Agroforestry study visit to Malawi and Zambia, 20–30 January 2002

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And special thanks are due to all the farmers who went out of their way to share their experiences in agroforestry with the visitors. As they say in *Chichewa* in Malawi, we say to those farmers *"Zikomo kwa mbili*".

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1

Introduction

The agroforestry study visit to Malawi and Zambia from 20 to 30 January 2002 was sponsored by the Technical Centre for Agricultural and Rural Cooperation (CTA), and co-hosted by CTA and the Malawi Agroforestry Extension (MAFE) Project, in cooperation with Malawi's Ministry of Agriculture and Irrigation.

CTA was established in 1983 under the Lomé Convention between ACP (African, Caribbean and Pacific) Group of States and the European Union Member States, and now operates under the Cotonou Agreement. Its tasks are to develop and provide services that improve access to information in agricultural and rural development and to strengthen capacity of ACP countries to produce, acquire, exchange and utilise information in these areas. CTA organises study visits as one of its strategies for promoting the exchange of information. The MAFE Project was established through a collaborative grant agreement between the United States Agency for International Development (USAID) and Washington State University, and is implemented by the Land Resources Conservation Department in Malawi's Ministry of Agriculture and Irrigation. The project aims to improve natural resource management and sustained farm productivity by encouraging the adoption of agroforestry and soil conservation practices.

1.1 Rationale for the study visit

Among the participants in the study visit were experienced researchers, extension and development workers, seed experts and trainers from public and private sectors in Eastern and Southern African countries. These countries are faced with common land use problems for which agroforestry solutions are relevant. The current agricultural policies of the respective governments are geared towards enhancing food security and income generation by increasing farm production. The study visit provided the participants with an excellent opportunity to see at first hand a range of agroforestry technologies being implemented by farmers and/or researchers to address land-use constraints. Both Malawi and Zambia have had over a decade of experience in collaborative agroforestry research and development, and this experience formed an important basis for the visit.

Sites were selected to show the participants a wide range of agroforestry initiatives and activities relevant to participants' countries. These included:

- agroforestry technologies for improving soil fertility (e.g., improved fallows, relay cropping, tree/crop mixed intercropping, and use of herbaceous legumes such as *Mucuna* sp.);

- agroforestry technologies for soil and water conservation (e.g., contour tree planting, contour hedges, grass/tree strips;
- fodder banks;
- woodlots, trees on farm boundaries and around homesteads for fuelwood, poles and timber;
- live fences, using such species as *Acacia polyacantha*. and *Ziziphus* sp.;
- adoption of agroforestry by farmers, and impact of this strategy;
- individual and group farmer tree nurseries;
- seed collection, processing and distribution to farmers;
- promoting the domestication of indigenous fruit trees through collection of germplasm, evaluation, development of propagation techniques and fruit processing.

1.2 Study visit objectives

The main objective was to improve the participants' understanding of agroforestry through visits to agroforestry projects in Malawi and Zambia and through discussions with various actors in agroforestry development. The study visit gave participants an opportunity to see the latest advances in agroforestry development in the two countries achieved through collaboration between the NARS and with various regional research and development agencies.

It was envisaged that by the end of the study visit the participants would:

- be aware of the main land-use problems being addressed though agroforestry in Malawi and Zambia;
- be aware of the agroforestry technologies being applied or tested by farmers and/or researchers;
- learn about agroforestry technologies, their potential and limitations, and their dissemination;
- learn about farmer experimentation and farmer-to-farmer training, and the impact of these activities on technology dissemination and adoption;
- be more aware of agroforestry developments in their own countries;
- establish links among themselves and with various actors in agroforestry in Malawi and Zambia;
- be able to relate their experiences and problems to the approaches being used in Malawi and Zambia.
- have a greater understanding of the future direction of agroforestry research and development in the region.

1.3 Selection of participants

The study visit announcement was sent out to government and non-government institutions involved in agroforestry research, development, extension and training, and seed production and distribution in Botswana, Kenya, Malawi, Namibia, Swaziland, Tanzania, Uganda, Zambia and Zimbabwe. Each institution was asked to nominate 2–3 people from whom CTA made the final selection, based on:

- academic qualifications: at least a first degree (with a postgraduate degree being an added advantage);

- experience: more than 5 years experience related to agroforestry development;
- age: under 40 years old;
- the candidate not having participated in similar visit in Malawi and Zambia in the previous 2 years
- ensuring an even representation in terms of countries, experience, scientific discipline and gender.

Thirty nominations were received, from which 21 participants were selected. Two Kenyan participants dropped out at the last minute due to unavoidable circumstances.

1.4 Schedule

The tour started in Malawi and then moved to Chipata in eastern Zambia. The visits to farms and research stations were interspersed with presentations and discussions of country reports. At the end of each day the rapporteur for that day outlined the highlights to the participants and they discussed what they had seen during the day and the lessons learnt. At the end of the Zambia tour, the participants returned to Malawi to discuss and evaluate the study visit and formulate their conclusions and recommendations.

2

Agroforestry in the SADC region: an overview

The SADC region comprises 11 Southern African countries: Botswana, Malawi, Mozambique, Lesotho, Swaziland, Angola, Namibia, South Africa, Tanzania, Zambia and Zimbabwe. The region has a population of about 141 million people. Agriculture is the mainstay of the economies of most SADC countries. Not only does it contribute significantly to the GDP and employment, but it is also central to food security in these countries. The people depend on the land for food, energy, timber and medicine; for most of them, land is by far the most important natural resource that they have.

Most farmers are smallholder farmers, about 80% of whom are resource-poor, with their production still at subsistence level. Most farming in the SADC region is rainfed, with a unimodal rainfall regime. Mean annual rainfall ranges between 500 and 1200 mm. There is one growing season, from December to April, followed by a long dry season. The dominant farming system is subsistence maize and livestock production based on a free-range extensive system.

2.1 Land-use problems

Farmers in SADC countries face two major land-use problems: declining soil fertility and shortage of livestock fodder, particularly during the long, dry season. Other problems of regional importance are environment degradation through deforestation and cultivation of uplands, declining supply of fuelwood, soil degradation, and loss of biological diversity caused by slash-and-burn agriculture (Ngugi, 1996). These land-use problems are exacerbated by the following factors:

- Most countries in the region have high population growth rates, putting great strain on the natural resource base (annual regional growth rate is projected at 3%). Some countries have high population densities (200–400 people/km^2) in certain areas (e.g., in the Shire Highlands, southerrn Malawi);

- The rapidly growing populations have resulted in farm size reductions. In the Shire highlands, farm holdings per household are a mere 0.1–0.5 hectares. Small farm sizes preclude the practice of traditional land fallowing as a means of restoring soil fertility and productivity;

- Most smallholder farmers practice monoculture, with maize as the dominant crop. Maize tends to deplete soils, and thus continuous maize growing without replacing the nutrients that the crop removes leads to rapid declines in soil fertility and crop yield;

- Most farmers are resource-poor, and their farming practices are characterised by little or no use of fertilizer, resulting in very low yields (e.g., 500 kg/ha of maize). Very little animal manure is used to maintain soil fertility, mainly because most of the farmers do not own livestock. The free-range extensive livestock production system precludes the collection of livestock manure for application on fields. In some areas crop residues and cow dung are burnt as a source of energy, thus exacerbating the problem of soil nutrient depletion.

- The removal of government subsidies on inputs under the economic liberalisation programmes in most countries has led to an escalation in the costs of farm inputs, especially fertilizers and credit.

- The rapid increases in population has extended the area under cultivation, to the detriment of grazing areas for livestock. The shortage of livestock fodder, particularly in the dry season, has thus become a serious problem.

- Population pressure on land has aggravated fuelwood shortages, and this in turn has accelerated deforestation and the erosion of biodiversity.

2.2 Agroforestry development and potential in Southern Africa

Agroforestry is defined as 'a land-use system in which woody perennials (trees, shrubs, palms, bamboo) are deliberately used on the same land management unit as agricultural crops (woody or not), animals or both, either in some form of spatial arrangement or temporal sequence. In agroforestry systems there are both ecological and economic interactions between the different components" (Huxley *et al*., 1997).

Agroforestry has the potential to arrest land degradation and rural poverty by addressing the many land-use problems that confront smallholder farmers in the SADC region. Traditionally, African farmers have practised agroforestry since time immemorial (e.g., the slash-and-burn *chitemene* system practised by the Bemba people of northern Zambia; the *chagga* system involving trees and shrubs on farmland practised by the Wachagga people of the Kilimanjaro area in Tanzania; and the *taungya* or *shamba* system in Eastern and Central Africa). Therefore, applying new agroforestry technologies to tackle land-use problems is a practical proposition for most farmers in the region.

These land-use problems include:

- **Declining soil fertility.** Incorporation of nitrogen-fixing leguminous trees, shrubs or herbaceous plants into the land-use system improves soil fertility through, among other factors, enhancement of soil nitrogen and other nutrients. Inadequate nitrogen is one of the main factors limiting the production of maize and other crops on small holder farms in the SADC region. Resource-poor farmers stand to benefit the most from such low-input technology.

- **Shortage of livestock fodder**. Introduction of fodder trees and shrubs in the farming system has the potential to provide highly nutritious fodder for the livestock. *Calliandra* and *Leucaena*-based fodder banks have demonstrated great potential for peri-urban milk production in Zimbabwe and Kenya (ICRAF, 1998).

- **Natural resource degradation.**Agroforestry technologies have the potential to address the problems of:
  - deforestation (e.g., by planting trees on the farm)
  - soil erosion, through contour tree planting and afforestation of steep land
  - erosion of biological diversity (e.g., by practicing *in situ* conservation and/or domestication of indigenous fruit and medicinal trees)

- **Shortage of fuelwood and various tree products**.Using rotational woodlots and planting trees on farm boundaries and/or around homesteads can contribute to the supply of fuelwood and various tree products, such as timber, poles and fruits. The production of fuelwood on the farm has the additional benefit of saving labour, which is particularly beneficial to women who are the main source of farm labor and spend long hours collecting firewood from distant places for domestic use.

2.3 Agroforestry research

Since the mid-1980s the International Center for Research in Agroforestry (ICRAF), in collaboration with national agricultural and forestry research systems, has spearheaded agroforestry development in Southern Africa. The launch of the SADC-ICRAF Agroforestry Project in 1986, in particular, has stimulated rapid advancement in agroforestry technology research and generation. This regional project involves Malawi, Tanzania, Zambia and Zimbabwe. National governments and donor agencies have contributed financial support to agroforestry development in the region; other agencies involved include the international agricultural research centers (IARCs) and non-governmental organisations (NGOs) such as the World Vision, the Lutheran World Federation and CARE International.

- research (technology generation and dissemination);

- capacity building in research and training. The training has focused on researchers, extension specialists and farmers. With the help of ICRAF, agroforestry education has been expanded and strengthened at university, college, school and farmer levels, partly through the introduction of agroforestry as a subject in the curriculum and through the production of appropriate teaching materials. The African Network on Agroforestry Education (ANAFE), formed in 1993 and based at ICRAF headquarters, has been very active in promoting agroforestry education in Eastern and Southern Africa (Temu *et al*., 2001).

Multipurpose tree screening

Agroforestry research includes collecting and screening the germplasm of multipurpose trees for use in generating agroforestry technologies. The trees are evaluated for adaptability, response to management practices (e.g., spacing, pruning), competitiveness, weeding needs, biomass yield, and effect on soil and crop/fodder yields. Several indigenous and exotic agroforestry tree species have been identified, notably *Sesbania sesban, Leucaena leucocephala, Gliricidia sepium, Cassia siamea, Cassia spectabilis*, Australian acacias (e.g., *A. crassicarpa, A. julifera*), *Azadrachta indica, Melea azederach,*

Pilliostigma thonningi, Tephrosia vogelii and *Cajanus cajan* (Maghembe *et al*., 1997; Saka *et al*., 1990).

A region-wide collection of *Sesbania* and *Tephrosia* species has been conducted by the SADC-ICRAF Agroforestry Project, based on excellent performance of these species in improving soil fertility and on the need to broaden the species genetic base. Out of the 106 species and provenances of *Sesbania* collected in the region and evaluated, only 24 demonstrated potential for use in improved fallows. Four of these seem to be tolerant to the mesoplatys beetle, a serious pest of *Sesbania* in the region (ICRAF, 1997).

Some promising multipurpose tree species such as *Leucaena* have turned out to be highly susceptible to *Psyllid*. The SADC-ICRAF project has identified some *Psyllid*-tolerant species.

Soil fertility

Improved fallows. Two and three-year *Sesbania sesban*-based fallows have proved highly effective in soil fertility restoration in the region, particularly in Zambia where land is not a limiting factor and therefore fallowing to restore for soil fertility is a practical proposition. For example, maize grain yield following a 3-year *Sesbania sesban* fallow without N fertilizer in Chipata, Zambia was 2.27, 5.59 and 6.02 t/ha after 1, 2 and 3 years fallow respectively, compared with the control plots with 1.6, 1.2, 1.8 t/ha after 1, 2 and 3 years of continuous cropping (Kwesiga *et. al*., 1994). The *Sesbania* fallow also yields wood as a bonus. The wood is highly valued as fuelwood, particularly in parts of Malawi where fuelwood is scarce. Even in areas where farm size is too small to accommodate fallows, niches where land is left fallow for one reason or other can use the improved fallow technology. This technology has limitations (e.g., dependence on one species and the need to establish trees every 2 years after the decline of soil fertility during the cropping phase). Through research, alternative species which can be directly seeded (instead of using seedlings) are being sought. By 1998, 4665 farmers in Zambia were experimenting with improved fallows. In Malawi over 1000 farmers were experimenting with improved fallows, relay cropping and mixed intercropping with *Gliricidia* (ICRAF, 1998).

Relay cropping. This technology involves inter-planting maize and *Sesbania* seedlings concurrently but maintaining the desired maize population. After harvesting the maize crop, the Sesbania trees are left to grow during the ensuing dry season, utilising residual moisture. The trees are cut down before the following planting season and the leafy residues incorporated into the soil. Stems and woody branches are harvested as fuelwood. This process is repeated in subsequent cycles. The results from Makoka Research Station, Malawi, demonstrated higher maize yields from relay-cropped plots than from plots that had been continuously monocropped with maize without fertilizers. Although the application of fertilizers resulted in the highest yields of all, relay cropping, in which maize yields were double that from control plots, proved the best option for resource-poor farmers in the Shire Highlands. Most of these farmers cannot afford chemical inputs. The fuelwood from the system is a highly valued added advantage in an area with an acute shortage of fuelwood (Maghembe *et al*., 1997). Relay cropping is best suited to densely populated areas where farm sizes are too small to accommodate normal rotational fallows.

Mixed inter-cropping with *Gliricidia*. One of the drawbacks of improved fallows is the laborious planting of trees every 2–3 years. Maize/*Gliricidia* inter-cropping is an alternative technology for soil improvement that overcomes this problem. The maize and *Gliricidia* are established concurrently on the same plot. Tree growth is kept in check by pruning back to prevent maize shading. The nitrogen-rich tree prunings are left on the plot as green manure. *Gliricidia* is a nitrogen-fixing tree from Central America. It is adapted to repeated cutting back without dying. The tree takes 2–3 years to become fully established, depending on the climate. In the Shire Highlands in Malawi, as many as 2–4 prunings are obtained each year, giving 2–7 t/ha of biomass. The nitrogen equivalent that is added to the soil through the biomass ranges from 60 to 120 kg/ha/yr (Ikerra *et al.,* 1999). Maize yields in *Gliricidia* plots during the first and second year of establishment are similar to those from non-fertilized farmers' plots. Yields from the third year onwards, however, are markedly increased by *Gliricidia* manuring to an average of 1800–2500 kg/ha (Bohringer, 2001). Some of the drawbacks of this technology are the 3 years gestation period before the benefits start accruing, a shortage of *Gliricidia* seed and the high labour requirements for pruning. However, the elimination of biennial replanting of trees and the higher maize yields are considered sufficient incentives for farmers (Bohringer, 2001). *Gliricidia* and *Leucaena* coppicing fallows at Chipata have maintained maize yields at 3.5t/ha over six seasons without fertilizer applications (Mafongoya *et al.,* 2001).

Biomass transfer technology. Farmers in Southern Africa traditionally apply plant biomass to the soil as a fertilizer. In Masvingo Province in Zimbabwe, farmers collect plant litter from the woodlands to put on soils that are very sandy (Nyathi and Campbell, 1994). The *chitemene* system practised by the Bemba of northern Zambia involves collecting tree biomass and burning it in heaps. The crop, usually maize or millet, is then planted in the resulting calcium and potassium-rich ash. This biomass transfer technology involves applying leguminous tree/shrub biomass to the soil as a source of plant nutrients. The biomass is raised *in situ* either in a woodlot or hedges. Applying *Leucaena* biomass at the rate of 1–5 t/ha on sandy soils in Tabora has resulted in maize yields comparable to those from plots receiving 25–100 kg N/ha. Similarly, applying the biomass of *Leucaena* raised on rice bunds at 3–6 t/ha in Shinyanga has significantly increased rice yields (ICRAF, 1995). In the same study at Shinyanga, *Sesbania* gave higher biomass production and better rice yield response than *Leucaena* and proved to be more tolerant to water logging than *Leucaena*. The practicality of biomass transfer as a technology depends on the availability of land, suitable tree species, and labour availability. It may be more economic to feed the biomass to dairy cattle where milk production is profitable and use the animal manure for soil improvement. The sustainability of the system in the long term needs further study. Among the species evaluated for use in biomass transfer are *Sesbania sesban*, *Gliricidia sepium*, *Indigofera erata*, *Leucaena leucocephala*, *Senna siamea*, *Piliostigma thonningi* and *Erioenna cajanoides*.

Fodder supply

Several agroforestry trees species have been evaluated as sources of livestock fodder in the region. The most promising species are *Calliandra calothyrsus, Leucaena leucocephala* and *Acacia angustissima*. These are grown either in hedges along the contour on farms or in woodlots. The protein-rich fodder is used as a supplement in animal feed, mainly for dairy cattle.

Fuelwood and timber

Some agroforestry technologies aimed at soil fertility improvement, such as improved fertility and relay cropping, also yield fuelwood. At Makoka Research Station in Malawi, relay cropping is reputed to yield up to 1.7 t/ha/yr of fuelwood. In Chipata in Zambia, 3-year fallow using various species yielded sizeable quantities of wood (Table 1).

Table 1 Wood yield after a 3-year fallow

Species	Wood yield (t/ha)
Senna siamea	32
Leucaena	29
Sesbania	24
Gliricidia	21
Flemingia	18
Calliandra	11

Several Australian *Acacia* species, such as *A. julifera, A. leptocarpa* and *A. crassicarpa*, have been identified for fuelwood and tobacco curing in Tabora, Tanzania (ICRAF, 1997). In Shinyanga, Tanzania, the farmers have adopted rotational woodlots using a range of tree species (e.g., *Albizzia lebbeck, Acacia polyacantha, Azadirachta indica, Leucaena leucocephala* and *Senna siamea*) for fuelwood and timber (poles) (ICRAF, 1996). A 4-year-old woodlot of *Acacia polyacantha* and *Leucaena leucocephala* at Shinyanga yielded over 12–15 t/ha of fuelwood annually (ICRAF, 1997). Boundary and homestead tree establishment also contribute to household fuelwood supplies.

Soil and water conservation

Research in Southern Africa has shown the effectiveness for soil and water conservation of agroforestry technologies such as contour tree planting, contour hedges and woodlots on steep slopes. *Leucaena* contour hedges have effectively controlled soil erosion on steep slopes in Ncheu, Malawi (Banda *et al*., 1994). Over the longer term, these hedges result in the formation of terraces on the upper side of each hedge, and it is then much easier to manage the terraces. Several multipurpose trees, including *Gliricidia, Senna spectabilis* and *Tephrosia,* have been identified in research on contour planting.

Indigenous fruit trees

The domestication of indigenous fruit trees is a significant agroforestry initiative in the SADC region. The importance of indigenous fruits as a source of nutrition and of cash was highlighted by ethnobotanical surveys conducted by ICRAF and national scientists in Malawi, Tanzania and Zambia in 1986-1988 (Maghembe *et al*., 1992; Karachi *et al*., 1991; Kwesiga *et al*., 1992). The surveys found, however, that all the 50 or more species of fruits consumed and/or sold by households were all collected from the wild; none was cultivated on the farm. The rampant deforestation of natural forests and woodlands is threatening indigenous fruits. The launch of the programme to domesticate and improve indigenous fruits under the SADC-ICRAF Agroforestry Project in 1993 was aimed at reversing this situation (Magembe, 1995). The research has shown that several indigenous fruits trees under farm management are fast growing and start fruit bearing 3–4 years after establishment. For example, *Azanza garkeana,*

Annona senegalensis Vangueria, infausta and *Tamarindus indica* yield fruit after 1–3 years of growth (Maghembe, 1995). A collaborative regional research programme funded by Bundeministerium für Wirtschaftliche Zusammenarbeit (BMZ) on indigenous fruit trees is focusing on *Strychnos cocculoedes, Uapaca kirkiana, Parinari curatellifolia* and *Sclerocarya birrea*. For *Uapaca kirkiana* and *Sclerocarya birrea*, 24 and 40 provenances, respectively, have been collected regionally for evaluation and selection at sites in Malawi, Tanzania, Zambia and Zimbabwe. Some of the research is on propagation techniques, managing indigenous fruit trees, and utilising and marketing the products. By 2001, over 5000 farmers in the region were conducting on-farm trials involving the germplasm of some 20,000 indigenous fruit trees (Bohringer *et al*, 2001).

Conclusion

The research on technology development has been accompanied by process research, which aims to discover how, why and where particular technologies perform the way they do. The answers to such questions would help improve the technologies and adapt them for new areas. Some of the process research includes studies on soil nutrient dynamics, competition effects on moisture and nutrient use, sustainability issues and the identification of new tree species so as to broaden germplasm base. Equally important is the research on policy, which aims to address issues such as land tenure and its influence on the adoption of agroforestry technologies. Some policy research is looking at technology dissemination and adoption pathways and impact.

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3

Field visits: observations

3.1 Malawi

DAY 1: MONDAY 21 JANUARY

A welcome address was given by Dr Trent Bunderson, Director of Malawi Agro forestry Extension Project (MAFE), the host institution. Then there was the official opening speech (*see* Annexes) given by Dr Charles Matabwa, Controller of Agriculture and Technical Services, Ministry of Agriculture and Irrigation, on behalf of the Government of Malawi.

Dr Gesa Wesseler, the CTA representative, welcomed the participants and thanked MAFE and the Government of Malawi for hosting the tour and the tour organisers for their hard work. The morning session closed with a debriefing of the participants by Professor David Ngugi, Consultant and Tour Organiser.

The participants then toured MAFE's Resource Center. The Center has cold rooms for seed storage and a warehouse for other seed, equipment and extension literature. Government departments and community-based organisations (CBOs) get extension material free-of-charge from MAFE. Non-governmental organisations (NGOs), individuals and other institutions pay 30% of the price. However, MAFE will soon be instituting a full cost-recovery programme. Perhaps this should have started earlier in order to build up strategic resources in view of the fact that donor funding to the project will soon come to an end.

Farm Visits

Farm 1: Mr Paul Jimu and Mrs Sipachoka
Machichi Village, Chief Masula, Lilongwe

Supported by the Department of Agriculture

Land-use problems

Soil erosion and poor soil fertility, and therefore low yields (particularly of maize, the staple food). The farmers could not harvest anything from their fields between 1980 and 1996.

Technologies seen

- Strips of vetiver grass planted on contour banks to control soil erosion.

- Mixed intercropping of maize with *Gliricidia sepium* and *Senna spectabilis*. According to the farmers, this technology produced less biomass than *Tephrosia*-improved fallows.

- Undersowing of maize with *Tephrosia vogelii*. Maize planted with *T. vogelii*. *Tephrosia* biomass accumulated in one season is incorporated into the soil at the start of the following season.

- Two-year fallow with *Tephrosia vogelii*. *T. vogelii* planted and left to grow for 2 years, then cleared after two seasons. Twigs were taken to the homestead for firewood. Some twigs were also sold to neighbors (evidence of severe shortage of firewood in this land-use system). Maize planted 4 weeks after incorporation of biomass failed. Although the extension officers were not sure why the crop failed, it was probably because of high temperatures resulting from the decomposition of *T. vogelii* biomass. There appears to be knowledge gap regarding the correct timing of maize planting after the application of *T. vogelii* biomass.

- Alley cropping of maize with *Tephrosia vogelii*. Maize planted with *T. vogelii* (5 rows maize / 2 rows *T. vogelii*). Biomass from *T. vogelii* alleys was applied on the maize crop in between the rows.

- Conservation of indigenous trees. The farmer left a few indigenous trees in the field for medicinal purposes, shade and fruit.

For some reason, the immediate neighbours of Farm 1 had not adopted agroforestry, but 20 farmers some distance away have since adopted the technology based on undersowing maize with *T. vogelii.*

Farm 2: Mr Manda Governor
Kupimbi Village, Mitundu Area

Supported by Tobacco Exporters Association of Malawi (TEAM) Tree Project

Land-use problem

Shortage of fuelwood for hanging barley tobacco leaf during curing.

Technologies seen

- Woodlot of *Senna siamea* and *S. spectabilis* planted around homestead.
- TEAM is funding a tree planting project in this area. Some of the trees are planted along farm boundaries.

