishyamba: woodlot
- Rugo: home compound
- Ubumenyi: knowledge, experience, science
Umurima crop field
Urutoki banana plantation
Urwagwa banana beer
Urururi permanent pasture
Inombe red, lateritic soil more clayey and heavier than urunombe red, lateritic soil
Mugugu heavy clay soil
Umusenga sandy soils, but with better water retention than urusenyi
Urusenyi sandy soils
Urubuye coarse, gravelly sand soil
Urunombe red, lateritic soil

Definition of terms

**Indigenous:** "Existing, growing or produced naturally in a region or country; innate, inherent, inborn." (Webster's New World Dictionary of the American Language, Second College Edition, 1986). Tree species that are native and naturally occurring in the study areas.

**Endogenous:** "Developing from within, originating internally." (Webster's New World Dictionary, 1986). Used to describe the nature of farmers' knowledge that is developed from within a local social system (ethnic group, people with a defined geographical or biophysical area) and based on that system's beliefs, values and norms, and definitions of problems and acceptable solutions.

**Exogenous:** All knowledge that comes from outside the local social system, i.e. from people from different geographic areas, different ethnic groups, or from (formal) research and extension. While researchers and extensionists could belong to the local social group, the knowledge they possess and advocate is (for the most part and in most cases) not based on the belief, meanings and values of the social group, but is derived from elsewhere. Thus, researchers and extensionists represent and belong to an exogenous (namely the scientific) knowledge system.

**Scientific:** Knowledge and technologies that are developed using scientific methods, i.e. inductive and deductive reasoning, hypotheses testing, controlled experiments. This research was carried out in two phases with different groups of farmers who are distinguished as informants, tree experts, consultants and comparison farmers. Each of these terms is described below.

**Informants:** The first phase of the research concerned the identification of farmers within the community deemed the most knowledgeable about trees and tree cultivation in the eyes of their fellow farmers. A variation of the wealth ranking game was used to extract information from a sample of farmers about the knowledge of other community members. The participants in the ranking game are the informants.

**Tree experts:** The farmers who know a lot about trees and tree cultivation are considered "experts" by their fellow farmers. It would be wrong to call them "expert farmers", as a
number of farmers referred to as tree experts were not thought of very highly regarding their farming skills.

**Comparison farmers:** Farmers who practice agroforestry and have knowledge about trees and tree cultivation that is different from the agroforestry systems and agroforestry knowledge of tree experts. This group of farmers was chosen to represent the general farm population for comparison with tree experts, in terms of education, socioeconomic and political factors, access to resources, etc.

**Consultants or farmer-consultants:** The term is used to refer to all farmers (both tree experts and comparison farmers together) who participated in the second phase of the study. These farmers acted as teachers for the researcher and his assistants, provided services, expert advice and helped explain their agroforestry systems, their underlying knowledge and the processes behind the generation of this knowledge.

The objective of studies of endogenous knowledge is to show that farmers do have knowledge, are actively engaged in research to develop this knowledge and can be experts in specialized fields just as people who have formal education and training based on scientific principles. If it is accepted that farmers have important contributions to make to development, and if they are considered equal participants in technology development, they should be treated as such and referred to with the same words.

**Acronyms and abbreviations**

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<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>BGM</td>
<td>Bugesera-Gisaka-Migongo</td>
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<tr>
<td>CARE</td>
<td>Cooperative for American Relief</td>
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<td></td>
<td>Everywhere (US NGO)</td>
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<tr>
<td>CGIAR</td>
<td>Consultative Group on International Agricultural Research</td>
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<tr>
<td>CIAT</td>
<td>Centro Internacional de Agricultura Tropical</td>
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<tr>
<td>D &amp; D</td>
<td>International Centre for Tropical Agriculture</td>
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<tr>
<td></td>
<td>diagnosis and design</td>
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<tr>
<td>ELCI</td>
<td>Environment Liaison Centre - International</td>
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<td>EMSP</td>
<td>Etudes de Milieu et Systèmes de Production (Characterization and Farming Systems Department of ISAR)</td>
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<tr>
<td>GNP</td>
<td>gross national product</td>
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<tr>
<td>GTZ</td>
<td>German Agency for Technical Cooperation (Gesellschaft fur Technische Zusammenarbeit)</td>
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<tr>
<td>ICRAF</td>
<td>International Centre for Research in Agroforestry</td>
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<td>ISAR</td>
<td>Institut des Sciences Agronomiques du Rwanda (National Agricultural Research Institute of Rwanda)</td>
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Bibliography