This farmer copied the woodlot technology from another farmer. They selected *S. siamea* and *S. spectabilis* because these species are resistant to browsing and termite attack. Some farmers from the five villages were trained as trainers. The group has a communal tree nursery but individuals establish tree seedlings on their individual plots. The trees are closely spaced for the production of sticks for hanging tobacco during curing. After tree thinning, farmers get fuelwood, as well as poles for construction. The farmers in Governor's village are diversifying into soil fertility improvement with *Faidherbia albida* and *Tephrosia vogelii.*

Farm 3: Mr Charles Msoya
Kasudze Village, Mitundu Area

Supported by Lilongwe West Evangelical Lutheran Development Programme (ELDP)

Land-use problem

Declining crop yields due to poor soil fertility and shortage of fuelwood and poles.

Technology seen

- Homestead and boundary tree planting.

The farmer's wife said fuelwood is a major problem. The farmer established a woodlot of *S. siamea* and *S. spectabilis* around the homestead. He has seedlings for expanding the area planted.

Farm 4: Mr Lantou Balala
Kasudze Village, Mitundu Area

Supported by ELDP

Land-use problem

Declining soil fertility.

Technology seen

- Modified annual *Tephrosia* fallow that was highly impressive in terms of growth vigor. The farmer hoped to at least double his maize yield. *Tephrosia* was preferred because it produced a lot of seed,

enabling farmers to be self-sufficient for seed. This was the farmer's first experience of planting *Tephrosia vogelii*. It is planted on the side of the ridge, on top of which maize is intercropped with beans. *T. vogelii* biomass is incorporated after one season's growth.

Farm 5: Mr Langton Balala
Kasudze Village, Mitundu Area

Supported by ELDP

Land-use problem

Poor soil fertility.

Technology seen

- Annual *Tephrosia* fallow.

Maize was planted 1 month after incorporating *Tephrosia vogelii* biomass from a 2-year fallow. Crop growth on this farm was vigorous, whereas the neighbour's crop looked very poor – yellow and stunted. The farmer reported that the neighbor had asked for seed for the next season.

Day 1: concluding remarks

- Farmer-to-farmer training seems to be an effective tool for extension in Malawi.
- Undersowing maize with *Tephrosia vogelii* proved very popular where there is a land shortage. Research should come up with species/provenances that produce a lot of biomass quickly. *Tephrosia vogelii* Madagascar (a provenance performing well in Zambia) could be a promising candidate.
- The extension service tended to approach farmers with individual extension messages, depending on extension officer's discipline or organisation. There is a need to pass integrated messages to farmers for better results and impact.

DAY 2: TUESDAY 22 JANUARY

Visited two villages (Chonde and Chembe) in Kasungu that are supported by an NGO, Total Land Care (TLC). TLC works with 10 villages. It is promoting the under-sowing *Tephrosia vogelii* in maize, as well as other technologies.

Farm Visits

Farm 6: Mr Scaliot Jose
Chonde Village, Kasungu

Land-use problems

The village headman and his youthful committee and the villagers hosted the participants and presented two technologies: soil fertility improvement and tree woodlot around homesteads. The major problems faced by the farmers are soil erosion, infertile soils and lack of fuelwood. The farmer used to get 2–3 ox carts of maize from non-fertilised fields.

A TLC representative gave an address about trees on the farm to a meeting attended by Chiefs, who reported back to their villages. The people, in turn, approached TLC for technical assistance.

Technologies seen

- Following the advice provided by TLC, the farmers set up group nurseries, pegged marker ridges and planted *Tephrosia vogelii* with maize and *Faidherbia albida* (dispersed planting) for soil fertility improvement. They produced a village work plan with assistance from extension officers in the Extension Planning Area (EPA).

- Very small woodlots of *Senna siamea* and *S. spectabilis* were planted around homesteads. The planted area is limited by a shortage of space (average farm size per household is about 0.3 ha). The trees are closely spaced (1 x 1 m) – a modification of the recommended spacing (2 x 1 m). The farmers prefer the two *Senna* species because they are not palatable to goats.

Farm 7
Chembe Village, Kasungu

Land-use problems

The problems faced in Chembe are similar to those in Chonde: low crop yields due to poor soil fertility, soil erosion and lack of fuelwood. Following the awareness meeting attended by the village headman for Chembe, the village started using agroforestry practices, and they have a hired watchman to guard the communal nursery from thieves.

Technologies seen

- 100,000 seedlings were raised last season, providing each household with 400 seedlings. The village planted strips of vetiver grass to control erosion, *Tephrosia vogelii* and *Faidherbia albida*

for soil fertility improvement, and bamboo for crafts, roofing, fencing and food (juice). The farmers learnt about the importance of *F. albida* from other farmers. For bamboo, TLC is tapping indigenous technical knowledge from a 'bamboo farmer' from a nearby village. A row of trees marks the village boundary from the road.

- To address their problem of shortage of clean drinking water, the villagers had dug a deep well and appealed to the study visit participants for assistance for the installation of a pump. This was an opportunity for an integrated rural development project and collaboration with partner(s). Group members donated cash towards the purchase of a pump, and CTA promised assistance. The farmers expressed interest in planting indigenous fruit trees to improve nutrition and generate income.

- As well as the ubiquitous maize and tobacco, the villagers had also planted paprika and groundnuts.

Chitedze Research Station

After a welcome address by Dr Banda, Officer in Charge, Dr Kabambe (Agronomist) showed the visitors his research. He is screening legumes for resistance to yellow witchweed and for their effectiveness as a trap crop for *Striga asiatica*. Preliminary results indicate that pigeon pea, *Mucuna, Sunnhemp* and *Crotalaria orchroleuca* are immune to yellow witchweed. Dr Kabambe also found that some trees can be used as trap crops for *S. asiatica*.

Day 2: concluding remarks

TLC had successfully used a group approach to mobilise the community for rural development Inadequate funding and training had resulted in the depletion of the agroforestry research team at Chitedze Research Station.

DAY 3: WEDNESDAY 23 JANUARY

Farm Visits

Farm 8: Mrs Govhati
Njolomole EPA, Ncheu District

Land-use problems

Soil erosion due to steep slopes. Overcrowding, poor soil fertility and shortages of fuelwood are serious problems in the district.

Technologies seen

- Planting vetiver grass on contour marker ridges,and building dams against gullies

- Soil fertility technologies, including alley cropping with *Tephrosia vogelii*, *Gliricidia*/maize mixed intercropping and undersowing of maize with *T. vogelii.* The farmers were also experimenting with *Faidherbia albida* systematic planting. It is, however, unlikely that *F. albida* will perform because the climate is too cold for it.

Since adopting *Tephrosia vogelii*/maize alley cropping technology, the farmer reported that she had doubled her maize yield to about 30 buckets from her field. *T. vogelii* in maize under field trials has increased maize yield from 400 to 2700 kg/ha.

She also reported other benefits, including the use of *T. vogelii* leaves as an insecticide against the maize stalk borer. The leaves are soaked in water overnight, strained and the liquid then sprayed. She uses the srtems of *T. vogelii* as fuelwood. The farmer reported one problem she had had with growing *T. vogelii* – a leaf-eating beetle. The beetle also attacks beans. So far she had not found a solution to the problem.

Farm 9: Mr Julius Masakadza
Ncheu District, Mulangeni Area

Land-use problems

The soils are very infertile. Consequently, maize growth is generally stunted, tasseling at 75 cm high, and there is a shortage of fuelwood.

The extension worker reported that 36 farmers in the area were practising agroforesty. Alley planting using *Leucaena* had been tried previously but did not perform well.

Technologies seen

- Undersowing maize with *Tephrosia vogelii*, the farmer's favorite technology. The farmer claims this gives more leaves. He plants two *T. vogelii* seeds between the maize plants. A lush green stand of maize at this farm was proof. The farmer had 3 acres, two of them cropped and one fallow (three seasons under *T. vogelii*). He used a small portion of his land to test the effectiveness of *T. vogelii*. He used home-grown seeds and gave some to other farmers. In addition to improving soil fertility, the *T. vogelii* fallow produced fuelwood.

- This farmer also practised biomass transfer with *Tithonia diversifolia*; he left a small natural woodlot to regenerate for fuelwood; and he had many indigenous fruit trees on the farm.

Day 3: concluding remarks

The two sites visited were proof of the wide and spontaneous adoption of agroforestry. Paul Tuwei, rapporteur for that day, wrote that "there was evidence that farmers were 'building little fertilizer factories' on farm and expanding their agroforestry plots".

DAY 4: THURSDAY 24 JANUARY

Makoka Agricultural Research Station, Zomba, Malawi

Tour of the SADC-ICRAF Agroforestry Project site at Makoka Agricultural Research Station, Zomba Prior to the tour, the Project Leader for Malawi, Dr Festus Akinnifesi, presented a paper on 'Experiences and Challenges in Developing Best-bet Agroforestry Technologies for Farmers in Malawi'.

The paper highlighted the links between soil fertility in Southern Africa and food security and the improvement of people's livelihoods. Low soil fertility, particularly shortage of nitrogen, was the major factor contributing to the low maize yields (0.5–1.0 t/ha) obtained by farmers in Malawi. Due to high cost, logistical problems and lack of credit, resource-poor smallholder farmers cannot afford inorganic fertilizers. Agroforestry was therefore a practical alternative for addressing the problem of low soil fertility. Dr Akinnifesi chronicled the evolution of ICRAF's activities in Malawi and Southern Africa in general. He outlined four development phases were outlined:

- 1986: design and diagnosis (i.e. identification of the problem);
- 1987– : on-station experimentation with a variety of agroforestry options;
- 1992– : increased on-farm experimentation and farmers' adaptation;
- 1997 to date: scaling up the technologies, accompanied by the relevant adoption studies, addressing second generation research issues, and impact assessment.

The SADC-ICRAF project has developed three major short-term options for replenishing soil fertility in Malawi. These include *Sesbania*/maize relay cropping, *Sesbania* improved fallows and maize/*Gliricidia sepium* 3-year intercropping. Through collaboration between ICRAF and NARS, over 20,000 Malawi farmers are benefiting from these agroforestry practices.

In addition to biophysical research in agroforestry, ICRAF and its partners are engaged in studies on the socioeconomic issues and the adaptability of the flagship technologies: improved fallows, relay cropping and mixed intercropping. Future ICRAF research emphasis will be on:

- soil fertility replenishment for improved crop production by smallholder farmers;
- incorporation of grain legumes in farming systems (e.g., pigeon peas, groundnuts, soybeans) as sources of nitrogen and protein;

- integration of livestock in the farming systems for sustainable provision of animal protein, manure and cash income;
- integration of high-value trees, including fruit and medicinal trees, in the farming system for improved health and nutrition.

After the briefing, the participants visited the following on-station trials:

- mixed intercropping with *G. sepium*;
- improved fallows of *G. sepium*, pigeon peas and maize stover incorporated;
- nursery research on propagation methods for indigenous fruit species;
- multi-locational *Uapaca kirkiana* provenance trial.

It rained heavily in the afternoon, resulting in the cancellation of a tour of two farms at Thondwe, neighbouring Makoka. Instead, theTanzania and Uganda country reports were presented.

DAY 5: FRIDAY 25 JANUARY

Farm Visits

Farm 10: Mr Janas
Chihunda Village, Makoka

Land-use problem

Fodder shortage.

Technologies seen

The farmer has two big Friesian cross-bred dairy cows which he feeds maize bran and fodder supplement. There is some elephant (Napier) grass and a well-tended stand of *Acacia angustissima* on the farm. The farmer observed a slight increase in milk production after feeding the fodder supplement. He has been able to educate his children from the income for sales of milk and crops. He cuts the fodder every 4 weeks and feeds the cows once a day. Manure is applied to maize field fresh or dry. The field is ridged for water conservation. The farmer wants to expand the area under fodder trees. Sometimes he allows animals to browse in the fodder bank. He was advised to dry the fodder and use it as supplement in dry season. He was also made aware of the importance of tending the Napier grass as a good basal feed. The group recommended that development workers expand their extension messages to include other issues relevant to the adoption and better performance of the technology. A question was raised about manure storage versus loss of nitrogen through volatilisation. The farmer was advised to compost the trash.

Farm 11: Chief Nelson Mukwaira
Chiradzulu Area

Land-use problems

Low soil fertility, shortage of cash.

Technologies seen

There was a lot to see at this farm. The innovative farmer is a retired miner and a part-time gardener. His son, who is working with him, was trained on budding and grafting at Bvumbwe Research Station. This farmer had several innovative ideas on farming in general.

- **Indigenous fruit trees**. He has a green house constructed from clear plastic. He is improving local mangoes through grafting with hybrid scions. Dotted around the orchard are composting heaps and pit beds of various sizes. The orchard is haphazardly planted to mainly exotic fruits: mango, guava, Mexican apples, mulberry, peach and granadilla (giant and normal). The farmer is filling gaps in the orchard with indigenous trees in distinct rows. In one portion of the farm, a variety of fruit tree species – guava, the 'tomato-sauce tree' (tree tomato), peaches (four species) and custard apple (*Annona squamosa*) – are widely interspaced in a maize field. Nursery rootstock of peach and apples is raised on the riverbank for budding.

- **Nursery.** The farmer hosts a group nursery of indigenous and exotic trees: *F. albida*, *Leucaena*, *Senna*, *Gliricidia* and *Melia*. The farmer generates cash by selling seedlings to the community and visitors after his needs have been met.

- Soil fertility trials. The soil-fertility improvement trials seen in the main maize field were:
  - maize and beans intercropped after fallowing with *Tephrosia* and *Crotalaria*
  - cassava interplanted with *Altelaria herbasmithii*
  - maize/*Gliricidia* mixed intercropping plus compost manure
  - maize/pigeon pea intercropping
  - hybrid maize/*S. sesban* relay cropping plus application of compost manure
  - hybrid maize plus 3 applications of compost manure and *Sesbania sesban*
  - modified Sesakawa method (2 maize pips per station spaced 25 cm apart)
  - contour markers with fruit trees for soil erosion control

  The *Gliricidia* is cut twice. *Gliricidia* is popular and preferred because, once established, there is no need for annual replanting. *Sesbania sesban* produces fewer leaves and it is necessary to add compost to improve soil fertility. The farmer grows *S. sesban* annually, as a relay crop. Both *S. sesban* and *Tephrosia volgelii* are more labour-intensive as they have to be sown and cut down every year. *Gliricidia*, on the other hand, can remain productive for over 10 years, without the need to replant.

- **Mushroom production.** The farmer is involved in mushroom production as an income-generating project. Maize stover is sterilised (cut and boiled) and inoculated with mushroom spawn. The mushrooms are harvested after 21 days. The produce is sold to a local hotel.

During the question and answer session at the end of the visit to this farm, the farmer said that the diverse crops on his farm (maize, fruits and seedlings) acted as an insurance against adverse weather and a source of improved livelihood for the family. Asked why he had no livestock on his farm, he said that cattle are expensive. He will venture into cattle production when he has raised enough capital. The group sought clarification on his role as the chief in the community. Is it an obstacle to or an agent for development? Does his role in conflict resolution affect community participation in extension or development? He said that 60 farmers around him depended on his leadership in agriculture. The study visit participants agreed that his farm was a very good learning centre, but there were fears that there were too many trials going on simultaneously, with too many visitors to the farm, who could disprupt the farming. The participants suggested that the farmer introduce a small fee for visitors.

3.2 Zambia

DAY 6: MONDAY 26 JANUARY

Drove from Malawi to Chipata, Zambia

Two scheduled farm stops en-route to Chipata via Salima had to be skipped due to road closure.

DAY 7: TUESDAY 27 JANUARY

Chipata, Zambia

Presentation of country reports

DAY 8: MONDAY 28 JANUARY

Msekera Research Station, Chipata

The station was established in 1932 and is one of nine national research stations. It is hosting ICRAF-SADC Agroforestry Project and the National Commodity Team for Legumes and Farming Systems. Msekara offers excellent links between regional and national projects.

After introductions and a welcome address by Dr Kanengo, the Station Head, an overview of the soil fertility programme in Zambia was presented by Dr P. Mafongoya, the Project Leader. A series of presentations by ICRAF staff followed:

- economics and policy, by Dr O. Ajayi;
- pests of agroforestry trees, by Dr G. Sileshi;
- accelerating the adoption and impact of agroforestry in Zambia, by Ms R. Katanga;
- domestication of indigenous fruit by Mr A. Nkonda;
- on-farm research by Mr E. Kuntashula.

These presentations were followed by a tour of on-station soil-fertility research projects. The major donors of the programmes at Msekera are: Government of Zambia, CIDA, Sida, Rockefeller Foundation, KEPA-Zambia (Finnish NGO), BMZ, ICRAF core funds and Plan International. The main points arising from the presentations was:

- **Soil fertility research**. This forms a major part of ICRAF's research effort. Agroforestry is considered pertinent to resolving soil fertility problems, particularly nitrogen deficiency which is by far the most limiting factor in most of the land-use systems in Southern and Eastern African countries. Following the demonstration of the positive impact of agroforestry on soil fertility, the ICRAF-SADC project has been involved in process research. Issues currently being investigated are:

  - biological nitrogen fixation (BNF);
  - deep capture of nutrients by agroforestry trees;
  - transformation of nitrogen;
  - improvement of soil physical properties;
  - soil-water use dynamics;
  - impact of agroforestry on infiltration rate.

- **Agroforestry tree species screening**. The SADC-ICRAF programme is screening a wide range of germplasm in order to develop alternative tree species for use in agroforestry technologies.

- **Fodder research**. Another important initiative is research on livestock interaction under smallholder dairy farming systems. Fodder bank are being evaluated.

- **Peri-urban agroforestry systems**.

- **Economics and policy**. The main focus is on: profitability issues, adoption studies (e.g., factors determining extent of adoption such as gender, size of field cultivated, household size, membership of farmer group, information flow) and institutional issues (e.g., labour, finance and influence of fiscal policies). New technologies are evaluated both on-station and on-farm. This evaluation also addresses the issues of sustainability and profitability

- **Agroforestry pests.** Current research is focused on serious pests of *Sesbania*, notably *Exosoma* sp. and *Mesoplatys*. Field studies are looking at antixeriosis and tolerance.

- **Technology dissemination.** Studies on dissemination are geared towards scaling up of agroforestry adoption by farmers. Currently, ICRAF is working with 34 partners. The main approaches in dissemination include farmer field days and demonstrations, farmer-researcher on-farm testing of technologies, training of farmers as trainers of other farmers, and exchange of visits by farmers. By far the most promising agroforestry technology in Zambia is *Sesbania* improved fallows. So far, over 18,000 farmers (10,000 male, 8000 female) have adopted the technology in Chipata District alone. On-farm technology testing has provided useful feedback to the researchers. The feedback has led to second-generation agroforestry research on fine-tuning of the technologies. ICRAF's dissemination programme has been successful due to good follow up and availability of resources such as transport, education materials and funds for training the trainers, many of whom are farmers.

On-station experimentation at Msekera

- Screening for 2-year mixed fallow species. The research results demonstrate the advantage in mixing coppicing and non-coppicing tree species in improved fallow technology. Such mixtures enhance the recycling of soil nutrients from deep soil horizons to the crop rooting zone.

- Screening species for 3-year fallows. The potential for 3-year fallows exists in eastern Zambia because land is not a limiting factor. ICRAF is therefore screening species for such fallows. The species being evaluated include: *Sesbania* (control) *Gliricidia*, *Leucaena*, *Flemingia*, *Calliandra* and *Senna siamea*.

- *Gliricidia* establishment and management trial. In experiments that have been running continuously for nearly 10 years, *Gliricidia*/maize mixed intercropping has improved maize yield under Malawi and Zambia conditions. Current research is focussed on methods of tree establishment (direct seeding, rooted seedlings, bareroot seedlings, cuttings). The use of coppicing tree species in improved fallows is advantageous as it avoids the need for annual re-establishment of the trees (as in the case of *Sesbania* improved fallows).

Farm 12: Dimon (Pvt) Ltd

Land-use problem

Shortage of wood for tobacco curing; and low soil fertility.

Dimon (Pvt) Ltd is a large-scale commercial producer of burley tobacco. It requires large quantities of bamboo-type sticks for tying the tobacco leaf for curing. The estate is collaborating with ICRAF in growing rotational woodlots of *Gliricidia sepium* to meet the demand for sticks. Some 27 ha were planted to this species. This may be the biggest plantation of *Gliricidia* in Southern Africa. After the initial thinning, the remaining trees will be allowed to seed and form a seed orchard. The estate has also established 2 ha of *Acacia crassicarpa* for wood. The woodlots also serve as windbreaks.

Dimon contacts smallholder farmers through field days. Some neighbouring farmers grow tobacco under contract arrangements with Dimon. Initial fuelwood trials with *Gmelina* and *Eucalyptus* were poorly adopted by farmers. These species are highly competitive with crops for water and nutrients, and therefore adversely affect crop yields.

Farm 13: Mrs Tafadi Mbewe
Chipata, Kalichero

Land-use problem

Declining soil fertility, accompanied by low crop yields.

Technology seen

- Improved fallows and coppicing fallows. The farmer learnt about improved fallows from attending field days at another farmer's farm. She is convinced that agroforestry trees provide better returns than fertiliser. She has 4 acres under agroforestry, and next season she will expand the area planted to trees.

  People visit her farm and are amazed at the dark green colour of the crop. This technology is appealing to Zambians because chemical fertilizers are very expensive. This problem is exacerbated by the lack of loans and a poor transport system.

Farm 14: Mr Hasan Sakala
Chipata, Kalichero

Land-use problems

Declining soil fertility; and shortage of tree products (fuelwood, timber).

Technology seen

- Woodlot of *Senna siamea*, *Leucaena macprophyla macrophylla, A. crassicarpa* (rabbit's ear). The farmer has had experience growing a *Gmelina* species before. The woodlot is intended as a windbreak. *Tephrosia* fallows are for soil fertility improvement. In order to guard his trees against fire hazards, the farmer is intercropping them with groundnuts and maize. A very good crop could be seen despite the undersowing. An attempt to grow *Acacia crassicarpa* failed due to termite damage.

- Screening of *Tephrosia volgelii* provenances for soil fertility improvement. The farmer was hosting the *Tephrosia* provenance screening trial on behalf of ICRAF under a 'researcher-designed, farmer-managed trial'. Twelve *Tephrosia* provenances were undergoing screening. One of them, Number 02971 (ex Madagascar), was doing extremely well. Compared with other accessions the Madagascar provenance was taller (5m) and carried high biomass. It was also observed that whilst the local provenance was already seeding 12 months after planting, the ex-Madagscar one was still vegetative and showed no sign of flowering. As an agroforestry species, *Tephrosia* is a desirable species because it does not require innoculation before planting.

Farm 15: Mr Harrison Chongwe
Chipata, Kalichero

Land-use problems

Declining soil fertility.

Technology seen

- Soil fertility improvement. The farmer became interested in agroforestry in 1994 after attending a dissemination meeting at a local farmer training centre. He also participated in an agroforestry tour to Malawi, organised by ICRAF. He started with improved fallows using *Tephrosia volgelii* and *Sesbania sesban*. *Sesbania* is established at a spacing of 2 x 2 m. At the time of the study visit the farmer was growing the third and second crop of maize after *Sesbania* and *Tephrosia* fallows, respectively. He has observed a marked maize yield increase in response to improved fallows. Neighbours were at first skeptical about benefits from fallows, but after seeing the good maize yield and the yield of useful firewood from *Sesbania sesban* plots, they were convinced.

  The farmer started experimenting with *Gliricidia sepium* in 1996. He cut and incorporated biomass in 1999 and got higher yields. He is conducting his own experiments using various tree combinations. ICRAF is now using this farmer to help train other farmers in the area, increasing the number of farmers experimenting with agroforestry in the area from six, initially, to the current figure of about 200 farmers. The farmer cited tree damage by cattle as the main problem that he has encountered since adopting agroforestry.

DAY 9: TUESDAY 29 JANUARY

Farm 16: Mrs Martha Daka
Kazunga Village, Chipata

Land-use problems

- Declining maize yields due to low soil fertility (cost of fertilizer too high). Maize yields following 2-year *Sesbania sesban* and *Tephrosia* fallow are much higher than yields from continuously cropped plots. The farmer was recruited by ICRAF to co-host on-farm trials in 1993. She has been trained on agroforestry and is used by ICRAF as a farmer trainer. Improved fallows are amenable to farmers' management practices, which depend on hand hoeing.

- *Sesbania* pests in the nursery and in the field.

Technology seen

- The farmer became interested in agroforestry after attending a field day where agroforestry technologies were demonstrated. She also harvests *Sesbania* seed for sale to other farmers. She has discovered that she gets better growth and ground cover by planting *Tephrosia* at 2–3 seeds/station instead of 1 seed/hole as recommended by extension officers. The local *Tephrosia volgelii* variety is shorter and produces less litter than the introduced Madagascar provenance. The farmer has enjoyed good return in terms of crop yield.

Farm 17: Mr Goma

On-farm screening of various agroforestry tree species. The trials were researcher-designed and managed.

Farm 18: Mr White and Mrs Daka
Chipata

Land-use problem

Declining soil fertility.

Technology seen

- Coppicing fallows. The farmers cut and incorporated the biomass of *Sesbania* and *Gliricidia.* They were observing their first maize crop. They became aware of agroforestry after visiting Msekera

Research Station. Where the two species are mixed, the crops are growing more vigorously than a single species. They consider the agroforestry venture to be very successful and more family members are adopting it.

Farm 19: Mr Oscar Mbewe
Chipata

Land-use problems

Poor soils for vegetable production.

Technology seen

- Biomass transfer. The farmer was recruited by ICRAF to try biomass from agroforestry tree species. Forty-five farmers, including Mr Mbewe, had applied leaf litter from *G. sepium* and *A. colinsi* to vegetable crops (onions). Rates used: 12 and 8 t/ha of *Gliricidia* and *Leucaena colinsi*, respectively. The farmers were testing the residual effect of the biomass on maize. From the positive results observed, many farmers had requested germplasm to plant.The farmer is convinced that trees are 'a very good option when one does not have cattle or chemical fertilisers'. Currently, 35 farmers have planted *Gliricidia* and *Leucaena* biomass banks. The extension workers have given out about 18,000 tree seedlings for establishing biomass banks.

Farm 20: Mr Whitehead Phiro
Chipata South, Jerusalem

Land-use problems

Low crop (maize) yield due to declining soil fertility.

Technologies seen

- The farmer owns 3.5 acres. Recruited in 1997 initially to host on-farm trials, he has expanded agroforestry activities to include: *Gliricidia*/maize mixed intercropping, *Sesbania* and *Tephrosia* fallows. During the visit, good stands of maize were observed: 1st year maize after 2-year *Gliricidia sepium*, 1st year maize after 2 years *Sesbania* and 2nd year maize after *Tephrosia*. The farmer was expecting at least 4-5 bags of maize per plot, compared to less than 1 bag per plot without fertilizer. Following training in agroforestry by ICRAF, this farmer is one of the ICRAF trainers.

Farm 21: Ms Sofiya Njobvu
Chipata South, Jerusalem Camp

Nothing recorded

Farm 22: Mr Jones Banda
Chipata Khapinde

Land-use problem

Shortage of livestock fodder, particularly protein-rich supplements.

Technology seen

- Fodder banks for dairy production. Mr Banda a large-scale farmer. He has 838 hectares on which he formerly grew seed maize. He gave up on maize production because of the high cost of inputs e.g. fertilizers which he had to travel long distances to get. Has practised dairying since 1986. He was screening *Leuceana* and *Acacia angustissima* for fodder. The farmer plants a small portion every year. However, the trees in the stand were too widely spaced. The farmer mixes fodder from trees with maize bran and feeds it to milking cows. Although he had a stand of Napier grass, it was poor looking. The farmer was advised to seek advice on the appropriate spacing and better management of Napier.

DAY 10: WEDNESDAY 29 JANUARY

Return to Malawi, and final discussions

4

Participants' reports

4.1 BOTSWANA

4.1.1. Agroforestry in Botswana

Kgomotsego Ranthokwane and Monia Mfolwe

Botswana is an arid and semi-arid country with total land area of 582,000 km^2. It is landlocked and shares borders with South Africa in the south and east, Namibia in the west, and Zimbabwe and Zambia in the north-east.

Rainfall, temperature, soils and vegetation

The annual rainfall ranges from 650mm in the north to 255mm in the extreme south-west. Day temperatures in summer can reach 40^{o}C, while winter days are invariably sunny and cool to warm. Temperatures in the evenings drop low and can reach freezing point in some areas.

The Kalahari sands cover 80% of the country. An estimated 6% of the total land area is said to be suitable for arable agriculture, while shrub-like vegetation, sparse savannah, open woodlands and dry deciduous forests cover 60% of the country. The main forested areas are in the north and north-eastern parts of the country.

However, the climatic and edaphic conditions in Botswana support a varied range of fauna and flora, which play a critical role in the social, economic and ecological well-being of the country.

Land tenure

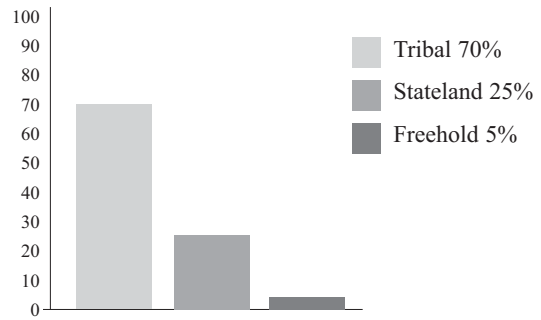
- Freehold (5%): The land is owned by an individual or group of people who have exclusive control over its use, and it can be transferred from one owner to another without obtaining permission from government.

- Tribal land (70%): This land is owned by the various tribes in the country and is administered through Tribal Land Act.

- State land (25): This land is owned by the State and is used in a number of ways – for communal grazing, national forest reserves, national parks, leasehold rights to individual or groups for different uses, etc.

The proportions of total land under the three major land uses changed between 1974 and 1995, but these changes were very minor. In communal areas this change has taken place due to the creation of new towns and the expansion of existing ones. The only significant change that has taken place is in the freehold. The government has over the years acquired some of the freehold land for resettlement programmes. These changes represent 1% of the total land under freehold.

Figure 1 Land tenure systems, 1997–98



Source: National Development Plan VIII

Apart from the above-mentioned changes, Wildlife Management Areas have also been established mainly in communal (17%) land and State land (8%). The creation of Wildlife Management Areas in communal land and State land is strictly for the conservation and sustainable utilisation of wildlife resources. This is in line with the Convention on Biodiversity, which Botswana has ratified.

Agroforestry in Botswana

Lundren (1978) defined agroforestry as all practices that involve the close association of trees or shrubs with crops, animals and pasture. It is the planned integration of agriculture and forestry. It is a collective name for all land-use systems and practices where woody perennial plants are deliberately grown on the same land unit as agricultural crops and/or animals, either in partial mixture or temporal sequences. There must be ecological and economic interaction between woody and non-woody components.

It can also be defined as a dynamic, ecologically based, natural resource management system that through the interaction of trees and the agricultural landscape diversifies and sustains smallholder production and increases social, economic and environmental benefits. Trees, crops and pasture/animals are the main components of agroforestry.

Agroforestry is a form of natural resource management that plays a key role in a wide range of situations. In 1989–90, a nationwide agroforestry study (Otsyina and Walker, 1990) was conducted in order to:

- Survey present land-use systems;
- Determine agroforestry potential in dealing with production and conservation problems.

The survey identified the major problems as:

- Low crop yields and productivity;
- Rangeland degradation due to severe overstocking and poor fodder supply;
- Over-exploitation of woodland around densely populated settlements, leading to acute shortages of wood products.

Traditionally, the people of Botswana do not practice tree planting. However, a few trees are often left in the crop fields and at homes to provide shade, fruit, etc. There are no organised agroforestry systems. Nevertheless, farmers have a good knowledge of local trees and their role in the provision of fuelwood, medicine, poles and fodder.

Agroforestry potential

Dryland agroforestry technologies have potential in all land-use systems identified. This potential is considerable in the humid eastern, southern and northern parts of the country, but few technologies are suitable for drier western districts.

The potential can be summed up as follows:

- Trees integrated into the system would improve soil fertility and water conservation;
- Trees would provide much-needed wood products (fuelwood, poles and fodder);
- Trees would offer a means for agricultural diversification and provide alternate sources of household income;
- Trees would improve the micro-climate and prevent adverse environmental degradation;
- Trees would provide opportunities for employment.

Before any appropriate technology could be recommend, data and information on multipurpose trees suitable for Botswana conditions is needed. Very little research on forestry, agroforestry, adapted tree species, management and utilisation exists. Research is an important requisite to agroforestry development.

Strategies adopted to address problems

- Adaptive trials of developed technologies on station and at Rural Training Centres.
- On-farm fields to modify techniques for farmer adoption;
- Farmer training and technology transfer through demonstrations, seminars, workshops and short courses;
- Research efforts will concentrate on high potential areas;

- Involvement of farmers in all aspects of development programmes;
- Training of extension personnel;
- Development of a reference manual for extension staff and farmers;
- Provision of necessary inputs (such as seeds and improved transport facilities);
- Collaboration between government institutions and NGOs involved in forestry/agroforestry development.

These and other measures will provide information on:

- Local demand for trees and tree products;
- Availability of trees and tree products;
- History of the local tree planting/agroforestry efforts;
- Local knowledge of agroforestry;
- Seedling availability;
- Availability of technical resource people;
- Land ownership;
- Land availability;
- Water availability.

Government support

In 1991 the Botswana Government signed a convention to combat desertification and rectified it in September 1996. The convention required each country to develop and implement a national action programme to combat land degradation. In addressing this problem, the government held consultation awareness seminars throughout the country. Some villages and communities showed concern about land degradation.

The government initiated community projects as part of a national action program to combat desertification in Botswana. There are four such projects in operation (Mabutsane, Khakhea, Sekoma and Mokobeng). The government supports the establishment of woodlots and agroforestry projects as they are in line with its policy of diversifying agricultural production.

Using Mokobeng as an example, the project here was funded by the Government of Botswana, UNDP and the community. The achievements included: an electrically operated borehole; the installation of an irrigation system; planting of trees (219 citrus, 92 indigenous, 163 exotic); and vegetable production

There are plans to establish an apiary and a small tree seedling nursery.

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4.2 KENYA

4.2.1 Adaptive on-farm fodder technology development: experiences of the national agroforestry research project in Embu, Kenya

PAUL K. TUWEI

The National Agroforestry Research Project (NAFRP) is a collaborative project jointly implemented by the Kenya Agricultural Research Institute (KARI), the Kenya Forestry Research Institute (KEFRI) and the International Center for Research in Agroforestry (ICRAF). The project is country-specific but functions as an integrated part of the ICRAF-coordinated East and Central Africa Agroforestry Research Network for Africa (E.A.-AFRENA). The Governments of Sweden (through SIDA) and Kenya fund the project.

The aim of the project is to improve the capacity of local agricultural/forestry institutions to carry out their own agroforestry research geared towards solving local problems and to generate information for the development of agroforestry technologies for the central Kenyan highlands.

The project zone was initially in the coffee-based land-use system of the highlands. The altitude ranges from 1300 to 1800 m.a.s.l. along the slopes of Mount Kenya and the Aberdare Range. The total land area of the project is approximately 3000 km^2. The topography is rolling, with medium to steep slopes. The rainfall is bimodal, and averages 1200 to 1500 mm per year. Thus, there are two distinct cropping seasons: the long rains are from mid-March through to May, while the short rains are usually from mid-October through to December. The soils are predominately humic Nitisols (FAO classification).

The zone has a high population density, ranging from 230 to 730 persons/km^2, with an average of 450 persons/km^2. Farms are usually small, ranging from 0.5 to 4 ha, with an average of 1.5 ha. Land tenure is based on individual ownership and income is derived from the sales of coffee, tea, surplus food crops, milk, macadamia nuts and off-farm employment. Food crop production is particularly important for subsistence needs (Minae and Nyamai, 1988).

The major constraints to the coffee-based land use system of the central highlands are:

- declining soil fertility due to continuous cropping without adequate applications of manure and/or fertiliser;
- soil erosion due to cultivation on steep slopes;
- shortage of fodder for dairy animals, especially during the dry season;
- shortage of fuelwood and other wood products;
- lack of additional income-generating enterprises apart from coffee

Project case study of *Calliandra calothyrsus* fodder development

In the central highlands of Kenya, improved dairy cattle are raised for milk production (Akyeampong and Muringa, 1994). Population growth in this region has led to high pressure on the land, with animals being managed almost exclusively under a zero grazing system (compulsory confinement) and fodder production from small intensively managed plots (Minae and Nyamai, 1988).

A common constraint to livestock production is the lack of high-quality forage, especially in the dry season, because the most common grass grown as animal feed, Napier (*Pennisetum purpureum*), is depleted during this period (Minae and Nyamai, 1988). The use of trees and shrubs has long been known as one of the most effective means of improving forage supplies in smallholder farms in the central and eastern highlands of Kenya, especially in the dry season (Murithi *et al*., 1993; Thijssen *et al*., 1993).

Initial studies. The agroforestry research project for the coffee-based land-use system proposed *Calliandra calothyrsus, Sesbania sesban* and *Leucaena leucocephala* as some of the species to be evaluated for fodder production on-farm because of their favourable fodder qualities. *Leucaena leucocephala* was subsequently attacked by the *Leucaena* psyllid (*Heteropsylla cubana*), and *Sesbania sesban* died out after a few loppings (personal observation). On-station trials of *Calliandra calothyrsus* and *Leucaena leucocephala* at various planting ratios with Napier grass showed that *Calliandra* can be planted with Napier on the basis of 1 row of *Calliandra* to 2 or 3 rows of Napier grass (Nyaata *et al*., 1998).

Feeding *Calliandra* to cattle. In the dry season from August to October 1994, a crossover experiment was conducted on 12 farms (15 cows) in the Manyatta and Ruyenjes Division of Embu District to study the effect of feeding cattle with *Calliandra* compared with commercial dairy meal containing 16% crude protein. Farmers with sufficient Napier and *Calliandra* were chosen. Three treatments were used:

1 normal feeding: the basal ration plus 1.25 kg of fresh *Calliandra*;
2 dairy meal: basal ration plus an additional 0.6 kg of dairy meal (designed to be isonitrogenous with treatment 1);
3 *Calliandra*: basal ration plus 2.5 kg of fresh *Calliandra*.

The milk yields of the three treatments were statistically similar (p=0.22), but the trends followed the predicted responses (Table 2). In terms of total nitrogen treatment, 1 and 2 were equal, but the dairy meal presumably had a higher digestibility than the *Calliandra*. Treatment 3 had the highest level of nitrogen but the difference was only about 15 g of N/cow/day.

Table 2 Adjusted dairy milk yields (kg) in Manyatta and Ruyenies, August-October 1994

Feed	Milk yield
Normal	10.1
Dairy meal	10.3
Calliandra	10.5

The results show a replacement value of 1 kg of dairy meal being equivalent to about 3 kg of fresh (about 0.8–1.0 kg dry matter) *Calliandra* in terms of milk production (O'Neill *et al.*, 1995). From the study it was found that 500 trees would be needed to feed one cow through a whole lactation.

Table 3 Community nursery expansion

Season	District	Community nurseries	Seedlings planted	Farms
1997LR	Embu	12	46,300	178
1997SR	Embu and Meru South	14	49,600	211
1998LR	Meru South and Kirinyaga	26	30,000	150
1999LR	Meru South and Kirinyaga	12	29,404	220
1999SR	Embu, Maragwa, Kirinyaga, Nyeri, Meru South and Central	117	490,000	2037
2000LR	Embu, Maragwa, Kirinyaga, Nyeri, Murang'a, Meru Central and South	150	528,000	2600

Availability of *Calliandra* seedlings to the farmers. As farmers became aware of the potential for *Calliandra calothyrsus* as superior fodder, the project was not able to meet the demand by farmers through its own tree nursery, so ways of raising the seedlings by farmers in their own nurseries were sought. A study was initiated with the farmers to come up with a feasible and affordable method of propagating *Calliandra* (O'Neill *et al*., 1997). It involved comparing three methods of propagation. These methods were potted seedlings (in polybags), open-rooted seedlings (in Swaziland beds) and direct sowing (seeds). The open-rooted seedlings were found to be farmer friendly as the cost of polythene bags was reduced and the survival was good.

Large-scale propagation of *Calliandra*. From the propagation studies, a pilot project was initiated in January 1997 to propagate *Calliandra calothyrsus.* The farmers had to be in an existing group (e.g., women's group, youth group, catchment etc.), and had to have an interest in fodder production. The groups were taught basic nursery practices and then given the seeds to start their own nurseries. Each nursery had extension personnel to assist the farmers in nursery management. The results are shown in Table 3. Each group had to leave some trees for seed production. A technical 'Bulletin on *Calliandra'* has been written to help extension agents in the dissemination of *Calliandra*, and other species are being tested to broaden the species range. Farmer-to-farmer visits have been facilitated for technology transfer.

Conclusion

The dissemination of *Calliandra* has been successful because of the involvement of the farmers and the extension agents with the researchers as partners in technology development. The whole process involved farmer participation, giving farmers a sense of ownership of the technology. Adoption rates were increased through farmer-to-farmer visits.

4.2.2 Utilisation and conservation of fodder trees and shrubs in Kajiado District, Kenya: starting with farmers' knowledge

Evelyne Kiptot

About 75% of Kenya's geographical area is classified as arid and semi-arid, and this area supports about 30% of the human and 50% of the livestock populations of the country (KEFRI, 1987). About 90% of the people in this zone depend on pastoralism. Throughout the centuries, these communities have accumulated indigenous knowledge about their natural resource base, which has enabled them to survive the often harsh environmental conditions. Until recently, both human and livestock densities were low, but high growth rates over the past decade, coupled with the subdivision/privatisation of the rangelands, has completely altered the lifestyles of the pastoral societies. The consequences have been overgrazing, land degradation, lack of dry-season fodder, loss of high-value species and acculturation. Despite the long-term sustainability of pastoral land management systems, they are now in a danger of breaking down and therefore it is no longer possible to rely on nature to supply the basic needs. The development and sustainable management of these resources, therefore, is the way to ensure present and future supply of these valuable natural resources

In an effort to improve pastoral land management systems, donor agencies have spent millions of dollars over the past two decades on research and development programmes. However, most efforts have been unsuccessful because development professionals failed to discuss problems and potential solutions with the recipients of research and development projects and overlooked the knowledge of the local communities. It is now widely acknowledged by the scientific community and development agents that success in development is more likely to be achieved when local peoples' knowledge is taken into account in project planning and development. Among the advantages of this approach are:

- better targetting of research to client needs if the results are to achieve high rates of adoption;
- the design of appropriate interventions that are technologically feasible, economically sound and culturally acceptable;
- the preservation of indigenous knowledge and skills;
- ensuring that local people take charge of their destiny.

It is against this background that a project was in initiated in 1999 to document the indigenous knowledge system underlying the management and use of fodder resources by the pastoral Maasai community of Kajiado district. The data collected will be used to design appropriate agroforestry interventions that are technologically feasible and culturally acceptable, to enable KEFRI to better target research to gaps in farmers knowledge and to support policy formulation and legislation that promote the sustainable use and management of rangeland resources while ensuring equitable access.

The project goal is to develop and promote high-value fodder trees and shrubs in the drylands and thus contribute to improved livelihoods, biodiversity conservation and environmental protection. The

specific objectives are to document indigenous knowledge about the use and management of tree fodder resources and to idetntify gaps in farmer knowledge and suggest priorities for fodder research and development

The study

Description of study site. The research was conducted in Mashuru Division, Kajiado District Kenya. It is a semi-arid-area with an annual rainfall of 500 mm in a bimodal pattern. The district is inhabited mainly by the pastoral Maasai who comprise 62.8% of the population. Raising of livestock continues to be their principal activity as they view it as security against famine, a dowry resource and a symbol of prestige. They practice no agriculture and depend mainly on the products of their livestock. The vegetation of the district is predominantly woodland grassland, open grassland and semi-desert bushland and scrub. Due to the harsh environmental conditions often experienced in this area, trees and shrubs play an important role in the Maasai livelihood system as they have the ability to tolerate a wide range of management practices and produce fodder when other species (grasses and herbs) have become dormant.

Strategies adopted. There is no easy or direct method to eliciting indigenous knowledge from informants and thus no single method is regarded as the most appropriate. However, the use of a multi-method approach (Rusten and Gold, 1991, Den Biggelar and Gold, 1995) based on a combination of techniques was used. This facilitated the collection of different types of data and knowledge, allowing a measure of triangulation, which was used to confirm the validity and consistency of indigenous knowledge.

Activities undertaken. The main activities undertaken in this study were:

- A household survey to collect socio-economic data and identify key topics and informants for the subsequent knowledge elicitation phase;
- Semi-structured interviews using key informants to gather in-depth information;
- Tree inventory to collect quantitative data on the ecological status of trees and shrubs on the rangelands;
- Group consensus method to countercheck information elicited from key informants.

Source of funding. Funding was provided by the SIDA/SAREC through the Research Programme on Sustainable Use of Dryland Biodiversity, National Museums of Kenya

The results

Livestock management system. The Maasai of Kajiado District have evolved an effective system of livestock management in order to ensure sustainability of livestock feed. They continue to use the

vegetation on a sustainable basis (except during drought years) through various strategies. These include: i) use of large diverse rangelands and high mobility (although this may soon change with the subdivison/privitisation of the rangelands; ii) use of tree fodder during the dry season; iii) rotation grazing where they have wet and dry season grazing; iv) setting aside/fencing off certain areas as grazing reserves known as *olopololis/olales* for use during critical periods. These areas are enclosed during the wet season when there is plenty of feed and they are managed in a way that allows tree species to mature and later become sources of forage and fodder during critical periods. *Olopololi*s/*olales* are usually privately owned and managed by individual households, and are usually about 1–4 ha each; they are exclusively for private use and no one is allowed to graze livestock in a neighbour's *olopololi* without the owner's permission. The number and size of *olopololis* per household varies according to individual initiative, availability of land and access to labour.

Tree fodder use, productivity and availability. The number of species used for fodder was remarkable. About 75 indigenous species of fodder trees and shrubs were mentioned and inventoried. Different parts of these species are eaten preferentially by different categories of livestock. These species play a very important role as a source of browse, especially during dry periods, constitute the major feed resource to livestock and qualitatively the main source of protein; pastoralists do not give any supplements to livestock, apart from salt.

Popular fodder species. During informal interviews and group discussions, a pair-wise matrix ranking exercise was undertaken by informants in order to identify the best fodder species for each category of livestock. *Acacia tortilis* (Forsk.) Hayne was unanimously selected as the best species for fodder for all four categories of livestock (Table 4).

Criteria used by pastoralists for species evaluation. Species evaluation was based on: fodder quality (linked to nutritive factors) and the physiological/physical/agronomic characteristics of the various species. From the pastoralists' perspective, fodder quality is determined by its effect on milk production and butter fat content, its ability to fatten livestock and its palatability.

The physiological/physical/agronomic attributes which were also considered include:

- the ability of fodder to satisfy;
- drought resistance;
- ability to withstand multiple browsing,;
- forage biomass;
- fodder availability during the dry season;
- presence of both edible fruit/pods and leaves.

Fodder toxicity

Farmers had considerable knowledge about the adverse effects of fodder species on livestock health. Detailed specific knowledge included: the extent of effects, variability of effects according to season and different stages of leaf development, and ways of minimising these effects. Some of the species known to have adverse effects on livestock are indicated in Table 5.

Table 4 The most important fodder species for various livestock categories

Livestock category	Species: Scientific name	Local name
Cattle	*Acacia tortilis*	Oltepesi
	Grewia tembensis	Oirri
	Sericocomopsis hilderbrandtii	Naibor ikunya
	Phyllanthus sepialis	Esambukike
	Lonchocarpus eriocalyx	O rpararwai
Goats	*Acacia tortilis*	Oltepesi
	Balanites aegyptiaca	Osarai
	Acacia mellifera	Oiti
	Acacia brevispica	Orgirgir
	Acalypha fruiticosa	Osiati
Sheep	*Acacia tortilis*	Oltepesi
	–	Oltiamiloi
	Balanites aegyptiaca	Osarai
	Acalypha fruiticosa	Osiati
	Acacia mellifera	Oiti
Donkeys	*Acacia tortilis*	Oltepesi
	Berleria eranthemoides	Olkilishashi
	Maerua angolensis	Enchani-osirkoni
	Boscia anguistifolia	Oleiroroi
	Turraea abyssinica	Enchanyangashe

Table 5 Fodder tree species considered toxic

Fodder trees	Stage at which toxic	Type of animal	Extent of effect
Balanites aegyptiaca	Unripe pods	Goats	Abortion
		Sheep	Abortion
Acacia tortilis	Unripe pods	Goats	Abortion
Acacia nilotica	Unripe pods	Goats	Death
		Cattle	Abortion
Commiphora africana	Young leaves	Goats	Diarrhoea

Implications for future research and development

This study has revealed the depth of knowledge held by pastoralists in Kajiado district. It has shown that indigenous knowledge has the potential to improve researchers' and development agents' understanding of the complex interdisciplinary field of natural resource management and so improve the design of agroforestry research and development programmes, making them more responsive to the needs of the target community.

This research has shown that Maasai pastoralists use various criteria to evaluate fodder species, based on nutritive factors as well as physical/agronomic attributes. An immediate implication of this is for the scientific community to consider farmers' criteria when screening trees for fodder value. Most research

on fodder quality has been based on crude protein and fibre content as the most important criteria, but the results show there are many other factors. Since much research on indigenous knowledge of fodder species has consistently identified various attributes which a good fodder tree must have, it would therefore seem reasonable for researchers to direct their efforts to these qualities. This can be done by linking up scientific knowledge of animal nutrition with farmers' knowledge and objectives. For instance, if the farmers' objective is to fatten livestock for sale, then fodder species that are known to increase animal body weight should be promoted.

The Maasai have developed a diverse set of management systems, such as seasonal mobility between wet and dry season pastures (transhumanse) and the setting aside of specific grazing reserves *(olopololis* and *olales)* to minimise risk against drought. Currently, land is being subdivided/privatised and therefore this system of mobility may no longer be sustainable. The current silvopastoral system of setting aside certain areas as reserves deserves to be promoted as it encourages natural regeneration and conservation of biodiversity.

Depending on the availability of funds, the following will be undertaken:

- Investigation of chemical composition, nutritional value and anti-nutritive factors of important species;
- Propagation trials;
- Improvement of rangeland resources based on farmers' knowledge;
- Studies on fodder preservation techniques and storage for use during critical periods.

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4.2.3 Agroforestry in the soil and water conservation programme, Kenya

James Juma Wekesa

Forestry extension activities for Individual farmers came to the fore in 1971 when the Forest Department established the Rural Afforestation Extension Scheme (RAES), a network of nurseries to supply tree seedlings to the rural population. RAES evolved into the Forestry Extension Services Division (FESD) within the Forest Department of the Ministry of Environment and Natural Resources FESD placed emphasis on activities that supported seedling production and tree growing by the farmers themselves, with training and extension as the main tools.

In 1977, tree seedling production was taken up by the National Soil and Water Conservation Programme (NSWCP) in the Ministry of Agriculture. The focus for the project was initially on tree nurseries but after 1988 a shift towards a more holistic approach took place. The project uses participatory methods of working with farmers, with more emphasis on training and extension than on producing tree seedlings. The main problem remained the provision of tree planting materials to farmers in a sustainable manner. The NSWCP's agroforestry extension has evolved to address the need for a multidisciplinary and participatory planning system at the local level for harmonising agroforestry extension work by both government departments and non-governmental organisations (NGO).

Programme objectives

The NSWCP was initiated in 1974 in four pilot districts and by 1977 it was in operation in 30 out of the 40 districts in the country. By the end of the programme in 2000 it was covering the whole country. The overall goal for the programme was formulated as increased production among farmers and pastoralists through sound land husbandry.

The specific objects were:

- Enhanced soil productivity through improved soil conservation and management;
- Increased as well as diversified production and use of trees and tree products;
- Promotion of effective control of run-off from physical infrastructure;
- Poverty reduction through promotion of income-generation-oriented activities and through raising awareness and capacity building.

Programme strategies

By 1987 the NSWCP had developed an extension strategy referred to as the catchment approach. The catchment approach was defined as an area identified by the community who were willing to work with a multidisciplinary team of experts in solving their problems. The approach has five basic steps:

- Catchment identification;
- Publicity and awareness creation;
- Catchment planning;
- Handing over;
- Monitoring and evaluation;

In 1997, when the last phase of the programme was being designed, there were eight problems that were being addressed:

- Soil fertility decline;
- Migration to semi-arid lands;.
- Social dynamics – increased population and reduced land sizes;
- Land tenure;
- Decline in farm productivity;
- The demise of subsistence farming;
- Poverty, labour and gender issues;
- Declining basic nutritional and health standards of rural households.

The activities to achieve specific programme objectives were implemented in an integrated manner. They included:

- Development of soil and water conservation techniques/technologies;
- Dissemination and application of soil and water conservation technologies;
- Promotion of the use of simple agricultural equipment and technologies;
- Increased knowledge of soil and water conservation among farmers through training;
- Increased knowledge of soil and water conservation among staff through training;
- Creation of awareness of soil and water conservation.

Collaboration

The NSWCP has been funded by the Swedish International Development Agency (SIDA) since its inception. Other collaborators include research organisations (national and international), private sector organisations and farmer groups. The collaboration has been both in technical terms through training and in actual involvement in the catchment activities. Government departments have also been key players in collaboration. The collaborators include: Kenya Agricultural Research Institute (KARI), Kenya Forestry Research Institute (KEFRI), International Center for Research in Agroforestry (ICRAF), Kenya Wildlife services (KWS), Canadian Aid for Rural Extension (CARE), German Technical Co-operation (GTZ) projects, churches and quasi-government parastatals.

Achievements and lessons learnt

The main achievements in terms of seedling production and training are shown in Tables 6 and 7.

Table 6 Seedling production

Period	Number of nurseries	Forest seedlings raised	Fruit seedlings raised
1987–88	44		
1988–89	43	2054472	262934
1989–90	43	3819000	771000
1990–91	43	4205614	783405
1991–92	646	1500000	350545
1992–93	849	3043305	220980
1993–94	453	5309229	999413
1994–95	452	4063882	616586
1995–96	480	2150433	455938
1996–97	–	181199	339887
1997–98	1298	–	–
1998–99	–	2243131	463891
1999–2000	–	–	

Table 7 Agroforestry training

Period	Nursery management	Seminars on agroforestry
1987–88	183	–
1988–89	–	–
1989–90	–	34
1990–91	151	53
1991–92	–	79
1992–93	506	32
1993–94	880	90
1994–95	621	82
1995–96	671	138
1996–97	–	–
1997–98	435	175

The total funding of nurseries, especially group nurseries, is not sustainable. It makes the groups dependent, and does not encourage them to develop sustainable strategies. Funding should be only for critical requirements; all else should be from locally available materials.

There is still a major limitation in terms of getting high-quality planting materials for fruit trees because of poor propagation methods. The licensing requirements may be a hindrance but technical expertise is the major limitation.

It is not enough to produce and distribute tree seedlings. There is a need to look into the survival rates of the planted seedlings to be sure of tree establishment.

Conclusion

The NSWCP ended in June 2000 but gave rise to a new project funded by SIDA – the National Agriculture and Livestock Extension Programme (NALEP-SIDA). NALEP-SIDA uses the shifting

focal area approach, a modification of the catchment approach. It is operating in 42 districts and five provinces in Kenya. The overall goal is enhanced contribution of agriculture to socio-economic development and poverty alleviation through pluralistic and efficient extension service for increased production, food security, increased income and improved environment. It is hoped that through a built-in agroforestry survey using participatory rural appraisals (PRA), carried out at the divisional level, issues will emerge which will guide the formulation of interventions and extension packages. The findings will determine the tree species produced in the focal areas and nursery production will focus more on group and individual efforts than centralised production. Emphasis will be on integration of improved fruit trees in the farming system. Species selection and management of various trees for different uses and purposes will be given priority in the agroforestry extension efforts.

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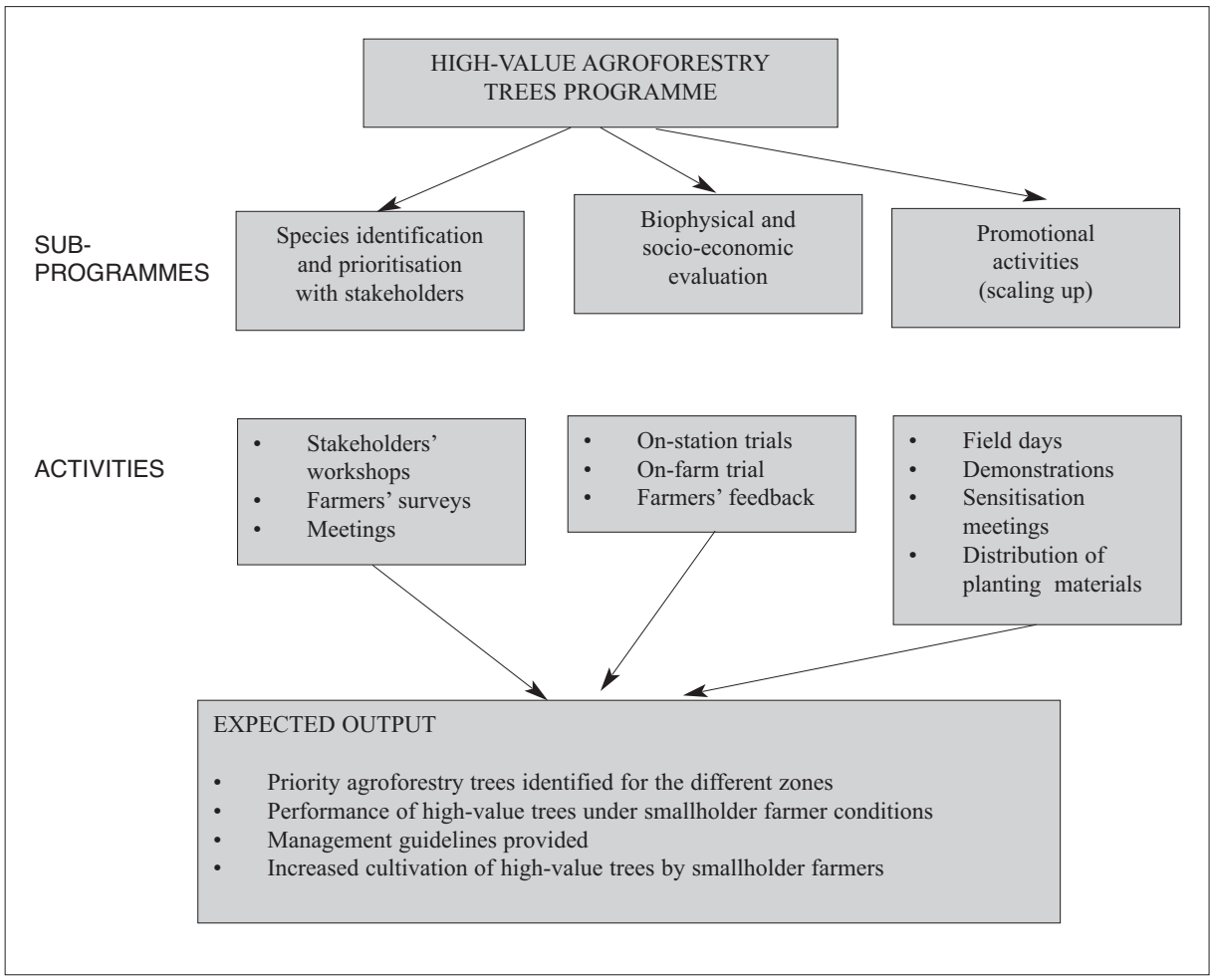
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4.2.4 Experiences and involvement in agroforestry research and development

JAYNE MUGWE

The National Agroforestry Research Project based at Embu, Kenya has mandate to develop and promote appropriate agroforestry technologies for the smallholder farmers in central Kenya to address problems/constraints identified in a diagnostic study of 1987 (Minae and Nyamae, 1988). Some of the major problems identified were shortage of cash-generating enterprises, increasing demand for tree products and low numbers and diversity of tree species. To address these constraints the project has an agenda of promoting cultivation of a wide range of tree species that would yield valuable products for cash income or cost saving. These trees have been named 'high-value agroforestry trees'. Their

Figure 2 Sub-programmes in the high-value trees programme



adoption has great potential for improving the economic status of households and thus making a contribution towards reduction of poverty levels among smallholder farmers. This programme is sub-divided into three sub-programmes, as shown in Figure 2.

Identification of high-value agroforestry trees with stakeholders

Identification and prioritisation of tree species with stakeholders is important as it reduces the chances of choosing less important species that will not be adopted. In this programme, to come up with priority high-value agroforestry trees, three activities were carried out. The first activity involved organising a stakeholders workshop with the objective to define and identify high-value trees and their products for smallholder farmers of central Kenya. After the workshop, farmer surveys were carried out in Meru, Embu, Murang'a and Nyeri Districts. The survey interviewed 160 households (40 households in each district). The major objective of these surveys was to ascertain the tree species that farmers wanted to plant in future. Also, local farmer meetings were held with the extension personnel in specific catchments. The aim of these meetings was to sensitise farmers about high-value trees and expose them to the results of the workshop and the farm surveys. Figure 3 is a schematic presentation of the process followed in the identification and prioritisation of high-value trees ready for planting by farmers.

From the workshop, over 50 tree species were identified (Mugwe *et al*., 2000). There was a general feeling that tree species and varieties, to be defined as high value, must generate cash for the farmer, preferably in the short term. They should also be compatible with the farming systems of the area, serve dual or several purposes for farmers, and be easy to establish, manage and harvest. Fruit trees were given high preference by farmers and other stakeholders due to tangible benefits that could be obtained within a relatively short time compared to timber trees. The importance of long-rotation high-value indigenous timber trees such as *Vitex keniensis* and *Ocotea usambarensis* was highlighted and suggestions made to overcome the long maturity period, policy and substitution with alternative tree species with a shorter maturity period.

Table 8 shows the high value trees found planted on farms of the 160 farms surveyed. A wide range of high-value trees were found, *Grevillea robusta* being prominent for timber purposes. Also included in the top ten were a mixture of exotic fruit trees (*Mangifera indica* and *Macadamia tetraphylla*) and indigenous timber species (*Cordia africana* and *Vitex keniensis*). In the survey, many farmers were interested in medicinal tree species but had minimal knowledge of them. The main species known and sought after by farmers was *Azadirachta indica*, found mainly along the coast. Other species preferred by farmers included *Croton* spp., *Caesalpinia volkensii* (in Embu and Murang'a) and *Erythrina abyssinica* (in Embu and Nyeri). Traditional medicinal practitioners, however, named a variety of medicinal tree species (Table 9).

Evaluation of biophysical performance and socio-economics

Cultivation of mango is widespread in the region and occupies a prominent place among other fruit trees due to its nutritional status (high in vitamins) and high market demand. Local (naturalised) varieties are grown by most farmers. These varieties pose problems of tree-crop interactions due to

Figure 3 Steps in the identification and prioritisation of high-value trees for smallholder farmers in central Kenya

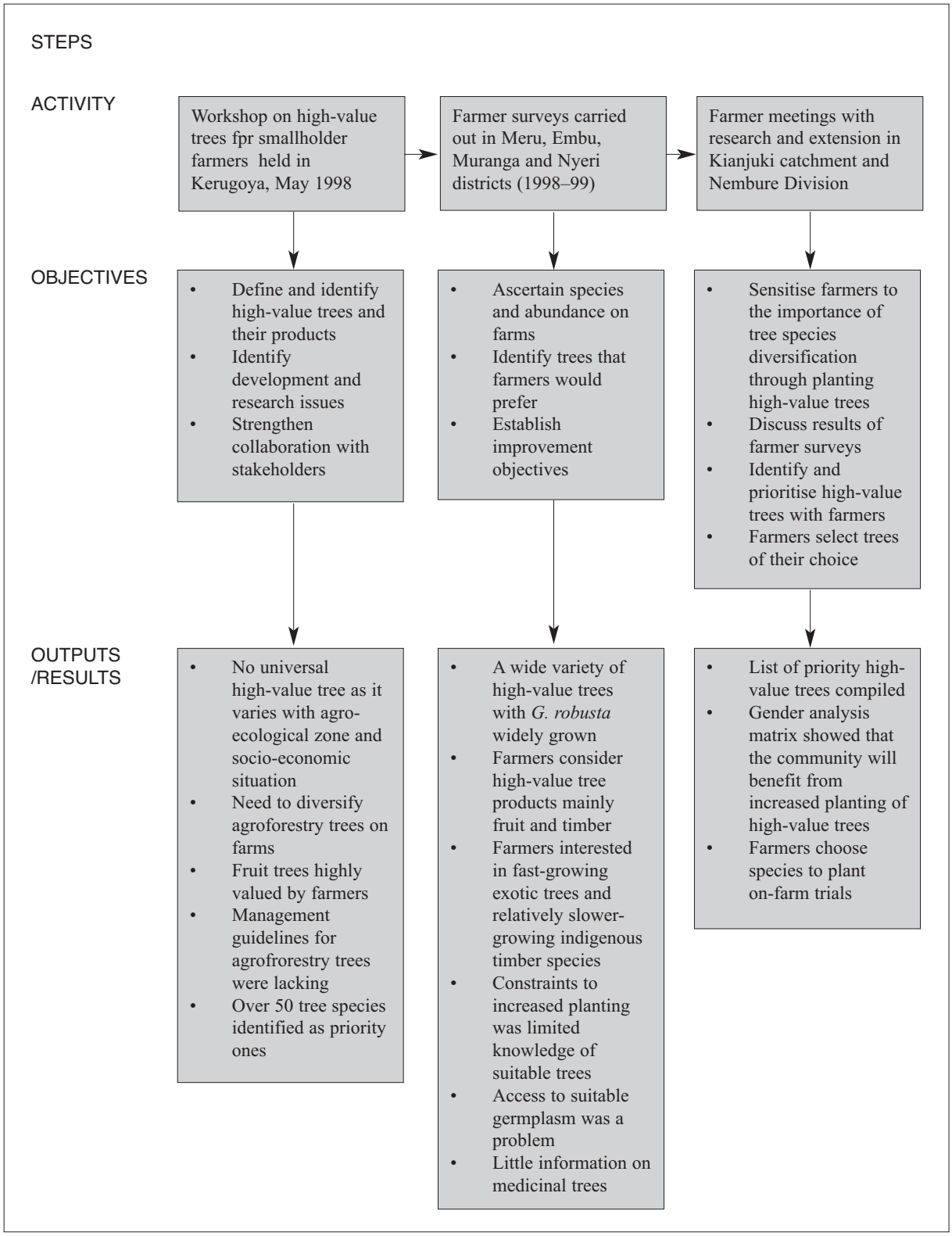


Table 8 High-value trees found planted on-farms in 1999

Botanical nomenclature	Main product	Total number	Central Meru	Embu	Murang'a	Nyeri
Grevillea robusta	timber	154 (96%)	40 (100%)	40 (100%)	37 (93%)	40 (100%)
Persea americana	fruit	137 (86%)	37 (93%)	37 (93%)	24 (60%)	37 (93%)
Mangifera indica	fruit	101(63%)	21 (53%)	32 (80%)	29 (73%)	32 (80%)
Macadamia tetraphylla	fruit	85 (53%)	20 (50%)	37 (93%)	16 (40%)	37 (93%)
Eucalyptus saligna	timber	54 (34%)	20 (50%)	15 (38%)	4 (10%)	15 (38%)
Cordia africana	timber	52 (33%)	4 (10%)	17 (43%)	7 (18%)	17 (43%)
Carica papaya	fruit	25 (16%)	3 (8%)	7 (18%)	2 (5%)	7 (18%)
Psidium guajava	timber	23 (16%)	3 (8%)	4 (10%)	4 (10%)	10 (25%)
Cupressus lusitanica	timber	15 (9%)	4 (10%)	4 (10%)	2 (5%)	15 (38%)
Vitex keniensi	timber	15 (8%)	10 (25%)	10 (25%)	2 (5%)	1 (3%)
Azadirachta indica	Medicine	14 (14%)	5 (13%)	5 (13%)		6 (15%)
Prunus africana	timber	14 (14%)	1 (3%)	1 (3%)		4 (10%)
Citrus spp.	fruits	11(7%)	5 (13%)	5 (13%)		3 (8%)
Cyphomandra betaceae	fruits	11(7%)			2 (5%)	
Eribotrya japonica	fruits	9 (6%)	2 (5%)	2 (5%)	3 (8%)	2 (2%)
Annona senegalensis	fruits	8 (5%)	2 (5%)	2 (5%)	4 (10%)	6 (15%)
Casuarina equisetifolia	timber	8 (5%)	1 (3%)	1 (3%)		3 (8%)
Markhamia lutea	timber	6 (4%)	3 (8%)	3 (8%)		1 (3%)
Albizzia gummifera	timber	4 (3%)				4 (10%)

Table 9 Medicinal tree species mentioned by traditional medicinal practitioners

Tree species	English name	Kikuyu name	Remedy	Botanical family
Azadirachta indica	Neem	Mwarubaini	Several diseases	Mediacceae
Prunus africana	Red stinkwood	Muiri	Postrate cancer, constipation	Rosaceae
Olea europaea ssp. *africana*	Brown olive	Mutamaiyu	Backache, painful joints	Oleacea
Strychnos henningsii		Muteta	Stomach ailments	Loganiaceae
Warbugia ugandensis	Kenya greenheart	Muthiga	Chest pains, toothache	Canallaceae
Erythrina abyssinica	Red hot poker tree	Muhuti	Liver problems, elephantiasis	Papilionaceae
Ficus thoningii	Wild fig tree	Mugumo	Liver problems, diarrhoea	Moraceae
Caesalphinia volkensii		Mubuthi	Malaria, gonorrhea, bilharzia	Caesalphiniaceae
Ocotea usambarensis	East African camphor	Muthaiti	Stomach ailments	Luaraceae
Zanthoxylum gilletti	African satinwood	Mucagatha	Severe colds, stomach ache	Rutaceae

their large canopies, in addition to low harvest index and poor marketing potential. The introduction of high yielding, improved mango varieties with high quality fruits, which are also dwarf (grafted), would address this constraint. The new varieties were, however, selected for monocropping and their performance under intercropping in smallholder farms might be affected. Information on how they would perform under intercropping and possibly low inputs is lacking. On-farm trials were therefore initiated with the main objective being to evaluate their adaptation under smallholder farmers' environment. The underlying hypothesis was that intercropping would reduce fruit production. The varieties being tested are Sensation, VanDyke, Tommy Atkins, Kent, Haden and Alfonso.

The trees started producing fruits at 3 years old. Table 10 shows production in Kirinyaga district. The best performing varieties that could be recommended for cultivation by smallholder farmers are Kent, Van Dyke and Tommy Atkins.

Table 10 Mean fruit production (per tree) in the 1999–2000 season in Kirinyaga (after about 6 years)

Variety	UM3		UM2	
	Range	Mean number of fruits/tree	Range	Mean number of fruits/tree
Sensation	12–250	108	12–220	109
Van Dyke	18–120	80	79–300	154
Kent	30–150	25	51–150	92
Alfonso	0–35	10	0–8	2
Tommy Atkins	25–120	156	13–221	120

Following the identification of these three varieties, a scaling-up programme was initiated in 2000. The activities involved training farmers on how to propagate their own quality seedlings. So far, we have worked with seven farmer group nurseries in four districts.

Promotion of high-value agroforestry trees

The aim of this activity is to promote the cultivation of a wider diversity of high-value trees through promotional activities such as awareness meetings, demonstrations, field days and increased on-farm planting. The objectives are to:

- Hold meetings with selected farmer groups to sensitise farmers about high-value trees;
- Promote and encourage on-farm planting by providing planting materials of unpopular species to farmers;
- Evaluate farmers' feedback on their priority high-value trees and the performance of trees planted on their farms.

Field days, farmers meetings, demonstrations and on-farm planting are major activities planned in this effort.

Conclusion

The implementation of the work has progressed well with collaboration from the various stakeholders: Extension personnel from the Ministry of Agriculture, NGOs, international research organisations and farmers. So far, more than 5000 seedlings of high-value trees (*Prunus africana, Warbugia ugandensis, Vitex keniensis* etc.) have been distributed for planting by farmers. Awareness of the importance of high-value agroforestry trees has been created.

In future, collaboration will be intensified with existing NGOs and government ministries so as to be able to reach more farmers, especially with regard to already identified species.

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4.3 MALAWI

4.3.1 Experiences and involvement in agroforestry research and development in Malawi

ALLAN CHILIMBA

In addressing the agricultural-related problems facing Malawi, research is being undertaken to identify new or improved agroforestry technologies that alleviate smallholder farmer problems, including low or declining soil fertility, fuelwood shortages and fodder deficiencies.These have very serious implications for food security and the country's economy. Soil degradation ranks as the most serious environmental problem facing Malawi.

Reductions in crop and livestock productivity, along with shortages in fodder, fuelwood and building materials, are undermining Malawi's agricultural self-sufficiency. Wood is Malawi's primary source of fuel; and the gathering of fuelwood, along with the clearing of land for crops, is a major causes of deforestation. Estimates indicate that cultivation is expanding at 3.5% per annum, and that demands for fuelwood and other tree products are increasing at similar rates (Nkaonja, 1985). The integration of trees with crops and animals in a form similar to natural systems offers a unique opportunity to address these issues.

Personal experience and involvement in agroforestry research and development in Malawi started after attending a Regional Training of Trainers Course on Agroforestry for sustainable rural development in the Zambezi Basin in 1997 when the Ministry of Agriculture nominated me for the Maize Productivity Task Force. In thisTask Force, I was the Desk Officer for Salima Agricultural Development Division, implementing demonstrations on organic matter technologies such as inter-cropping pigeon peas with maize, improved fallows with tephrosia, mucuna and crop rotation.

In 1999, I was made Commodity Team Leader for Agroforestry. I have implemented an agroforestry trial entitled ' Introduction of trees on cropland for improved soil productivity and wood supply for small holder farmers in Malawi'. The objective of the trial is to evaluate the benefits of integrating trees with maize on soil fertility, wood supply and crop yields. The other activity has been maintaining an alley cropping trial at the station and collecting more soil and grain yield data. This season, an indigenous fruit orchard is being planted at the station with the following fruit trees:

- *Uapaca kirkiana* (Mloza provenance) – 20 trees
- *Parinali culatelifolia* (Mulanje Mt. Provenance) – 10 trees
- *Mauritiana zizyphus* (Mangochi provenance) – 10 trees
- *Vangueria inflausta* (Makoka provenance) – 10 trees

- *Strychnos cocculoides* (Kasungu provenance) – 10 trees
- *Screlocarya birrea* (Makoka provenance)

As secretary for the National Agroforestry Steering Committee (NASC), I have been involved in organising agroforestry steering committee meetings, ensuring that the Malawi agroforestry newsletter, which helps to disseminate agroforestry information to stakeholders, is published in a timely manner. The main function of the Secretariat of NASC is to administer, disseminate and document information on agroforestry research and development in Malawi.

The NASC was constituted in 1984 with the aim of guiding and coordinating agroforestry activities among all sectors in the country (public, private, government and non governmental organisations), reviewing all matters related to agroforestry policy, research, education, training and extension, and advising government on specific recommendations on agroforestry research and development activities.

The NASC comprises members from agriculture, forestry, the University of Malawi, and the NGO community to reflect the multi-disciplinary nature of agroforestry. The main activities of the NASC include:

- Managing a functional agroforestry secretariat;
- Conducting two or more meetings in a year;
- Producing a bi-annual agroforestry newsletter (*Agroforestry News*);
- Conducting an agroforestry symposium once every 4 years.

The NASC is organising the Fourth National Agroforestry Symposium in March 2002 in Mangochi.

Objectives

The Agroforestry Commodity Team is investigating technologies that address problems of declining soil fertility, high fertiliser costs, soil erosion and run-off, and fuel and fodder deficiencies. The team is investigating suitable multi-purpose tree (MPT) species for permanent mixed inter-cropping, contour buffer strips for erosion control, alley farming, live fencing, boundary and homestead planting, and green manure and/or fodder banks.

Strategies

The major strategy is to strengthen collaboration between the Department of Agricultural Research and Technical Services and other stakeholders involved in disseminating agroforestry technologies through the NASC. This would prevent sending conflicting technical messages to farmers and ensuring that only appropriate technologies are disseminated to them. There are very important players, such as the Department of Land Resources and Conservation, the Department of Forestry, ICRAF, PROSCARP, MAFE and NGOs.

The second strategy is to revive the agroforestry nursery in order to provide agroforestry tree seedlings, including indigenous fruit tree seedlings, to farmers. The establishment of a national indigenous fruit orchard at Chitedze Research station will be a very important step in popularising indigenous fruits among the local people.

Strengthening the secretariat of the NASC is necessary in order to have agroforestry activities well coordinated in the country. The mission of the NASC is to improve and sustain soil productivity in Malawi by promoting the adoption of sound agroforestry, soil and water conservation and social forestry practices. The mandate of the NASC is to guide and coordinate these activities among all sectors in the country, to review all matters related to policy, research, education and extension and to advise government accordingly, with specific recommendations on agroforestry research and development in the country. The establishment of an operational policy framework that ensures that it is problem-solving at the farm level is a basic aim.

Although considerable progress has been made in certain areas of research, important gaps still exist. Based on this, our current plan of action reflects the following needs:

- to identify indigenous agroforestry practices by farmers and the opportunities to improve these practices;
- to focus on and promote technologies with high potential for impact;
- to expand and strengthen site-testing.

Specific activities to support these plans will include:

- Screening agroforestry MPT species in a wide range of agro-ecological zones for alley farming for fertility maintenance, livestock feed, green manure, fuelwood and fodder banks. Pruning from alley cropping provides substantial quantities of manure/mulch, fodder and fuelwood, as well as controlling erosion. However, lack of information on species choice and management has severely limited the adoption of the technology in Malawi. This suggests the need for quantitative research.

- Screening agroforestry MPT species in a wide range of agro-ecological zones for boundary planting, improved fallow and short-term woodlot and live fencing. Only a limited number of tree species have been researched for agroforestry in Malawi; thus both the indigenous and exotic flora represent an untapped potential for improving and developing agroforestry systems. Collection, screening and multiplication of MPTs will give greater scope for addressing farmer problems and needs.

- Expanding the research to include different crops and varieties in various agroforestry systems, with and without supplementary inorganic fertilisers (especially N, P, K and S). Our research has also shown that apart from N, P may also become limiting in agroforestry situations (Saka *et al*., 1991).

- Studying nutrient cycling, mineralisation and decomposition of organic material from trees, and the competition between trees and crops for light, nutrients, and water. So far, little is known about the

nutrient budget and flow in agroforestry systems. It therefore is one of our objectives to get an in-depth understanding of agroforestry systems and how they function. This information will be important in improving existing technologies. This work will also enable several Malawians to undertake graduate education and fellowships with the team.

- Investigating intercropping practices in agroforestry systems at different crop densities. Farmers in Malawi practice intercropping, but our research has not done much in this respect. Furthermore, our preliminary work (with the maize team) showed that intercropping and crop densities may have significant production impacts in agroforestry systems, and we would like to do more work in this area.

- To conduct both short- and long-term training for all levels of staff and to organise workshops, seminars and symposiums. Since agroforestry involves specialised fields such as forestry, horticulture and livestock production, and Bunda College does not specialise in these fields, it is proposed that some technical staff be trained in these fields, specifically: one diploma in horticulture (possibly from Arusha); two diplomas in agroforestry; and one diploma in livestock nutrition (perhaps from Egerton College in Kenya). Short-term training courses within the region and at IITA in Nigeria should also be explored.

Sources of funding and support

The current source of funding has been the Malawi government. The funding has been minimal and thus the agroforestry activities have been minimal. The agroforestry nursery is non-operational due to low funding. ICRAF supports two annual meetings of the NASC and is supplying the indigenous fruit seedlings.

Achievements to date and support needed

Recent agroforestry research activities have laid a sound foundation for making a significant impact on agricultural sustainability and food security in Malawi. Specifically, the team has:

- Developed management recommendations for several key technologies, which have been included in the Guide to Agriculture Production 1992–93 season. This is the first time that any such recommendations have appeared in this document in the country.

- Produced the proceedings of two agroforestry symposia.

- Developed and strengthened links with key agricultural institutions within and outside the country as an integral part of institutionalising Malawi's agroforestry programme.

Although some technologies are ready to be tested by farmers, further research and training will be needed to ensure agroforestry research continuity. Moreover, as agroforestry extension becomes more

important, fine-tuning of technologies will also become important. However, the effectiveness and continuity of the programme may be severely constrained by lack of operational funds and well-trained researchers in agroforestry. Malawi has lost all the well-trained manpower in agroforestry in the Department of Agricultural Research and Technical Services. Strengthening Malawi's institutional capabilities and effectiveness for undertaking research in agroforestry by establishing effective links with relevant local and international research centres is required. Capacity building of the Agroforestry Commodity Team will be a priority in order to improve research capability and delivery of advisory services. Also a priority will be training scientists to PhD and MSc level and providing short courses on agroforestry for the technicians working in this field.

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4.3.2 Agroforestry initiatives: the Malawi experience

Priska Munthali

Malawi's economy is highly dependent on natural resources and as these are being rapidly depleted or degraded, long-term food security and sustainable socio-economic growth is being seriously compromised. Agriculture contributes about 35% to Malawi's GDP and the sector is faced with serious threats in the wake of severe resources degradation, hence the agroforestry initiatives.

The problem

Land degradation in Malawi has become acute. This has manifested itself in form of soil erosion, a decline in soil fertility, deforestation, and diminishing surface and ground water. Soil erosion is rated as the number one environmental problem threatening the sustainable agricultural development. This has resulted in less productive soils to a point that the crop yields have been declining over the years, yet most smallholder farmers use inadequate or no fertilisers at all, resulting in below potential average crop yields. Thus the most important factors responsible for reduced crop yields are soil erosion, declining soil fertility and non-affordability of inorganic fertilisers.

Role of agroforestry. Agroforestry offers the potential to alleviate this problem by the integration of trees and conservation practices in the farming system to improve land productivity and natural resource management. Since agroforestry is the planting and management of trees on farm to derive benefits, it offers a wide range of technologies that can address some (not all) of the problems farmers are facing; this includes declining soil fertility. With farmers practising agroforestry, they derive benefits for their livelihood such as harvested products in terms of fruits, fodder, medicine, fuelwood etc., and also achieve soil fertility replenishment, resulting in increased crop yields, soil conservation and biodiversity. Therefore, agroforestry has the potential to contribute to sustainable food security and develop farmers' capacity to manage the natural resources.

Agroforestry initiatives

Institutions. The Department of Land Resources Conservation is in the Ministry of Agriculture and Irrigation. Its overall policy goal is to promote the efficient, diversified and sustainable use of land-based resources both for agriculture and other uses in order to avoid sectoral land-use conflicts and ensure sustainable socio-economic development. It is mandated to spearhead the promotion of agroforestry technologies in Malawi. The department has been implementing a number of agroforestry programmes with farmers since mid-1980s. The two donor-funded projects under the Department of Land Resources Conservation are helping to implement the mandate to scale up the promotion of agroforestry technologies. The projects are the Malawi Agroforestry Extension (MAFE) project, with Washington State University and USAID, and the Promotion of Soil Conservation and Rural Production (PROSCARP), funded by the EU.

MAFE's objective is to increase farmer adoption of best bet agroforestry practices developed over many years of testing and evaluation at farm level. MAFE provides technical training and training kits, germplasm and monitoring support to various partners with an aim of increasing outreach efforts. Currentl,y MAFE is working with over 40 government and non-governmental partners nationwide. PROSCARP's man aim is to strengthen soil conservation efforts.

The Department of Agriculture Research and Technical Services through the Agroforestry Commodity Team has been conducting on-station and on-farm trials in agroforestry over the past 15 years. Similarly, the International Center for Research in Agroforestry (ICRAF) has for the past 10 years been conducting trials and recently embarked on a dissemination programme. The collaboration of the Department of Agricultural Research with institutions such as ICRAF through NASC has resulted in the development of biophysical feasible and profitable technologies.

There is a growing number of NGOs in Malawi which are actively involved in natural resources management in general and agroforestry in particular. They include the Christian Service Committee, World Vision International and Action Aid.

The Department of Forestry in the Ministry of Natural Resources and Environmental Affairs supports agroforestry programmes through its extension arm and the Forestry Research Institute of Malawi (FRIM), the main supplier of tree seeds.

Training institutions such as Bunda College and the Malawi College of Forestry and Natural Resources College are important institutions in agroforestry, providing trained manpower for this field.

Promoting agroforestry technologies. The following are some of the technologies which the Department of Land Resources Conservation and other institutions are promoting:

- Dispersed systematic interplanting with *Faidherbia albida*. The *Faidherbia* tree has a unique feature of dropping nutrient-rich leaves when crops are growing and it is in very high demand by farmers, but the major problem is that it takes a long time for benefits to be realised.

- Under-sowing with *Tephrosia*. This simple low-cost practice has undergone rigorous testing and adaptation with farmers throughout the country. It involves sowing *Tephrosia* seed as an intercrop at the same time that maize is planted. The farmers have two options. The first is to sow the *Tephrosia* seed annually and incorporate the biomass at the start of the following season. The other option is to leave *Tephrosia* as fallow for the following season in order to increase the biomass yields.

- Mixed cropping with *Gliricidia sepium.*

- Improved fallows. A piece of land is left to fallow with nitrogen-fixing trees planted to it for at least two growing seasons. The species used for this particular technology are *Sesbania sesban* and *Tephrosia vogelii.* However, this technology is not very popular because of small landholding sizes, especially in southern Malawi.

Table 11 Adoption rates of key practices

Technology/practice	Target 2001	Results 2001	Results 1996 to date	Targets 2002
Undersowing *Tephrosia*				
Seed distributed (tons)	10.0	9.50	–	10.0
Area (ha)	5,000	2,765	5,841	8,000
Number of farm families	14,635	26,635	57,000	23,000
Soil-improving trees				
Seed distributed (tons)	1.5	1.4	–	2.0
Area (ha)	5,880	11,148	28,268	11,732
Number of farm families	14,635	39,488	96,236	43,764
Trees for wood /other uses				
Seed distributed (tons)	7.0	7.5	–	10.0
Number of trees (millions)	9.8	9.3	–	10.0
Number of farm families	30,838	59,311	210,865	39,135

Source: MAFE Annual Report 2000/2001

- Homestead and boundary planting. This is one of the popular forms of tree planting in Malawi and species such as *Senna siamea* and *S. spectabilis* are recommended because they are fast growing and can be easily coppiced.

Achievements. Despite the many years of investment in agroforestry research and development, adoption by smallholder farmers is still low. However, there has been a small increase in the adoption of the various technologies. Table 11 shows the adoption results for 2000–2001, provided by MAFE.

Constraints to adoption of agroforestry technologies

Although agroforestry is a good alternative for increased production, the adoption of various technologies and practices is constrained by a number of problems, including:

- Limited access to tree seed and planting materials. This is the most limiting factor since seeds are not readily available;

- Apparent long gestation period of some technologies before they achieve impact and lack of many short-term alternatives for farmers;

- Policy environment is not conducive to scaling up agroforestry as far as seed pricing and limited outlets are concerned;

- The extension system is not geared to agroforestry because of limited training in this area; the promotion of agroforestry technologies has been mainly in the hands of Land Husbandry Assistants and as a result farmers have limited knowledge and skills in agroforestry;

Table 12 Achievements by the Department of Land Resources inDecember 2001 from eight ADDs

Technology /activity	Target	Achievement December 2001	Cumulative achievement July – December 2001
Agroforestry, and soil and fertility improvements			
Number of agroforestry nurseries	1255	38	897
Number ofseedlings raised	5,460,513	156,319	3,377,255
Number of male farmers	22,393	2,454	59,050
Number of female farmers	21,377	3,176	27,090
Total farmers	4,770	5,630	86,140
Undersowing			
Area covered (ha)	3,730	5,820.35	5,827.45
Male involved	6,456	6,819	6,837
Female involved	2,586	5,794	5,811
Total	9,042	12,613	12,648
Improved fallow			
Area covered (ha)	76	4.52	4.52
Male involved	56	13	13
Female involved	62	6	6
Total	118	19	19
Systematic interplanting			
Area covered	1330	482.8	482.8
Male involved	253	2,280	2,280
Female involved	347	1,644	1,644
Total	600	3,924	3,624

Source: LRCD, December monthly report, 2001

- Limited adaptability of some tree species, calling for area-specific tree species recommendations and the adaptation of technologies to the prevailing socio-economic circumstances of smallholder farmers.

Conclusion

Since agroforestry offers a feasible and profitable option for long-term soil fertility improvement, there is a need to consider certain factors for more effective programmes:

- Most extension field workers lack knowledge in agroforestry, and thus there is need for training to equip them to provide better support for farmers in this field;

- A sustainable mechanism of financing and distributing the seed needs to be established and strategies need to be put in place to allow farmers source their own seed; instead of relying on MAFE and the national seed distributor (FRIM), consideration should be given to using rural agri-dealers to distribute seed;

- There is a need to strengthen the extension support system for monitoring the progress of the activities being implemented and also to strengthen community based monitoring to ensure the sustainability of the programmes.

The goal of increasing household food security through maize production is very important but becomes elusive as farms continue shrinking in size, soils become exhausted and the prices of farm inputs keep on escalating. Strategies can be put in place, however, to help the smallholder farmers escape the poverty and hunger cycles. There is also a need to consider soil conservation measures which form an integral part of any sound land-use management. Such measures should be in place in all areas where agroforestry is practised. Agroforestry offers smallholder farmers a brighter future if they adopt the technologies suited to their circumstances and needs.

4.4 NAMIBIA

4.4.1 Agroforestry as farming practice in the Kavanga Region, Namibia

Bonifacius Sihova

The Kavango communal farmers traditionally practice agroforestry, unknowingly, as do some other rural farming communities in Namibia.

The Agroforestry Programme was introduced into the Kavango Region in 1993–94 under the umbrella of the Kavango Agroforestry Working Group (KAWG). The Ministries of Agriculture, Water and Rural Development (MAWRD; Directorate of Research and Specialist Services) and of Environment and Tourism (MET; Directorate of Forestry) were the major players. The programme was mainly supported by Canada Namibia Cooperation (CANAMCO) under Oxfam Canada. A full time agroforestry professional was recruited by CANAMCO to run the programme.

Basic agroforestry principles were taught to technicians in MAWRD in the Kavango Region. This was done by holding courses at Mashare agricultural development Institute. The technicians in turn gave similar courses to the farmers. Follow-ups and research studies in the villages were also carried out by CANAMCO officials in collaboration with MAWRD and MET where necessary.

Farmers and communities at large were very interested in the many uses of trees/vegetation to humans and animals, in the interaction between forests, animals and humans. Other villages, such as Mupapama in the Mashare Constituency, went to the extent of conserving certain portions of the forest as forest reserves for specific reasons: firewood, poles for construction, medicines, browsing and fruits.

The KAWG functioned very well until 1997, when the CANAMCO Project came to an end and was replaced by the Lihepurura Kavango Trust (LKT) with was less interested in agroforestry. The programme was also supported by MAWRD, donor funds from the EU via the Rural Development Support Programme but lost that support during 1998–99. Ministries faced budgetary constraints and lacked trained staff.

Programme objectives

The main aim of the programme is to promote the role trees and vegetation play for human welfare. Technologies incorporating trees with crop cultivation and soil fertility improvement are also being investigated through this programme. The programme has two components: the influence of trees on crop production and the functions of trees for combating deforestation. Deforestation affects some parts of Namibia very negatively and the rural communities recognise the need to protect and establish

forests/vegetation. The main reasons for establishing and protecting the forests are harvesting for fuelwood, poles for house constructions, shade in the fields, medicinal use, grazing areas for animals and wild fruits – in other words, creating awareness among rural communities of the utilization of natural resources such as trees, plants and soil, and their interaction with humans. This creation of awareness is as important at the upgrading of the skills of agricultural and forestry technicians in the application of the agroforestry technologies.

Progress and achievements

The Directorate of Forestry (DoF) in the Kavango Region is carrying out forestry trials at Mashare in collaboration with the Hamoyi Forestry Research Station. A plot of forestry establishment trials has been established at Mashare for forestry research use.

Mr Sihova heads the agroforestry component at Mashare. He works closely with the Hamoyi Forestry Research Station and other officials in the DoF in Kavango. *Faidherbia albida* provenance trials have been established at Mashare and other Agricultural Development Centres (ADCs) in the Kavango Region and other regions. Sites identified for the 1995–96 season were Hamoyi (Kavango), Mashare (Kavango), Ogongo Agricultural College (Omusati) and Bukalo ADC (Caprivi). These trials are for testing and evaluating trees suitable for Namibian condition. The trees are good for browsing by goats, cattle or other animals. Another objective is to evaluate the influence of the trees on soil fertility (nitrogen fixation, etc.). The period of this experiments is targeted for 20 years from 1996.

The agroforestry programme is trying to get sufficient on-the-job and in-service training in agroforestry for technicians.

Village research shows that certain trees are preferred by community members for different uses. Table 13 gives examples, drawn from the village of Mupapama (Kavango Region, 1995–96); the local vernacular used in this table is Rukwangali.

Table 13 Uses of agroforestry trees in Mupapama, Namibia

Local name	Botanical name	English name	Grazing	Construction	Firewood	Fruit
Mugoro	*Terminalia sericea*	Silver terminalia	x	x	x	
Muwowo	*Commiphora angloensis*	Sand corkwood	x	x	low	
Murere	*Diplorhynchus condylocarpon*	Horn-pod tree	x	low	low	
Mutundungu	*Burkea africana*	Sand syringa		x	x	
Mwege	*Dichrostachys cinerea*	Sickle bush		x	x	
Uguva	*Pterocarpos angolensis*	Kiaat, African teak		x	low	
Ugongo	*Ricinodendron rautenenii*	Mangetti		low	low	x
Uhahe	*Baikiaea plurijuga*	Zambezi /R(Z) teak	x	x	x	
Usivi	*Guibourtia coleosperma*	Large false mopani		x	x	x
Utu	*Strychnos pungens*	Spine-leaved monkey orange	x	low	low	x
Uguni	*Strychnos cocculoides*	Corky bark monkey orange	x	low	low	x

Faidherbia albida (formally *Acacia albida*) is new in the Kavango area but good for browsing. The large false mopani trees have been tested for soil fertility effects on millet in one farmer's field but no significant results could be obtained due to short period of test (one season only). All indigenous fruit trees are being protected, even in the crop fields. This was the main reason of evaluating whether the trees would contribute towards soil fertility or have any negative effects on crops.

Strategies for addressing the problems

The agroforestry bodies need full support from Ministries or donor organisations where possible. The KAWG has created created awareness of agroforestry practices among farmers and among government technicians. Short courses, campaigns and leaflets are some of the ways of getting the message across.

KAWG used to organise events to expose participants to the benefits of agroforestry that can change someone's perceptions towards the utilisation of natural resources. The formal agricultural training colleges are introducing agroforestry as a subject in their curricula.

The future

More work needs to be done in the field of agroforestry in Namibia. There is a great need to address the issue of agroforestry as part of normal farming systems among rural communities. A viable programme needs to be established to bring about these changes. To do this, MAWRD needs to include agroforestry in its work programme if the human resources required are to be available. Where the lack of human resources is a constraint, training programmes need to be put in place to fill this gap. In Kavango, for instance, there is the potential to conserve the natural resources, if effective awareness campaigns are conducted.

As the colleges are including agroforestry in their curricula, full support is needed from communities as well as the government and organisations.

I see this study visit to the Eastern and Southern Africa as a major step in the realisation of the value of agroforestry in any farming system practised.

4.5 TANZANIA

4.5.1 The HASHI experience and activities in agroforestry

Charles Ng'atigwa and Emmanuel Minja

The Shinyanga region in Tanzania, which was once extensively forested with woodland and bushland species, is now facing environmental degradation problems. The most notable ones are deforestation, forest degradation and soil erosion. Deforestation began in the 1920s when the government launched a campaign for the eradication of tsetse fly and quelea birds. Large areas were cleared of trees and bushes. Furthermore, poor land-use practices in efforts to meet the basic needs outweighed conservation, thus contributing to deforestation. The consequences have been a decline of soil fertility and crop yields, loss of biodiversity, shortage of fodder, and inadequate water supply and fuelwood. Over 95% of households in Shinyanga use fuelwood as the main source of energy. Instead of nourishing the soil, cow dung and crop residues are sometimes used to supplement fuelwood due to shortages.

The area has low inherent soil fertility and a population of 2.5 million, with a growth rate of 2.9%. Crop production is the most important activity, with livestock rearing second. Traditionally, Sukuma people keep large herds of livestock, which fulfil various social functions. In view of that, farmers tend to increase livestock numbers at the expense of the few remaining natural resources. The increased pressure on land and changes in the traditional Sukuma land-use patterns is now evident. Fallow periods have been shortened drastically (1–2 years) or have disappeared in many areas. As such, the land is characterised by low soil fertility and most people resource-poor farmers who cannot afford to buy fertilizers.

The establishment of the HASHI project in 1986 was the government's effort to address these problems. Various approaches were applied but agroforestry was seen to have good high potential for solving the problems of deforestation, land degradation, shortages of fodder fuelwood, and declining soil fertility.

The objective of the HASHI project is to improve the condition of forest resources and the livelihood of the local communities in Shinyanga by working to support and promote community-based forest practices through agroforestry technologies. It aims to build the communities' capacity in agroforestry development through participatory approaches. The project is funded by the governments of Tanzania and Norway.

Extension strategies

The project adopted several strategies for addressing the problems of land degradation and its effects through agroforestry. The main ones are listed in Table 14.

Table 14 Extension strategies

Strategy	Activity	Methods/tools used
Development through information	Dissemination of the agroforestry information to communities	Video shows, calendars, meetings and participatory approaches (e.g., PRA)
Skills training	Training of the local communities on techniques such asnursery establishment, tree management and constructing improved bee hives	Lecture sessions in class Practical sessions Farmer to Farmer visits Seminars
Institution building	Formation of local organisations (e.g., village environmental conservation teams and grazing associations) to enhance local capabilities and skills	Workshops Meetings Field visits
Conviction through demonstration	To convince communities on the viability of some agroforestry practices	Interactive video shows Demonstration plots
Facilitation	To enable the local communities to carry out situation analysis, identify problems, suggest solutions and prepare work plan.	Participatory approaches (PRA) Theatre for community development (e.g., dance troupe)
Advisory services	Monitoring implementation of agroforestry activities	Regular visit to farmers Dialogue

Collaborators

The HASHI project facilitates and supports initiatives and activities that are negotiated among its partners. Some of its activities require support and collaboration with other programmes and projects. These include those shown in Table 15.

The research and extension components of the project have developed several agroforestry options, which are disseminated to farmers. Farmers now have a basket of options from which they can choose the agroforestry technologies they would like to adopt.

Agroforestry options

The following is a list of agroforestry options that HASHI project has managed to recommend to local communities:

- Rotational woodlot which involves three phases – planting, fallow and clearing phases;
- Ngitiri system, which encompasses natural regeneration of indigenous tree species;
- Fruit orchards;

Table 15 Programme partners and areas of collaboration

Programme / project	Area of collaboration
The Netherlands Government	Community training Staff training Participatory appraisal and planning Natural resources management (*in situ* conservation)
TaTEDO	Training on improved charcoal production kilns and tree management with emphasis on environmental conservation Promotion of improved charcoal and firewood stoves
World Vision Tanzania	Tree nursery establishment Capacity building
OXFAM	Training in animation and awareness raising skills
Domestic water supply program	PRA and formation of water user groups
Church organisations	Awareness raising and nursery establishment
Local groups (e.g., GSG)	Landscaping Promotion of youth initiatives in tree nurseries, grass root networks.
Norwegian Agency for International Development (NORAD)	All aspects of the project

- On-farm conservation of indigenous species, whereby some tree species are left on the farm during land preparation for cropping and farmers continue to nurture them;
- Boundary planting with selected tree species;
- Live-fencing with woody species;
- Apiculture, especially in areas where the Ngitiri have reached maturity.

Other achievements of the project include:

- Development of training materials on agroforestry;
- Establishment and management of on-field trials by farmers (action research);
- The spillover effect is now seen on the ground, in that there are farmers who are copying agroforestry technologies from their fellow farmers.

The most preferred indigenous tree species that are left on farmland during land preparation include *Brachystegia speciformis, Acacia polyacantha, A. tortilis, A. nilotica, Combretum* spp., *Balantine aegytiaca, Tamarindus indica, Terminalia* spp. and *Msingisa* spp. The problems experienced in agroforestry extension include:

- Livestock, termites and severe droughts frequently damage planted trees;
- Vastness of the area to be served by the few staff of the project, and inadequate facilities to reach many farmers;

- Insecure land tenure system and ownership (customarily owned) pose a threat to agroforestry development;
- Laxity in some village councils in enforcing by-laws that could promote agroforestry;
- Difficulties in getting feedback from the farmers on the performance of adopted technologies;
- Competition for scarce resources (water, light and nutrients) among the trees and crops, leading to a decline in crop yield;
- Insufficient land;
- Negative attitude of farmers towards some tree species that are perceived to have high potential for depleting soil fertility;
- Insufficient knowledge about the compatibility of some tree species with certain crops.

Lessons learned/experience gained:

- Agroforestry is practiced mainly on farms that are near to households;
- Women have better access to tree products obtainable from indigenous tree species conserved on farmland, as opposed to planted trees which in most cases are exotics with high commercial value and dominated by men;
- The survival rate for trees planted in agroforestry is higher (3080%) as they benefit from the management of agricultural crops;
- Most farmers prefer boundary planting due to land scarcity;
- The success of on-farm research has been spectacular despite scepticism observed at the beginning of the project; scientists were worried about the consequences the trials failing. Instead, the results pleased both the scientists and farmers;
- Communities are increasingly conserving the environment through agroforestry, with the focus on the natural regeneration of trees in cropping land/farmland, an approach that is cost-effective;
- Many people know tree species with high medicinal value such as *A .indica* (neem);
- On rotational woodlots, some farmers are retaining most of their trees for prestige and revenue despite the research recommendations that harvesting should start at least after 6 years. Only pruning is undertaken.

Future plans

- To conduct household inventories to identify all those participating in agroforestry and establish a database;
- To mobilize more farmers to participate in agroforestry;
- To enhance the exploitation of comparative advantages of scientific and indigenous knowledge of agroforestry;
- To establish contact groups for dissemination, monitoring and evaluation of farmer's on-farm research;
- To promote the domestication of valuable trees/plants.

Support is required for arranging fora for the exchange of knowledge in agroforestry between scientists and farmers and for promoting the need for farmers to keep records of practices and achievements in agroforestry.

4.5.2 Agroforestry research and development in Tanzania: my experiences and involvement

Gerson Isaac Nyadzi

Tumbi Agricultural Research and Development Institute (ARI Tumbi) is one of the seven zonal agricultural research and development centres under the Ministry of Agriculture and Food Security in Tanzania. It is the research centre in the Western Zone covering Tabora and Kigoma Regions. Agricultural research activities conducted at ARI Tumbi fall under four major research programmes: Special Research Programmes (Agroforestry, Soil and Water Management), Crop Research, Livestock Research and Socio-economic Research Programmes.

ARI Tumbi is the leading centre in agroforestry research and development in Tanzania. Apart from that, since 1987 ARI Tumbi has housed the SADC–ICRAF Agroforestry Project under the Special Research Programme. The main objectives of the Agroforestry Research and Development Programme are to screen, evaluate and develop appropriate agroforestry technologies to alleviate fuelwood shortage for curing tobacco and for domestic uses, fodder shortage, and declining soil fertility in the cereal/ tobacco land-use system.

The programme is located in Tabora region in western Tanzania. The main feature of the farming system in the region is maize production, with tobacco is grown as a cash crop. Livestock is an important component in the system. The livestock production is extensive and is based on traditional communal grazing. Peri-urban dairy production is becoming important as a source of income for smallholder farmers.

Large tracts of forests are cleared every year for crop production and fuelwood needed for curing tobacco, and this leads to severe deforestation. The climatic and edaphic factors for the region are presented in Table 16.

Table 16 Main characteristics of Tabora, Tanzania

Parameter	Tabora
Mean annual rainfall	880 mm
Length of dry season	5-6 mnths
Min. temperature	25^{o}
Max. temperature	32^{o}
Soil texture	Sandy to sandy loams
PH	4-6 (H_20)
Total nitorgen	0.03%
Available phosphorus	3-12 mg/kg
Organic carbon	0.4-0.8%
Total population (region)	1,300,000

Programme goal and activities

The main goal of the agroforestry research and development programme in Tabora is to improve the economic and nutritional well being of resource-poor farmers through research, development and dissemination of appropriate technologies to reduce deforestation, improve food security and contribute to poverty alleviation. Programme activities include:

- Screening of multipurpose trees (MPTs) for fuelwood production, fodder, soil fertility improvement, medicines and fruit production;
- Development and evaluation of agroforestry technologies on-station and on-farm, including rotational woodlots, fodder banks, boundary planting and improved fallows;
- Dissemination of technologies to collaborating institutions and non-governmental organisations (NGOs);
- Training and capacity building of scientists, extension agents, farmers, policy-makers and other stakeholders.

Programme constraints and opportunities

Predominant constraints include low and unreliable food production and fodder shortage, degradation of non-renewable resources and decreasing access to fuelwood supplies. Deforestation has created large tracts of unproductive lands throughout the country, especially in areas where tobacco is grown, reducing species diversity of the Miombo woodlands. Annual fires and severe overgrazing have contributed to dry season fodder shortages.

Considerable awareness has now been created among farmers on the severity of environmental problems and the potential of agroforestry in solving some of these problems. Agroforestry technologies being developed and tested are being prioritised for widespread adoption in Tabora as well as other regions in Tanzania through tree planting campaigns. There is the political will and a conducive environment for the promotion of agroforestry in Tanzania.

Source of funding and support

The programme has been implemented by the International Center for Research in Agroforestry (ICRAF) in collaboration with the Ministry of Agriculture and Food Security since 1987. At present, it is divided into the Tanzania Agricultural Research Project Phase II (TARP II) funded by the World Bank and the ICRAF Agroforestry Project funded by Canadian CIDA. BMZ funds research on indigenous fruits. The national professionals who receive their salaries from the Government of Tanzania carry out all the research and development activities, including ICRAF project activities, at the institute. The Tanzania ICRAF team leader, who is based in Shinyanga region about 200 km from Tabora, backstops ICRAF research activities.

Collaboration between ICRAF and Ministry of Agriculture and Food Security has been strengthened with the new phases of both the ICRAF and TARP II projects. Links with local universities, such as Sokoine University of Agriculture and the University of Dar es Salaam, and other research institutions, such as the Tanzania Forest Research Institute (TAFORI), have been strengthened to promote collaborative research, exchange of visits, training and capacity building in agroforestry research. Facilities for field research are provided for associates and students.

Links with other international research centres such as IFS, PGRC and AFRENA have been strengthened. We have contacts with the University of Wageningen in the Netherlands, and there are plans to develop a directory of relevant institutions and to expand our international network to initiate collaborative research in agroforestry. Soon all District Councils in the zone will start contributing funds for agriculture research activities in the zone.

The constraints to this collaboration include:

- Different priorities and planning timing with partners and collaborators;
- The limitation of projects and NGOs which work in agroforestry, especially in Tabora region due to poor infrastructure such as roads;
- Lack of transportation and communication facilities such as vehicles and email connections.

Programme progress and achievements

Rotational woodlots. The rotational woodlot is one of the most promising technologies being developed in Tanzania for fuelwood supply and soil fertility restoration. Woodlots continue to interest farmers and policy-makers, and there is a high demand for seeds and seedlings of potential fuelwood and timber species among farmers. The main activities undertaken include:

- Research on tree growth performance, wood yield and nutrient dynamics;
- Continuous monitoring of existing woodlots and farmers' assessment for wider adoption;
- Sensitisation of farmers through village meetings and Participatory Rural Appraisals;
- Training of farmers and distribution of seeds for nursery establishment;
- Monitoring of seedling production and distribution of seedlings.

Simple methods for propagation and establishment of Australian *Acacia* species have been developed and are being communicated to farmers. A significant improvement in soil fertility was observed on a 5 year-old rotational woodlot in on a farm. Maize grain yield increases ranging from 0.8 kg/ha to 1.8 kg/ha were recorded on rotational woodlots with *Acacia* species. Wood yields on a 5-year-old *Acacia* woodlot in Tabora District ranged from 24 to 77 t/ha.

Soil fertility improvement. Apart from rotational woodlots, trials on improved fallows are conducted to improve soil fertility and crop production using fast-growing trees, shrubs and herbaceous legumes. In addition to *Sesbania*, which is tolerant of nematode attacks, coppicing species such as *Gliricidia sepium*, *Leucaena pallida* and *Acacia angustissima* as well as herbaceous legumes have been introduced for evaluation in improved/coppicing fallows. The main activities undertaken were:

- Evaluation of biomass yield and soil fertility changes;
- Evaluation of maize yield after 2 years of fallow;
- Improved fallow evaluation and monitoring on farm.

Herbaceous legumes such as silatro and *Clitoria ternatea* significantly improved maize yields by over *Sesbania* as natural fallows after 2 years of fallowing in Shinyanga and Tabora. The fallow phase of rotational woodlots provided important soil fertility and crop production potential. Three- to five-year-old woodlots showed increase maize yields. The addition of 50% of recommended fertiliser further improved efficiency of nutrient use and subsequent maize yields. The application of phosphorus to *Sesbania* fallows at planting significantly improved *Sesbania* biomass and maize yields in 2-year fallows.

The main problems encountered were:

- Lack of soil laboratory at the institute limits analysis of plant and soil samples;
- Lack of expertise in mycorrhizal research, which affects work on the *Acacia* woodlot;
- Poor seedling survival due to problems of water in many villages.

Future activities include:

- Nutrient and water dynamics in rotational woodlots;
- Impact assessment on rotational woodlot will be conducted at household and village levels;
- Improved fallows with herbaceous legumes and coppicing species will be further evaluated on-farm;
- Monitoring of soil fertility changes both on-farm and on-station;
- Sensitisation of farmers on soil fertility management and improved fallow.

Fodder banks for peri-urban dairy production. Fodder continues to be a major livestock development constraint in the region. Fodder banks are being developed to assist smallholder dairy and oxen farmers to supplement animals with high quality feed, especially, during the dry season. Fodder bank development and evaluation activities are centred on species evaluation, nursery establishment and training of farmers on managing fodder banks and fodder supplementation.

Achievements include:

- 22 new lesser-known *Leucaena* species in addition to *Gliricidia sepium* and *Acacia angustissima* were evaluated for fodder production on-station. Three *Leucaena* species (*L. pallida*, *L. shannonni* and *L. collinsii*) gave high seasonal yields ranging from 3 to 8 t/ha. Out of these, *L. pallida* has now been introduced on-farm for farmer evaluation;
- *Gliricidia sepium* and *Acacia angustissima* have been very persistent and responded well to repeated cutting management. Yields after 5 years of cutting ranged from 3-5 t/ha. Their potential for use in fodder banks is high;
- The fodder bank technology continues to excite farmers in Tabora. Farmers are now producing their own seedlings for the fodder banks. The main species planted are *G. sepium*, *L. pallida* and *A. angustissima*;
- Farmers have recorded significant increases in milk production (10–18 litres/animal/ day) from supplementation of 2–4 kg of *Leucaena* leaves per day.

The main problems encountered were:

- Poor nursery management and seedling growth, mainly due to lack of water and appropriate management skills;
- Lack of improved dairy animals.

Future activities include:

- Most of the participating farmers intend to either establish new fodder banks or expand existing fodder banks. The programme will continue provide technical guidance;
- It is expected that more new farmers will establish fodder banks in preparation for receiving heifers from the Heifer Project International in collaboration with the Moravian church in Tabora;
- Sensitisation of farmers on establishing tree nurseries and training on utilisation of fodder.

Domestication and processing of indigenous fruit trees. The programme has research activities on the indigenous fruits domestication, processing and utilisation. BMZ through ICRAF and the World Bank through TARP II fund all the activities.

Domestication of medicinal trees. This is one of the new activities. Over 80% of rural people in the region still rely on traditional medicine for health care. Deforestation and the booming local trade in traditional herbs, harvested mainly from trees, are diminishing supplies in the wild. Some of the priority medicinal trees identified are so over-harvested that they will become extinct unless something is done to reverse the situation. Three priority research areas were identified during the workshop:

- Germplasm collection and propagation of the priority medicinal tree species (PMTs);
- Local participation and collaboration in domestication of the PMTs;
- On-farm cultivation and conservation of the PMTs.

Achievements include:

- Appraisals identified and prioritised trees used in traditional medicine in Shinyanga. Knowledge on traditional medicinal trees and their uses was captured and documented. Analysis of the respondent prioritisation revealed the following 10 priority species: *Securidaca longipedunculata*, *Zanha africana, Cassia abbreviata, Entada abyssinica, Turraea* sp., *Albizia anthelmintica, Entandrophragma busei, Combretum zeyheri, Zanthoxylum chalybeum* and *Terminalia sericea* Their scarcity in four of the five districts surveyed showed the urgent need for their domestication;
- Specimens of tree parts sold as traditional herbs were purchased and preserved for further analysis.

The main problems encountered were:

- Traditional healers and farmers have expressed a great desire to see programmes established as soon as possible to help them propagate and develop quality medicinal products from the PMTs. Unfortunately, tree domestication work is a painfully slow process and we do not have the capacity to meet such expectations in the short term.

Dissemination of agroforestry technologies. The goal of the dissemination component is to promote wide adoption of promising agroforestry technologies. The following form the core strategies of activities in Tanzania:

- Increasing awareness of stakeholders and farming community;
- Enhancing interaction and collaboration among stakeholders in agroforestry research and development;
- Training of partners and clients in agroforestry dissemination and development;
- Increasing germplasm supply for major agroforestry species.

Training and capacity building. Several undergraduate and post-graduate students benefited from research and data collection from our sites. Two programme staff have been offered scholarships for PhD studies and all are conducting their research at our project sites.

It is envisaged that there will be an expansion of partnerships and definition of collaboration with new partners. There are also plants for training of extension officers and farmers and field visits.

Future plans for the programme

- Potential and impact of promising technologies will continue to be monitored in all districts;
- Economic and monetary benefits of rotational woodlots, fodder banks and improved fallows will be assessed, as more data become available;
- Social and economic impact assessments of tree planting and agroforestry on farm households over the past 10 years will be conducted;
- Funding will be solicited from all the District Councils in the zone to contribute to agricultural research activities in the zone in a sustainable manner.

4.5.3 Experience and involvement in agroforestry: research and development in Zanzibar

Makame Kitwana Makame

Zanzibar consists of two sister islands, Unguja and Pemba. The islands are located at 39^0E and between latitude 5^0S and 6^0S, with a total area of 2,332 km^2 (Unguja 1,464 km^2 and Pemba 868 km^2) The islands are dominated by coral rag on the eastern sides.

The climate is influenced by the monsoon winds, with a bimodal pattern of rainfall and intermittent showers, followed by the dry season. There are four major seasons: the long rains (Masika) from the end of March to mid May with a peak in mid April; the relatively cool season (Mchoo/Kipupwe) with intermittent showers from June to August; the short rains (Vuli) from the end of September until December with a peak in November; and the dry spell (Kaskazi) which comes soon after short rains and ends with the onset of long rains. The average annual total rainfall is about 1,700 mm for Unguja and 1,800 mm for Pemba, allowing plant growth most of the year.

The temperature is also typically equatorial with very little variation between the seasons. December to February is the hottest period and June to August the coolest. The mean annual maximum is 30.3^0C for Unguja and 29.3^0C for Pemba; the minimum is 23.5^0C and 21.1^0C, respectively.

The 1988 census showed the population of Zanzibar to be 640,578 with an annual growth rate of 3%. Most people depend on agriculture and related activities for their livelihood. They are mostly subsistence farmers who grow at least three crops in different associations in order to avoid risks and uncertainties. Traditionally, farmers in Zanzibar prefer mixed cropping systems, with intercropping of perennials, tree crops and annual food crops being common.

The agroforestry programme

The on-farm agroforestry research programme in the coral rag area of Unguja Island started in 1993 with the aim of studying and developing agroforestry system with farmers that incorporate trees, food and or cash crops. Farmers-designed trials were established in 1994 with the objective of assessing farmers' preferences for planting niches and arrangement of different tree and crop components and to relate these to their farms and household characteristics.

The coral rag comprises the rocky areas of eastern Unguja and occupies about 60% of the island's total land area (Krain *et al.,* 1993). The potential for agriculture and forest development in the coral rag is thought to be high given the greater availability of land than in the plantation areas (Kombo, 1994). The soils are fragile and drought prone, however, and support a system of shifting agriculture which is increasingly becoming unsustainable as demands for forest product and intensify. The most critical

land-use problems in coral rag, which agroforestry has the potential to address, are decreasing fallow period, declining soils fertility and wood and fodder shortages (Harvey, 1995).

Programme objectives

The trials are farmer-designed and managed with the objectives of:

- Observing how farmers experiment and managed different tree and crops combinations;
- Assessing farmers' preference planting niches and arrangement of different components, and associating this with household and farm characteristics;
- Identifying farmers' problems and criteria for evaluating species and combinations;
- Identifying future needs and/or extension recommendations.

Programme strategies and activities

The farmer-designed trials were established as the main component of the on-farm agroforestry research programme, following on Participatory Rural Appraisals (PRAs). Other complementary methods were also used to illustrate how farmer-designed trials fit into the research process as a whole.

Participatory Rural Appraisals. PRAs were conducted before the establishment of the trials to learn from farmers' knowledge and their experience with different agroforestry technologies and species, and to identify which species were most appropriate for farmer experimentation

Farmer selection. PRA findings were used to highlight criteria for the selection of research-oriented farmers. The selection considered both rich and poor farmers.

Species selection. Species were selected largely on the basis of farmer interest expressed in the PRAs and on availability.

Meetings with farmers prior to trial establishment. The aim of these meetings was to discuss the objectives, risks and consequences of carrying out the trials.

Assessment of the trials. Farmers were visited once a month over the year following trial establishment. Farmers' observations and comments were recorded during these informal visits. The trials were also assessed with farmers in structured interviews held in farmers' fields four to five times after planting and again 1 year after planting. Multidisciplinary teams made up of Village Forestry Officers, Cash Crop Research Officers, Food Crop Research Officers and Subject-Matter Specialists from the Sub-Commission for Extension carried out the assessments.

Farmers' network: workshops and study tour. Participatory workshops and study tours were conducted to bring together the network of farmers involved in the trials. Participants visited different farms and research plots to share ideas and evaluate aspects of agroforestry system design and

management. Farmers also took part in priority-setting exercises, thus influencing the direction of the research programme.

Continuation of the trials and expansion of the network. The results of early monitoring visits and the outcome of workshops showed that many farmers had a strong interest in continuing with the research work. Planting material was then provided for a second year, but this time according to farmers' preferences rather than as a standard package as had been the case in the first year. A wider range of indigenous tree species and fruit trees was made available. The objective here was to gain an indication of farmers' preferences through their own selection of different tree and crop species in quantities appropriate to their farming objectives. In the second year of the trials the network was also expanded in two of the areas where research was ongoing.

Funding and support

The On-Farm Agroforestry Research Programme formed a component of the Zanzibar Cash Crop Farming Systems Project, which received funds from the Overseas Development Administration (ODA). The programme also had links with the Zanzibar Forestry Development Project funded by FinnIDA and the Government of Zanzibar. Being an on-farm and farmer-designed programme, the main collaborators were farmers from five districts of Unguja Island. Currently, the government monitors the programme through field visits.

Achievements and lessons

Establishment: decision-making and problems. The farmers in the trials made their own decisions on where (i.e., in which niches) and in what arrangement to plant trees and crops in their plots. They found that tree planting competed with other important activities, such as rice harvesting and fuelwood collection.

Farmers' assessment. Farmers evaluated the tree species according to the following criteria. For good growth and survival, *Psychotria bibracteatum, Casuarina equisetifolia, Rhus longipes, Macphersonia gracilis* and *Flueggea virosa* were allowed to naturally regenerate in their plots. For fire resistance, *Psychotria bibracteatum, Acacia auriculiformis, Annona senegalensis, Steculia apendiculata* and *Flueggea virosa* were left. On resistance to browsing, *Psychotria bibracteatum, Acacia auriculiformis, Senna siamea, Steculia apendiculata*, *Suregada zanzibariensis* and *Flueggea virosa* were preferred. *Psychotria bibracteatum, Annona senegalensis* and *Flueggea virosa* were preferred for drought resistance.

Researchers assessment. With the exception of *Gliricidia sepium*, all the distributed and planted trees showed survival rates of over 60%. The highest survival rates were for the citrus species and *Psychotria bibracteatum*, followed by *Acacia auriculiformis* and *Casuarina equisetifolia*. Problems experienced in the field included pest damage caused by snails, grasshoppers and rats, browsing damage and lack of rain.

Tree and crop combinations. Farmers mixed coral rag crops with either the exotics or indigenous trees supplied to them, or with naturally regenerated trees, which they deliberately left in their trial, plots. The effect of shading is well understood by almost all research farmers, and the pruning of trees inside the plots and on boundaries was less well understood in several cases. Farmers have also noted that chillies can be intercropped for 3–5 years without being adversely affected by shading,

Farmers' preferences for planting niche and arrangement. Farmers' choices of planting niches and arrangements were influenced by differences in land tenure and gender. Only men established woodlots. Women preferred to plant trees in mixed arrangement, often with trees scattered in cropland. In areas where land tenure is secure, trees were established on external boundaries.

Indigenous trees. The most important indigenous trees identified in farmer's plots were *Psychotria bibracteatum, Senna petersiana, Flueggea virosa, Bridelia micrantha, Psidium guajava, Vitex doniana, Mytenus mosambisensis* and locally known mbunduki (unidentified). Some of these species were particularly suitable for mixing with crops, particularly *Psychotria bibracteatum* and *Rhus longipes* because they could be pruned to reduce competition with crops for light and also provided useful fuelwood and construction materials.

The main lessons were:

- One of the strengths of the approach associated with farmer-designed trials is that the research closely reflects farmer's rather than researchers' objectives, and gives a better indication of the potential of agroforestry than trials designed by researchers. One of the weaknesses identified in conducting the trials was that working with large groups of women provided less reliable information on their priorities and preferences than with smaller groups and individuals;

- The most widely used niche in the trials was scattered trees in cropland, especially by women who appeared to place greater emphasis on food production rather than a more commercial agroforestry as was the case with male farmers. The importance of this niche in farmer's agroforestry strategies cannot be overemphasised, given the ultimate move to more sedentary agriculture in the coral rag. Both exotic and indigenous tree species that compete little with crops, that are multipurpose and easy to manage, and that help maintain soil fertility should be identified. The results of the farmer-designed trials suggest that species such as *Psychotria bibracteatum* and *Rhus longipes* are potential candidates;

- Land tenure clearly influences farmer's decisions on where they will plant trees and needs to be understood in all the study areas where we are working. The most important tenure constraints at the community level in the coral rag are the lack of rights to exclude livestock and prevent damage from fire. The interest shown by farmers in planting indigenous species and encouraging natural generation, as well as the good survival rates for these species, indicates that there is strong potential for diversifying the tree component in farmers' fields using indigenous MPTs;

- A positive impact of the trials was the opportunity seized by farmers to experiment and disseminate their research results. A negative impact was the jealousy created by the distribution of free

seedlings to network farmers and conflict arising from damage caused by grazing animals in trial plots. This conflict arose mainly in areas where farmers in the wider community lacked access to planting material.

The future

The farmer-designed agroforestry trials allowed both farmers and researchers to make useful observations on species suitable for different planting niches in coral rag farming systems. The trials also identified some of farmers' most important problems and their criteria for assessing the performance of agroforestry technologies.

The farmer-designed agroforestry trials are part of a research programme in which a number of complementary research methods were used. At the core of the programme is a network of farmers conducting their own research. The expansion and strengthening of research networks within villages is the next step in the programme. This will further strengthen participatory agroforestry research and extension at farmer and village level. The network participants will continue to play a leading role in prioritising future research, as well as participating in planning and implementing research in collaboration with the Ministry.

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4.6 UGANDA

4.6.1 Agroforestry research and development in Uganda

Byabashaija Denis Mujuni

The science of agroforestry in Uganda is of recent origin, although the practice is a very old one. There are numerous types of indigenous agroforestry systems in different parts of the country, ranging from the coffee and banana gardens intercropped with *Ficus natalensis*, *Markhamia lutea*, *Measopsis eminii* or *Ricinus communis* in the Lake victoria crescent to the 'parkland' systems of the drier areas of the north. In the West Nile and northern Uganda, it is common practice to intercrop *Cajanus cajan* with millet and simsim, while in the Teso region *Tamarindus indica*, *Mangifera indica* and *Butyrospermum parkii* are commonly retained or planted on farmlands.

Since 1988, research efforts have been made to enhance the productivity of these agroforestry systems and to develop new systems to meet the needs of the local population. At the same time, agroforestry promotion has become a key component in many development programmes and is now acknowledged as a key component of Plan for the Modernisation of Agriculture (PMA) in Uganda.

Agroforestry programme

The overall objective of the programme is to integrate trees on farms, improve the productivity of land and protect the natural resource base, in order to increase farm incomes, contribute to food security and promote environmental resilience through agroforesty technologies.

The specific research and development objectives are to develop and disseminated agroforestry technologies to farmers for:

- Increased farm incomes;
- Food security;
- Improved rural livelihoods;
- Conservation of the natural resource base (forests, soils, water etc.).

The work involves strategic and adaptive research both on-station and on-farm.

The main activities are in the Southern highlands (Kabale, Rukungiri) and the Lakeshore area (Mukono, Wakiso, Mubende). There are limited activities south-eastern Uganda (Iganga), the Eastern Lowlands (Tororo) and the Eastern Highlands (Mbale).

Achievements to date include:

Research and dissemination

- The use of tree hedgerows in checking soil and water run-off is gaining widespread acceptance in Kabale district, plus the use of short-term tree fallows to regenerate the fertility of degraded portions of terraces. Significant amounts of fuelwood are obtained at the end of these fallows;
- *Grevillea robusta* is being grown in many parts of the country, and *Alnus acuminata* has been adopted in the highland areas;
- Improved fodder banks have been introduced in some areas in the Lake Victoria shore region and Kabale district;
- Work at Kifu has generated tree-pruning methods which can reduce tree competition with the associated crops, while at the same time producing wood by-products. These methods will probably increase the adoption of agroforestry technologies as competition from trees discourages tree planting;
- Some work has started in Kabale and Kifu on the domestication of *Prunus africana,* whose bark is used to produce medicine against prostate cancer;
- Agroforesty technologies are being disseminated among farmers in the vicinity of Mabira Forest Reserve so as to reduce pressure on the forest for tree products;
- Community tree nurseries have been disseminated in some areas, so farmers can raise their seedlings independently;
- Provision of high-value fruit trees such as temperate and lowland species;
- Establishment of seed orchards (on-farm and on-station).

Capacity building

- Formal training in agroforesty: Agriculture and forestry educational institutions have already incorporated agroforestry in their curricula. At Makerere University, agroforesty can be pursued alongsie a Masters Degree, in addition to having a good content in the forestry and agriculture degree programs. At the technical level, agroforestry is now a prominent component in the diploma programme for agriculture and forestry at all Colleges. Nyabyeya Forestry College also recently started offering a stand-alone diploma in agroforestry;

- Staffing training: Graduate and post-graduate;

- Awareness creation workshops. A number of farmers have been exposed to a variety of agroforestry technologies and in some cases adoption has taken place. Many NGOs and CBOs are conducting agroforestry training as part of their rural development programmes. They offer a good platform for transforming research findings into routine household activities aimed at increasing land productivity and incomes.

These achievements have been made possible through the support of EU and USAID. Other donors include FAO, SIDA and NARO/GOU. Among the collaborators are ICRAF/AFRENA, Sesakawa Global 2000, Africa 200 network, CIAT, Africare and other NGOs.

There are several factors that favour the expansion of tree growing on individual or public land. These include the favourable government policies, institutional arrangements and the expanding markets for wood products locally and regionally.

The way forward

As a scaling-up strategy for agroforestry development in Uganda, a networking body called the Uganda Agroforestry Development Network (UGADEN) was established during a National Agroforestry Workshop in September 2001. It was attended by over 140 participants representing a wide range of stakeholders (farmers, development organisations, researchers, education, private sector, donors, local and national leaders). The structure of UGADEN will comprise a Steering Committee, coordination secretariat and coordination offices in each of the 12 ecological zones in the country. The major elements that the network will deal with are:

- Tree seed;
- Training/education/capacity building;
- Coordinated production and dissemination of materials;
- Share and assess relevant development approaches for agroforestry;
- Documentation;
- Marketing and processing of agroforestry products;
- Monitoring, evaluation and impact assessment;
- Research support for agroforestry development;
- Policy and publicity.

The main aim of the network is to explore and facilitate efficient, collaborative scaling-up of appropriate, profitable and environmentally sound agroforestry innovations in the various agro-ecological zones in the country for the improvement of rural livelihoods. UGADEN is a new and innovative approach with strong links to smallholder farmers and local governments. It is an attempt to create synergies and to reach out to much larger numbers of farmers with high quality agroforestry dissemination work.

Other plans to promote agroforestry in Uganda include:

- Building the capacity of farmers to integrate forestry into all farming systems;
- Developing the capacity of service providers (NGOs, CBOs, private contractors, government agencies) in agroforestry;
- Intensifying participatory research in agroforestry technologies;
- Supporting development of high quality planting material;
- Integrating agroforestry into school curricula and other community training programmes;
- Intensifying domestication of species locally harvested from the wild.

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4.6.2 National tree seed centre (NTSC), Kampala, Uganda: status report

WALAITA S. JAVAN

Uganda used to have abundant natural resources of tropical forests but these have severely been reduced because of increased agricultural activities resulting from the increase in human population, overgrazing and urbanisation. Loss of forest cover has been estimated at 50–200,000 ha annually. Loss of forest cover has resulted in loss of biodiversity, productivity and food security. Forests are known to influence environmental factors, which are tied to agricultural production. Forests and trees protect water catchment areas, soil erosion and fertility, which contribute to sustainable agriculture. Loss of forest cover has affected the quality of life for rural communities.

Currently, there are 4.9 million hectares of forests in the country, representing 24% of the total land area. About 81% of the forest cover are wooodlands and 19% tropical high forests. More than 70% of forest cover is on private land. The remaining 15% are managed by UWA and the Forest Department manages another 15%. Districts manage about 5000 hectares of forests. Tropical high forests cover 925,000 hectares.

The Government of Uganda has recently approved a plan entitled the Modernisation of Agriculture and Poverty Eradication Action Plan. It aims at increasing income and quality of life of the poor through increased productivity, improvement of household food security, increased employment through secondary processing and services and sustainable management of natural resources. Tree planting, particularly on farms, has been identified as an opportunity for rural communities. It is anticipated that considerable quantities of tree seed will be needed for the envisaged tree planting activities.

The Uganda Government has approved a new National Forestry policy. Implementation of the new policy requires radical changes in the forestry sector. It is expected that the present forest department will be restructured into an autonomous National Forestry Authority, which will be responsible for the management of the permanent forest estate. The following developments will create favourable tree seed marketing opportunities in the area of multipurpose tree planting:

- Because the need for planting multipurpose trees (MPTs) on farmlands has increased considerably, there has been a consequent increase in demand for MPTs. Ongoing efforts to scale up the impact of agroforesty in Uganda will result in significant increase in seed demand for MPTs. The forecast indicates that more than 70% of seed needed for planting in Uganda is accounted for by MPTs;

- Tree planting will be undertaken by communities on buffer zones surrounding major forest reserves, a measure expected to reduce pressure on the remaining natural forests in Uganda;

- Enrichment planting is to be done on degraded natural forests that have poor stocking. Future planting is also to be done in savanna areas, where more than 100,000 hectares are known to be suitable for the development of industrial plantations;

- It is anticipated that tree planting will be undertaken in areas alongside for peri-urban plantations;

- One of the most critical issue is fuelwood, which commands a significant (>90%) proportion of total energy consumption in Uganda. It is expected that Uganda's population will continue to depend on fuelwood as a renewable source of energy for the foreseeable future. Areas with high population densities are expected to experience fuelwood scarcity, and planting trees should help resolve the situation.

- Wood consumption in Uganda has been estimated at between 150,000 and 200,000 cubic metres of sawn timber, which requires 0.75 to 1 million cubic meters of round wood annually. The wood market has a preference for indigenous hardwood timber, which has put significant pressure on a few tree species – *Milica excelsa*, *Entandrophragma* species, *Khaya anthotheca, Olea welwitschii* and *Lovoa* species. Forecasts indicate that there will be a shortage of timer and other wood products in Uganda within the next 10–15 years. Planting trees is expected to avert this situation.

Objectives of the National Tree Seed Centre

The overall objective is to establish an integrated forest sector that achieves sustainable increases in economic, social and environmental benefits from forests and trees by all the people of Uganda, especially the poor and vulnerable

The developmental goal has three pillars:

- Poverty eradication through sustainable livelihood development amongst small-scale, mainly rural stakeholders, with strategies based on-farm, in natural forests or off-farm;
- Economic development (targeting forest industries development amongst large-scale, commercial investors, focusing mainly on plantations);
- Sustainable forest resource management (targeting local, district, national and international interests in biodiversity and environmental conservation).

The immediate objective is the sustainable provision, promotion and conservation of genetically suitable seed and other reproductive material of good physiological quality to meet present and future needs for tree planting activities in Uganda.

The sustained provision of good quality seed and plant material encompasses the following factors:

- Seed produced by the seed centre should meet present and future needs for tree planting activities in the country;
- The NTSC will generate revenue that can sustain the operations of the centre in the long run;
- The government is prepared to support the promotion of good practices to improve the quality of seed produced by the private sector;
- Good quality seed of known origin with desired genetic and physiological quality, which can produce plants which are adapted to planting sites and should be able to grow not only to full rotation but also for several rotations on the same site;

- The physiological quality of seed has to do with viability, vigour, health, condition of morphological structures and specific gravity of the seed;
- The genetic quality of a viable seed population has to do with the genetic superiority of the mother tree population, which is potentially inherited in the seed population, and the degree to which the genetic composite of the mother population is represented in the seed population.

Project achievements

The achievements to date are as follows:

- Facilities of the NTSC at Namanve improved;
- Human resource development plan prepared and implemented;
- Annual plans for forecasted seed sales and procurement prepared and implemented;
- Methods and technologies for handling, storing and sowing tree seed, and for vegetative propagation of priority species improved;
- Aggressive marketing programme planned and implemented;
- Plan implemented for training, information and extension in tree seed procurement and use;
- Seed sources of priority species, sufficient to meet the country's needs and representing major ecological zones (seed zones), identified, described, protected and managed;
- *In situ* and *ex situ* gene conservation stands for selected priority species established and managed.

These achievements have been attained through:

- Serious capacity building to enable the seed centre to produce good quality seed;
- Seed procurement (forecasts on seed demand, preparation of national seed production plans, flowering, fruiting, crop assessments, seed collection, processing, testing, storage, distribution and seed documentation);
- Tree improvement activities (identification, description of seed sources, development of new seed sources, screening populations, testing species and provenances to find those most adapted to planting sites, establishment of clonal and seedling seed orchards for selected priority species);
- Conversation of genetic resources.

Seed provision and procurement

The NTSC has been initiated to meet tree seed demand, but there is limited knowledge on actual demand for seed in Uganda. A recent study on the seed demand/supply situation has revealed that the country has a potential seed demand for more that 20 tons of seed of various tree species annual. The NTSC has supplied less than 10% of this potential seed demand over the years. It will make an effort to improve seed production and increase its market share for tree seed through aggressive marketing.

Experience elsewhere has shown that tree seed centres cannot and are not expected to meet demand for all seed needed for tree planting programmes in a country. Sometimes it is uneconomical to organise

collections of small quantities of seed in remote parts of the country. In other cases, seed demand is so high that seed centres have to share the burden of seed supply with the private sector. The NTSC is to cooperate and support the private sector to improve the quality of seed produced by others. It is therefore employing both centralised and decentralised seed procurement strategies to supply good quality seed needed for tree planting activities in the country.

Centralised seed procurement strategy. In this strategy, the seed centre uses its trained personnel to collect seed for species which are difficult to collect and handle including recalcitrant species, species with long rotations that require careful selection of parents, and seed which has to be collected from standing trees that require specialised climbing skills. Centralized seed collections will be demand driven.

Decentralised seed procurement strategy. The latest review of the project recommended that the seed centre should contract out the collection of many species to reduce costs of seed production. Species that are contracted out include agroforestry species, species with short rotations, species which are easy to collect and handle, and orthodox species.

The NTSC has recruited seed collection contractors, trained them to be able to identify suitable seed sources, and to produce good quality seed. It will work with the contractors and set minimum standards on quality of seed to be collected by the contractors. The purchase price for each individual species to be contracted out has been set. Supervision of contracted seed collections is critical for quality control. The extent of supervision depends on species. The NTSC prepares annual seed production plans for species contracted out. The quality of seed will be guaranteed by carrying out training of contractors.

Movements of the contractors are carefully monitored, based on a system of supervision to ensure quality control. Before the seed centre pays for any seedlot, it will be necessary to carry out routine quality tests (moisture content, seed weight, purity, germination and viability). One precondition for the success of this strategy is that the NTSC needs cash to pay for seed delivered by contractors. The few trials of procuring seeds through contractors have revealed that it is necessary to have a flexible financial management system that will allow the seed centre management to pay for seed delivered at the seed centre.

Seed procured by the private sector. Recent surveys on seed demand/supply have confirmed that many individuals are involved in production of seed either for their own planting programmes or for sale. The studies have revealed that the private sector supplies more than 50% of seed used for tree planting activities in the country. The quality of seed collected by the private sector is not known because private seed collectors do not have facilities to conduct routine seed tests. It is also possible that most of the seed collected by the private sector originates from inferior seed sources, as reflected by poor performance of young plantations.

Recent surveys have also revealed that lack of good quality seed is a constraint that hinders tree planting efforts by rural communities. Production and trade in tree seed have also been identified as livelihood opportunities for many rural communities. It is important to carry out training to improve the quality of seed produced by the private sector. In the Plan for Modernization of Agriculture,

extension services will be coordinated by the National Agricultural Advisory Services (NAADS). Rural communities are expected to request services through NAADS. The NTSC could be contracted through NAADS as a service provider to carry out training and offer advisory services on methods, which will improve the quality of seed produced by the private sector.

A sudden increase in demand for agroforestry seed in the country has resulted in increased participation by the private sector in the supply of seed for MPTs. While private sector initiatives have significantly complemented the provision of seed, most seed has been procured and distributed without matching seed sources and planting sites. There has also been indiscriminate use of seed.

Currently there is no tree seed law to regulate the tree seed trade in the country to protect both the investments by the private sector and the interests of seed suppliers. This is why it is difficult to ensure that seed used in Uganda meets minimum set standards.

Funding and collaboration

The government of Uganda and NORAD currently supports the NTSC. NORAD is now committed to the extent of 1,000,000 million (Kor) for one year, and after that the NSTC will be expected to generate funds to run its activities. It is hoped that offering of these services will not be exploitative, but rather executed on a cost-recovery system.

The NTSC is collaborating with: ICRAF/AFRENA in matters of seed testing and quality control, seed collection and exchange of technical information; Makerere University in seed research; NGOs, especially in information delivery and seed distribution; the Kenya Forestry Research Institute (KEFRI); the Tanzania National Tree Seed Centre in information exchange and staff training; the Zimbabwe National Tree Seed Centre in tree improvement; and UFRO, IPGRI and the DANIDA Forest Seed Centre in technical matters.

4.6.3 Agroforestry development activities in Kabale District: Africare's Uganda Food Security Initiative

Silverio Atuzarirwe

In Uganda, agricultural production gains have been made primarily through the expansion of cultivated area rather than through better management of land already under production. Land degradation, low and declining agricultural productivity, and poverty are severe interrelated problems in Uganda. Once Uganda's soils were considered to be among the most fertile but the manifestations of land degradation appear to be increasing. Annual average soil losses in Uganda have been estimated at more than 70 kg of nitrogen, phosphorus and potassium (NPK), which is considered to be one of the highest rates in sub-Saharan Africa. Although there is scanty documented evidence on soil erosion, it is viewed as serious problem, especially in the highlands.

The highlands of south-western Uganda, formerly called Kigezi – 'the Switzerland of Africa' – was for several decades a key food producing area in this region. Due to the high population pressure estimated to be 370 persons per km^2 (projections from 1991 national census), intensive land cultivation with minimum inputs, land degradation is threatening food security in the district. Farmers' yields are typically less than a third of potential yields found on research stations, and yields of major crops are reported to be declining. A survey carried out by Africare in 1997 found that the land holdings are very small, with 34% of the households of an average of 7 children own less than 0.21 ha of land. These poor resource farmers neither apply commercial fertilisers nor practice any form of crop rotation. The study found that more than 96% of the respondents had observed declining crop yields in the past 5 years. Recent AFRENA-Uganda Project studies indicate that an estimated 10% of formerly arable land in the region has become so degraded that it is now permanently out of production (as opposed to lying fallow) and that the area of abandoned land is increasing by about 3% per year. Land degradation undoubtedly contributes to low and declining agricultural productivity in this area. This deterioration of the natural resource base has increased rural poverty, malnutrition and inability to meet basic social needs.

As in other parts of Uganda, biomass primarily consisting of forest resources and other organic matter remains the major source of energy in Kabale. Although biomass can be an environmentally sound source of energy, its current practices of production and use are often unsustainable and have adverse effects on the environment. Results from the National Biomass Study indicated that in Kabale fuelwood production is meeting only 60% of demand. In Kabale it is common to find women preparing a meal and heating using crop residues as fuel. Its practice has negative implications on soil fertility management as it takes away materials that would otherwise decompose and replenish soils with nutrients. Fuelwood collection in Kabale is work for women and children. Most women are already overworked and the further away the source of fuel the greater their workload becomes; this reduces the time available for other household and income-generating activities. A study conducted in Kabale revealed that fuelwood scarcity has influenced both the amount of food cooked and its type. People are

being forced to choose foods that do not require a long time to cook, although they may not be the best from the nutritional point of view.

Although Uganda is making some promising progress in reducing poverty, 44% of her people still live in absolute poverty. In the rural areas of south-western Uganda the figure must be much higher than the national average. Low and declining productivity has led to poverty, food insecurity and inadequate supply of wood, and food insecurity can in turn contribute to land degradation. Poor and food-insecure households cannot afford to keep land fallow, invest in land improvements that put some portions of land out of crop production or are expensive to construct and maintain, or use costly inputs such as fertilisers.

To reverse the trend of rapidly degrading soil, food insecurity and poverty, Africare with funding from United States Agency for International Development (USAID) has been implementing the Uganda Food Security Initiative (UFSI) since 1997. The goal of the UFSI is to improve food security in Uganda by:

- Reclaiming and enriching degraded soils;
- Increasing food production and reducing post-harvest losses;
- Improving year-round farm-to-market roads;
- Improving food access and utilisation by all members of the household. Based on AFRENA research work in Kabale, Africare and the target villages identified agroforestry as an appropriate means of tackling problems of land degradation, shortage of wood, and poverty.

UFSI's approach to land management

Results from the 1997 baseline survey conducted by Africare in Kabale clearly indicated that poor land management was one of the major constraints in this farming system. Farming in this part of the country is highly complex and diverse, with farmers growing a wide variety of crops on small and scattered pieces of land. Each farmer and his/her farm seems to be completely different from the next farm and probably any other in the community. Because of these highly complex and diverse conditions, it was considered prudent to actively involve the land users themselves in diagnosis, planning, monitoring and evaluation of the project activities.

This approach was considered essential from the start to allow farmers to play a greater role in developing and fine-tuning the best combinations of wide varieties of land management practices. It is farmer-centered and makes the best use of locally available resources such as knowledge and materials.

This collaborative process started with village meetings held in an interactive participatory manner (PRA) with the objective of:

- Diagnosing and analysing the prevailing land management practices.;
- Planning and evaluating alternative land management practices that are practical and applicable in situations that better exploit available resources.

During these initial meetings in the target villages, farmers discussed new practices they wanted to include in their farming activities and planned for their improved practices. It was also discovered that farmers had heard about agroforestry and the work AFRENA was already doing in the district. At that point agroforestry started becoming an interesting topic in the village meetings.

Through this process Village Action Plans (VAP) were developed and agroforestry started featuring prominently among the proposed activities. Although most communities had some information about agroforestry, nothing was at the time being done to integrate trees on their farms. Establishment of community nurseries for the provision of tree seedlings was identified as a priority activity in the VAP. However, shortage of extension services and planting materials came out clearly as the main constraints to the adoption of agroforestry. Africare and the communities agreed on different roles in implementation of the VAP, with the communities committing themselves to providing all the locally available materials and labour.

Africare agreed to provide the resources considered crucial but not locally available, such as tree seed, basic nursery tolls and the necessary technical support in form of training. Since AFRENA-Uganda had already developed and tested technologies such as hedgerows capable of solving the identified problems, Africare, a development-oriented organisation, did not have to invest its resources in technology development. This formed the basis of the successful and mutually beneficial partnership between the two organisations. AFRENA has been providing tree seed and other planting materials in addition to training Africare extension agents, and Africare's extension efforts have effectively promoted the adoption of agroforestry technologies. Another area Africare exploited in its extension was the farmer-to-farmer learning techniques. Farmers tend to take up technologies faster and with a higher degree of confidence from fellow farmers with similar resources. Farmers do not just do things because they are told to do so, but must have confidence that what they are about to do will make a difference in their lives. Africare facilitated farmer-to-farmer exchange visits, farmer field days and study tours, and these were very successful tools in agroforestry technologies adoption.

To implement, coordinate and monitor the VAP it was realised that there was need for a village production committee. The community discussed and decided on the criteria of membership and the roles of committee members. The committee members have played an important part in mobilising the other farmers and resources. Whenever the committee members had been trained they would go back and train other farmers on these new practices. The early adopters were also encouraged to work as Volunteer Farmers (VF) to take a lead as facilitators and trainers of other farmers in their respective areas. But there is need to equip the VF with in-depth knowledge, skills and facilitation to do a better job. As a way of strengthening the farmers groups at village level, production committee members have been trained to monitor and evaluate their own activities and they have been arranging community evaluation meetings to review the VAP and evaluate its implementation, including an assessment of successes and failures.

Progress and achievements to date

UFSI has facilitated target villages, groups and individuals in the establishment of tree nurseries in 12 sub-counties of Kabale District. In total, 119 community and group nurseries have been established

Table 17 Tree seedlings transplanted in UFSI target villages since 1998

Sub-county	Tree species			
	Calliandra	***Grevillea***	***Alnus***	**Total**
Bufundi	171,360	16,851	200	188,411
Muko	453,292	33,752	1900	488,944
Hamurwa	192,860	37,135	2600	232,595
Bubare	754,215	7,043	1700	762,958
Kitumba	376,946	33,181	700	410,827
Kamuganguzi	119,180	34,100	6600	159,880
Rubaya	438,195	62,290	200	500,685
Buhara	195,325	15,535	2800	213,660
Maziba	273,076	11,856	0	284,932
Kaharo	230,924	21,164	2100	254,188
Rwamucucu	289,367	30,697	0	320,064
Kashambya	348,424	52,305	6900	407,629
Total	3,843,164	355,909	25,700	4,224,773

since the inception of this activity. The production committees have done an excellent job in mobilising the people and other resources. The seedlings planted out on-farm are given in Table 17. The establishment of the community/group nurseries acted as an entry point in these target areas. This approach has succeeded in attracting large numbers of people for training purposes. It builds confidence among farmers and they share their experiences while carrying out the group activities.

Because of the diversity in farmers' needs in respect of number of seedlings due to their different perceptions and land holdings, conflicts started to emerge. This sometimes ended up with some farmers dropping out of the group. Some farmers with big chunks of land were not getting enough seedlings to meet their needs and started asking for seeds to start their own small individual nurseries. Individual nurseries are now on the increase and the demand of farmers is to be on their own because of the high degree of flexibility on individual nurseries. Group nursery members make a rota and somebody has to be at the community/group nursery on certain days and times. Other conflicts sometimes emerged over transplanting when group members had shared their seedlings. The success of the group depends to a great extent on the leadership skills of their production committee. The leadership skills of the management committees have been enhanced since the inception of these group activities. The leaders are more articulate in identifying their problems and designing activities to solve them. In successful groups the farmers have been empowered because they can collectively make their voices heard whenever they are confronted with a common problem. Such groups have succeeded in controlling common problems, such as free-ranging animals that attack their trees when they are still young.

Farmers' benefits

The continuity of any activity depends mainly on whether it makes sense to the intended users, solves some of their problems in relation to other possible alternatives. The agroforestry activities developed and tested by AFRENA and currently being promoted by Africare make a lot of sense to the farming community because they seem to be tackling the real issues that affect people in Kabale.

About 90% of the tree seedlings raised and transplanted in the target villages are *Calliandra* and *Calothyrsus* seedlings. Farmers prefer these species because of the many uses they get out of it. More than 75% of all *Calliandra* has been planted in hedges to reduce soil and water movement on steep slopes. The impact of these hedges in soil and water conservation is clearly evident by comparing neighbouring fields with and without hedges. There is an accumulation of topsoil on the up-slope side of the hedge and terraces start forming on the fields with hedges, while the field without hedges has a continuous slope most of the time, with evidence of soil and water movement in form of gullies. The hedges are maintained by pruning to reduce their effect on crops growing in adjacent alleys. The pruned leaves are used in different ways, depending on a farmer's needs. Its common in UFSI target villages to incorporate the pruned leaves into the soil during land preparation for soil fertility improvement. Farmers with zero-grazing animals take the pruned leafy biomass home for their stall-fed animals and improve their milk production. Those who carry the leaves away have been advised to return the animal manure to the crop fields, otherwise the hedges will only be working as barriers and will not make substantial contribution in soil fertility improvement.

On degraded slopes and upper parts of terraces, improved fallow are being planted for soil fertility replenishment and the provision of wood products, such as stakes for climbing beans and fuelwool, that are always in short supply.

With AFRENA-Uganda, Africare has distributed 850 grafted avocado, 200 grafted apple and 100 pear plant materials. In line with the PMA, promotion of high-value fruit trees is aimed at improving household incomes and nutrition. Although yield data for these temperate fruits in Kabale is not yet available, published data from similar agro-ecological zones is the highlands show impressive economic returns and there is no reason why it should not be a highly profitable enterprise Kabale.

Sustainability strategy

From that start, UFSI addressed the sustainability concerns of the initiated activities. It actively involved farmers to play greater roles in planning, implementation, monitoring and evaluation of their activities. Farmers' involvement in problem analysis created an understanding that an important problem exists, and it has paid off because there was total commitment reflected in their willingness to take quick action and make contributions, as noted earlier. Their willingness to freely participate in these and contribute part of their meagre resources instilled the spirit of ownership of all the initiated activities, and continuity is more or less guaranteed. The formation of village production committees has strengthened the local community structures with regard to managing the natural resources.

Acquisition of good quality tree seed has been a big issue in the target villages. There is no single solution for this problem, but a multi-faceted approach is being undertaken to find a lasting solution. Africare has been establishing agroforestry demonstration plots on sub-county headquarters and other institutions such as churches and schools. These demonstration plots can be managed to provide seed during the inter-season fallow periods. Farmers have been trained in seed collection techniques and are encouraged to manage some trees on their farms to meet their seed requirements. Another strategy has been to attract private investment in tree seed production.

Conclusions and recommendations

Despite the impressive impact made during the UFSI's first phase, the task of rehabilitating degraded land and improving soil fertility is still a major one. Africare's successes have been partly due to its ability and willingness to form partnerships with other stakeholders operating in the same area. A case in point is the strong and mutually beneficial collaboration with the AFRENA Uganda. If agroforestry is to be scaled-up to meet the challenges of the growing population in the highland areas of Kabale, such collaborative partnerships need to be formed and farmers need to be at the centre of it all.

The local government systems have a major role to play if all that has been initiated in project mode is to be sustained. They can play a central role in natural resources management since they are composed of community representatives who are well versed in the local issues in their respective areas. They could take on responsibility for:

- Integrating the promotion of agroforestry into their development plans and ensuring that such activities are covered in their budgets;
- Enacting laws that will support agroforestry adoption;
- Mobilising and sensitising the communities to integrate tress in their farming systems.

4.7 ZAMBIA

4.7.1 Promotion and dissemination of improved fallows in Eastern Zambia: World Vision experiences

Donald Mwelwa Phiri

World Vision Zambia identified soil degradation as the fundamental biophysical root cause of food insecurity among the farmers in Katete, Chadiza, Mambwe, Chipata South and North. Nitrogen is the most severely depleted nutrient. This problem can be remedied through the use of imported inorganic fertilisers, but inorganic fertilisers are beyond the reach of the small-scale farmers. The World Vision Integrated Agroforestry project has been promoting a cheap and sustainable way of providing the much needed nitrogen. This is being done through the promotion of the agroforestry approach espoused by the International Center for Research in Agroforestry (ICRAF), the use of nitrogen-fixing trees and improved fallows.

Improved fallows build upon traditional fallow practices by incorporating fast-growing, nitrogen-fixing vines, shrubs and trees into traditional fallows, in order accelerate the natural soil regeneration process. Whereas traditional fallows require up to 20 years to improve the soil, improved fallows can significantly improve soil fertility in only 2 years, depending on rainfall and the growth of the selected tree species. There are also secondary benefits of improved fallows, such as the provision of fuewood, medicine, fodder, erosion control, weed suppression and shade. The improved fallow species being promoted include: *Sesbania sesban, Tephrosia vogelii*, *Cajanus cajan* and *Gliricidia sepium.*

Objectives of the programme

- Objective 1: Improve farmer productivity (crop yield per ha);
- Objective 2: Improve farmer access to agricultural extension and training;
- Objective 3: Develop and increase farmer access to market information.

This project focuses on objective 1. The practice of fallowing is not a new concept in Zambia (Kwesiga and Chisumpa, 1992). However, the use of improved fallows is a new concept. Baseline results indicated that although 66% of the respondents were aware of improved fallows, most of the farmers did not posses adequate knowledge to plant their own improved fallows. In order to reduce the knowledge gap on improved fallows, the project has been facilitating community sensitisation meetings and courses. These are conducted by a lead farmer with the help of the Block Development Facilitators (BDF), Block Extension Officers (BEO) and Camp Extension officers (CEO). The training conducted by the lead farmers is done in the villages. As improved fallows are a new concept, efforts

are made during farmer training sessions to discuss the use of improved fallow technology. In addition, farmer visits are arranged to demonstration plots as well as to ICRAF on-farm trials. Farmers that show interest are registered and assist with initial seed on a loan basis.

Sources of funding and collaboration

The project has been working in close collaboration with many stakeholders in agroforestry The International Center for Research in Agroforestry (ICRAF), the Lutheran World Federation (LWF), the District Women Association (DWA) and the Ministry of Agriculture Food and Fisheries have provided the project with useful feedback on the technology.

Achievements and lessons

Most of the farmers are planting *Tephrosia* improved fallows (more than 50%). The trend in all the sites tended to be the same, more *Tephrosia* fallows and less *Sesbania sesban*, *Gliricidia sepium* and *Cajanus cajan*. The farmers indicated that they preferred *Tephrosia vogelii* to *Sesbania sesban* because it was less labour-intensive; *Tephrosia* does not require any nursery phase (see Tables 18 and 19).

One issue emerging from the work to date is that it is important to give farmers the chance to make a choice on the species that they want to plant. This will give farmers the opportunity to make choices on the species to use based on local agro-climatic conditions as well as on their own constraints in adoption and use. These factors may include lack of knowledge and competing labour demands from other household activities. Giving the farmers opportunity to choose between several species allows them to take responsibility for the process of soil fertility replenishment on their land and empowers them.

The main lessons learnt are:

- The project should continue developing and applying better methods for forecasting seed requirements, and facilitating the establishment of sustainable, community-based seed production and distribution systems. Particular attention should be given to *Cajanus cajan* and *Gliricidia sepium* seed, the two fallow species are currently in short supply in the project;

Table 18 Improved fallows species planted by the farmers involved in the World Vision Integrated Agroforestry Project, 2000–01 cropping season

Species	Male	Female	Group	Total
Tephrosia vogelii	7,077	4,360	32	11,469
Sesbania sesban	1,261	294	13	1,698
Cajanus cajan	511	457	4	972
Gliricidia sepium	202	48	6	256
Total	9,051	5,159	55	14,395

Table 19 Seed procured for the 2000–01 season

Improved fallow species	Quantity
Sesbania sesban	1,693
Tephrosia vogelii	9,598
Gliricidia sepium	76
Cajanus cajan	326

- Working with farmers concentrated in one geographical area (clustering approach) appears to be better working than with the same number of farmers scattered over a wider geographical area. Using the former method allows resources to be used more efficiently;
- Working through farmer groups is more efficient way of reaching more beneficiaries than working through individual farmers. There were more farmers testing/adopting improved fallows in areas where active farmer groups existed;
- Well-targeted and well-planned farmer field days are an important tool in promoting the adoption of improved fallows;
- It is important to allow farmers to choose the fallow species which they prefer. Availability of seed should not be a constraint.
- Farmer-to-farmer transfer of information is very effective.

The future

- We need to follow up on the issue of root-knot nematodes in *Tephrosia vogelii* fallows (how widespread is the problem; what are the solutions, etc.);
- We need to find ways of lengthening the post-fallow effects (soil fertility);
- There is a need to define the biophysical limits of the various improved fallow species;
- We need to find ways of sustaining germplasm supply;
- We need to establish if direct seeding of *Sesbania sesban* is possible.

References

Kwesiga, F. and Chisumpa, S. 1992. *Ethanol Botanical Survey in Eastern Province, Zambia.* AFRENA Report 49. ICRAF, Nairobi, Kenya.

4.8 ZIMBABWE

4.8.1 Agroforestry in Zimbabwe

John Mutangadura and Livai Matarirano

The problem of low soil fertility in the SADC region has been documented by many authors, and has been reported to be the main cause behind falling maize yields, a staple in sub-Saharan Africa. The predominantly light textured soils of the communal areas in Zimbabwe have been extensively cropped with little or no addition of fertilisers, leading to severe depletion of nutrients, especially nitrogen and phosphorus. Net annual nutrient depletion exceeding 30 kg/ha N and 20 kg/ha P has been estimated in Zimbabwe. In some communal lands with higher rainfall in northern Zimbabwe, soil depletion is so severe that maize will yield virtually no grain without fertiliser.

Few options exist to ameliorate soil fertility for the smallholder farmer in Zimbabwe. Use of cattle manure is declining due to the fall in livestock herds. Land holdings are getting smaller and, consequently, the traditional practice of regenerating soil fertility through long duration native grass fallows is no longer feasible. The application of mineral fertilisers has declined considerably and in many years they are not applied at all. The ever-increasing cost of agricultural inputs in Zimbabwe, especially fertilisers, has thus impacted negatively on the agricultural industry. It is imperative, therefore, that cheap sources of nutrients be found to arrest the decline and to improve productivity. There is a need to develop sustainable and viable soil fertility improvement technologies for the resource-poor farmer in Zimbabwe.

It is towards this goal that agroforestry has been identified as a promising technology in soil fertility replenishment and management, as it offers a low-cost nutrient capital injection.

Livestock feed has not been spared from the rise in cost of agricultural inputs. These have gone beyond the reach of many, leaving livestock to depend totally on natural grass, and in some cases plant residues. The result is that livestock only get sufficient feed during the wet summer season when the grass is green, and are very weak during the dry season. This has impacted negatively on milk production, whether for family consumption, sale or both. Milk production in the smallholder sector offers an entry point for agroforestry. Leaves of tree legumes such as *Leucaena leucocephala* and *Calliandra calothyrsus* can be harvested, dried and fed to livestock as supplements during the long dry season. This ensures the availability of a protein source-milk to families during the dry season. It should be noted that these tree species have been reported to vary in performance with changes in biophysical conditions, hence the need for screening. It is also important to note that most of the tree species used are cross cutting, i.e. they can be used for both soil fertility replenishment and as livestock feed. Given the variability of the climate in Zimbabwe, it is important to assess performance of these multipurpose trees (MPTs) over the whole range of biophysical conditions.

Table 20 Summary of problems, agroforestry strategies, activities, funding and collaboration in Zimbabwe

Problem	Strategy	Activities	Source of funding and support	Collaborators
Low soil fertility	2-year *Sesbania sesban* and Cajanus cajan improved fallows	Planting the fallows Quantifying biomass production Planting maize in 3rd season Comparing growth and yields	ICRAF, Govt. of Zimbabwe	ICRAF, AGRITEX
	2-year Sesbania sesban improved fallows intercropped with cowpea and velvet bean	Planting the fallows Planting cowpea and velvet bean a month after establishment Quantifying harvested cowpea leaf material and grain Quantifying system biomass production Planting maize in 3rd season Comparing growth and yields Economic analysis Developing recommendations	ICRAF, Govt. of Zimbabwe	ICRAF, AGRITEX
Low soil fertility, fodder unavailability	MPT performance evaluation for fodder and soil fertility replenishment	Planting MPTs across a range of biophysical conditions Assessing growth Assessing biomass quality Developing recommendations	ICRAF	ICRAF

Table 21 Annual legumes, grain and biomass production

Crop	Fresh leaves (vegetables, kg/ha)	Grain (kg/ha)	Dry above-ground biomass (kg/ha)
CBC1	1320	493.7	1170
Landrace	995	107.6	1305
Velvet bean	–	–	1795

Agroforestry objectives, strategies and activities

- To develop and promote sustainable and viable agroforestry technologies for soil fertility amelioration and livestock fodder supply;
- To assess the performance of agroforestry technologies and tree species across a range of biophysical conditions;
- To give farmers some harvest during the fallow phase.

The strategies and activities are shown in Table 20.

The progress achieved can be summarised as follows:

- 2-year *S. sesban* and *C. cajan* improved fallows: the trees and shrubs were cut in September 2001 and the plots planted to maize. The trial is still in progress.

- 2-year *S. sesban* improved fallows intercropped with cowpea and velvet bean: the progress achieved here is summarised in Table 21.

- Performance evaluation of MPTs: the trial was established during the 2000–2001 season. This is a slightly longer-term trial and the differences are not yet clear.

There is need to increase the number of tree species under evaluation. Assistance is being sought from countries with environments similar to Zimbabwe who have tested different species, so that their species can be evaluated in the Zimbabwean farming environment or results from their trials can be extrapolated. Technologies tested in these countries can also be appropriately applied to Zimbabwe.

It is important to point out that the sites hosting all the trials are still few, and tree species under evaluation are also few. Financial limitations are a major factor and cannot be divorced from all operations of such trials. In Zimbabwe financial support is dwindling and this impacts negatively on new projects.

The future

It is expected that the completion of these experiments will see the uptake of the technologies by farmers and play a major role in their day-to-day farming activities. The inclusion of farmers from the start (many farmers host the trials) is likely to ensure continuity once research is through. Extension agents are also part of the research, and this is likely to impact positively on dissemination.

We are open to feedback and advice from other countries and individuals with more experiences in agroforestry and would appreciate contributions towards establish a strong agroforestry base, as most of our work is still research.

4.8.2 The SADC-ICRAF Zimbabwe Agroforestry Project: bringing trees back to the farm

John Mutangadura and Livai Matarirano

The SADC-ICRAF Zimbabwe Agroforestry Project was initiated in 1991. This project is part of the Zambezi River Basin Agroforestry Project for Sustainable Rural Development. Globally, the International Center for Research in Agroforestry (ICRAF) is supported by the Consultative Group on International Agricultural Research (CGIAR). The Zimbabwean project is funded mainly by the Canadian International Development Agency (CIDA). Bundeministerium für Wirtschaftliche Zusammenarbeit (BMZ) supports the domestication and use of indigenous fruit trees from the miombo woodlands in Southern Africa. Some agroforestry technologies have shown great potential in improving smallholder farmers' agricultural production. Here we present the summarised findings of three examples of the kind of work carried out by ICRAF and national scientists since 1991.

Research

ICRAF's research in Zimbabwe has been looking at the management of organic materials derived from leguminous tree foliage in biomass transfers for soil fertility improvement. Communal farmers in Zimbabwe often collect decomposed leaf litter from the miombo woodlands to use as organic fertiliser. Leaves from leguminous trees are of higher quality, but this is variable among species. The main quality factor in these leaves is the level and nature of polyphenols. Polyphenols affect the rate and extent of degradation of leaf material. Polyphenols in fresh leaves are degraded more easily than those in dried materials. Results from experiments at Domboshawa showed that the application of fresh leaf prunings doubled maize grain yields compared with the application of sun-dried prunings.

Short-term, planted fallows. These 2- to 3-year fallows of three leguminous trees/shrubs – *Acacia angustissima, Cajanus cajan* and *Sesbania sesban* – have doubled or tripled maize grain yields without adding inorganic fertilizers. The scientists concluded that the *Acacia* and *Cajanus* fallows could only sustain maize yields above 2 t/ha for 1 year without inorganic fertilisers. *Sesbania* fallows, however, seem to be able to sustain this yield for at least 2 years. Synergistic effects were observed with the application of 50% of the recommended rate of inorganic fertiliser to the multi-purpose tree (MPT) fallows. This effect was consistently observed for 3 years. This technology, when adopted by resource-poor farmers practising low-external-input agriculture, can sustain maize yields in degraded areas.

Fodder bank technology. This is based on high-yielding *Acacia*, *Calliandra*, *Cajanus* and *Leucaena* species and has demonstrated great potential for improving livestock productivity. These MPTs can be used to replace the costly commercial concentrate or supplement protein feedstuffs traditionally used in cattle production. Smallholder farmers are heavily reliant on the natural veld for feeding both dairy and draught animals. The quality and quantity of this feed resource is greatly diminished for the 4 months of the dry season. MPTs used in experiments at Domboshawa produced browseable fodder with

yields ranging from 2.5 to 8 t/ha. *Leucaena leucocephala* has shown the highest potential for sustaining high milk yields above 14 litres per cow per day. Other species and provenances of *Leucaena*, *Canajus cajan, Acacia angustissima* and *Calliandra calothyrsus* have also shown promising results. Use of tree fodders as supplements to purchased concentrates can reduce production costs from as much as 80% of total milk production costs to a mere 20% – so putting more money in the farmers' pockets! In Zimbabwe, the fodder technology has received wide acceptance by smallholder dairy farmers.

Domestication of indigenous fruit trees. This has shown that it is possible to grow wild fruits on farms just like we do with exotic fruits. The project has been working in the following areas:

- Species priority setting;
- Screening of germplasm of selected species;
- Developing horticultural techniques that allow easy and fast propagation of selected species;
- Fruit utilisation and marketing.

Dissemination

The ultimate goal of the Zimbabwean project team is to help improve the livelihood of farmers (improved cash flows, land-use productivity, household nutrition and welfare of farmers and their families) through agroforestry. The agroforestry technologies that have been tested on-station have also gone on-farm for farmer testing and evaluation.

Participatory planning is carried out with stakeholders to aid the process of farmer testing, dissemination and development. Annual planning and review meetings, in which all stakeholders participate, produce programme plans for the year. These plans are then implemented in collaboration with various partners (totaling 33 in 2001). Of note in this project is the close collaboration between ICRAF and the Department of Research and Extension, the Dairy Development Programme, the Forestry Commission, the Department of Agricultural, Technical and Extension Services (AGRITEX) and some non-governmental organisations (NGOs).

Dissemination has so far concentrated on the following areas:

- Practical farmer training sessions combined with field visits to pilot sites;
- Exchange visits between sites for the purpose of training and practical information exchange among farmers;
- Extension officer and teacher training sessions organised jointly with the Forestry Commission and SCOPE, with resource persons from ICRAF, the Forestry Commission and/or SCOPE. The training sessions always include field trips facilitated by ICRAF;
- Production and distribution of a national agroforestry newsletter, *Living with Trees in Zimbabwe*, which is produced regularly. Contributions for the newsletter come from all stakeholders;
- Production and distribution of factsheets;
- Wide distribution of planting material (seeds and seedlings) to clients;
- Networking with various partners in development to facilitate synergy in dissemination and development activities.

4.8.3 Agroforestry development experiences in the Forestry Commission of Zimbabwe

Abisai Mushaka

The smallholder farming sector (communal areas) of Zimbabwe covers an area of 16.35 million hectares which represents 42% of the country. It is 'home' to about 70% of the country's population of 11.5 million people who depend mainly on agriculture for their livelihood. The predominantly poor rural communities living in this sector rely mostly on natural resources such as forests (which are considered a free resource) for the provision of basic goods and services. This has contributed to extensive deforestation in the communally owned grazing areas, with some districts now having less than 30% woody vegetation cover. Furthermore, Zimbabwe is losing about 7,000,000 m^3 of wood each year through agricultural expansion and the harvesting of timber and non-timber forest products. It is against this background that a number of agroforestry initiatives have been put in place by government and non-governmental organizations (NGOs) since early 1980s.

In Zimbabwe, the agroforestry program I am involved in has focused on two main areas:

- Reviewing and building on existing tree-planting practices;
- On-farm assessment and promotion of promising agroforestry species and technologies.

Reviewing and building on existing tree-planting/agroforestry practices

The surveys were aimed at taking stock of the current tree-planting practices in communal areas and on identifying ways of improving and strengthening them through research, extension, institutional adjustments and policy changes. The following conclusions were drawn from the studies.

There has been considerable tree planting in communal areas, with up to 27 species being planted in a district. Most of the trees are exotic fruit trees grown for domestic consumption and sale. The occurrence and prevalence of tree cultivation is higher in wetter than in the drier districts. Consequently, the most practical option is to concentrate on the better management of existing trees in the drier districts and on tree planting in the more deforested wetter areas. Tree planting is concentrated in areas owned by individual households such as the homestead, garden and field boundaries.

Eucalypts were the second-most (after rubber hedge) dominant cultivated non-fruit tree species in the study areas. However, the trees' high water demand necessitates the need for research on its effects on the adjacent crop. Such work will help define spatial arrangements that minimise the trees' adverse effects on crop performance and on the water table.

Afforestation in Zimbabwe has relied mainly on eucalypts, predominantly *Eucalyptus camaldulensis* (Dehn). Performance of the species under smallholder farmer management is largely unknown. A study

was commissioned by Zimbabwe Forestry Commission to establish the growth-limiting factors to the performance of *E. camaldulensis* in some selected areas of Zimbabwe.

The study has shown that *E. camaldulensis* can sometimes perform fairly well in the drier areas and perform poorly in the higher rainfall areas. What is required are specific recommendations based on specific site conditions.

Across all the surveyed sites initial growth rates were quite comparable up to about 4 years. From the fifth year growth differences were very significant, so much so that there was very little correlation between growth parameters (height and diameter at breast height) and the age of trees. It may thus be hypothesised that *E. camaldulensis* growth is constrained after the fourth year of establishment in the surveyed drier communal areas.

In most of the surveyed dry areas (regions 4 and 5), the mean annual increment was more than 7 times smaller (often reaching 10 times) than that for similar aged stands in regions 1 and 2. *E. camaldulensis* from the preliminary results does not seem to be suited for afforestation in these areas. There may be a need to screen for alternative species for drier areas or investing in the management of woodlands.

Boron, magnesium, potassium, phosphorus and iron, the most deficient nutrients, may require further attention especially in plantation forestry. Significant gains may be realised by manipulating nutrients. Significant correlation was shown between the growth parameters and foliar boron and manganese for trees less than 4 years and foliar copper and foliar boron for trees older than 4 years. There is a need to establish whether this relationship can be manipulated through fertilisation to improve the productivity of *E. camaldulensis.*

On-farm assessment and promotion of promising agroforestry species and technologies

Agroforestry has been promoted in Zimbabwe for the past two decades. In spite of this relatively long timespan, agroforestry has largely remained on-station. On the ground, it has remained limited to integration of existing forestry/horticultural practices with agricultural crops. Granted, there has been some isolated plantings of fodder banks and other technologies, particularly in areas with small-scale dairy projects. Poor adoption has been attributed to the unavailability of agroforestry seed, inappropriate promotion of promising technologies and lack of back-up services.

The Department of Conservation and Extension (CONEX) of the Forestry Commission is building on the wealth of farmer experimentation by systematically identifying farmer needs that can be addressed through agroforestry, selecting relevant species, practices and technologies with farmers, providing necessary training back-up for the establishment and management of the practices and technologies, and reviewing performance under farmer management.

The programme, funded under the Agricultural Sector Support Program (ASSP) by DANIDA, aims to:

- Broaden the tree species range (and thus products and services) planted by farmers;
- Integrate promising tree species into existing farming systems;

- Compliment on-going research efforts by generating information on on-farm planting and management of candidate tree species;
- Inculcate a culture of on-farm experimentation in the extension services through training and involvement of extension officers in the design, implementation and management of on-farm trials and demonstrations;
- Shorten the time lapse between research and implementation.

The selection of appropriate species, practices, technologies and planting sites was done by farmers based on their individual needs and preferences. Where farmers did not have prior experiences with a species or technology, they chose technologies based on the advertised attributes as explained by extension officers

The indigenous fruit tree species chosen and tried by farmers across the eight districts were *Flacourtia indica, Ziziphus mauritiana, Tamarindus indica, Sclerocarya birrea, Strychnos cocculoides, Vangueria infausta* and *Diospiros mespiliformis*. Indigenous species were *Afzelia quanzensis* and *Pterocapus angolensis. Kigelia africana was* chosen for fodder. Australian acacias tried by farmers were *Acacia auriculiformis, Acacia melanoxylon* and *Acacia holosericea.* Other fodder species were *Leucaena leucocephala, L. Pallida, L. diversifolia, L. esculenta* and *Acacia angustissima.* Most of these will be planted as fodder banks with and without agricultural crops. Farmers chose African acacias such as *Acacia tortilis*, *Faidherbia albida* and *Acacia nilotica* for live fences. For soil fertility improvement *Cajanus cajan* and *Sesbania sesban* were chosen. These were planted mainly as improved fallows.

The provision of adequate amounts of quality seed at the required time remains a critical challenge. Strategies employed to ensure farmers had tree seed to plant include farmers' own collection, germplasm exchanges, formal requisition from the Forest Research Centre and requisition from the International Center for Research in Agroforestry (ICRAF). In spite of the above strategies, some of the preferred seed could not be obtained as it was out of stock and/or the fruiting season had passed, and some of the seed was obtained in very small amounts.

5

Evaluation, conclusions and recommendations

The participants' assessment of agroforestry developments in Malawi and Zambia is best summarised by their ratings of the technologies that they saw (Table 22) and by their understanding of and comments on factors that might hinder advancement of agroforestry in the region (Table 23). The overall conclusions and recommendations are evidence of participants' appreciation of the issues relevant to the promotion of agroforestry in Eastern and Southern Africa. A follow-up of the recommendations by the participants in the respective countries would go a long way towards enhancing the use of agroforestry technologies.

5.1 Research

Conclusions

- The research has provided a basket of technology options to farmers. Some of the technologies so far developed include improved fallows, relay cropping and mixed intercropping for soil fertility improvement; boundary and homestead tree planting for supply of fuelwood, poles, timber and fruits; woodlot establishment on steep slopes for soil conservation and firewood; fodder banks for livestock using species such as *Leucaena, Calliandra* and *Acacia.*

- Integration of livestock in agroforestry research and development was weak compared to research on soil fertility and fuelwood problems.

- The current agroforestry technologies seem to be based on a narrow range of agroforestry tree species, (e.g., *Leucaena*, *Sesbania*, *Gliricidia* and *Tephrosia*).This situation is fraught with great risks should diseases or pests that is specific to one of the species break out in the region.

- Farmers were conducting their own experiments in agroforestry. Often they came up with successful solutions to common problems. Through such experimentation, farmers had discovered that planting *Tephrosia* at three plants per hill instead of the recommended one plant per hill gave better ground cover and higher biomass yield.

- The conduct of on-station and on-farm research in parallel provided good feedback between farmers and researchers. This was evident in the wide range of second-generation research issues that the on-farm research had raised for follow up by the researchers.

Table 22 Technologies rated highly by participants

Technology	Number of respondents	Ranking
Improved fallows (relay cropping, *Tephrosia vogelii* undersowing)	13	1
Coppicing fallows	8	2
Fodder banks	5	3
Biomass transfer for high value crops	4	4
Rotational woodlots	3	5
Domestication of indigenous fruits	3	5
Tephrosia vogelii fallow	2	6
Mixed species fallows	1	7
Relay cropping	1	7

Table 23 Participants' identification of problems affecting the development of agroforestry in Malawi and Zambia

Problem	Number of respondents	Suggested solutions
Lack of extension information/knowledge	11	Community/partner-based seed production, centralised and decentralised seed systems, sub-contract growing and collection
Shortage of seed	9	Training staff, farmers and partners, awareness campaigns, workshops, demonstrations, visits for policy-makers, district authorities, multi-disciplinary extension approach, use local governments, CBOs, provide more resources
Labour intensiveness	3	Exploit partnerships to minimise cost, promote less laborious technologies (e.g., *Tephrosia* fallows)
Shortage of land	3	Develop intensive agroforestry systems, e.g. coppicing fallows and relay cropping
Land tenure (e.g., matrilineal inheritance system)	2	–
Poor funding of research and extension	2	Widen range of donors (e.g., rope in district councils, private companies)
Inappropriate technologies or lack of back-up information	1	Incorporate farmers' system (e.g., intercropping in the design of technologies, increase range of options)
Poor institutionalisation	1	Institute multi-departmental agroforestry steering committees
Technology packaging not well integrated	1	Address issues pertinent to adoption of technologies in a holistic manner

- While the incorporation of *Tephrosia* biomass in the soil had beneficial effect on yields of subsequent maize crop, there were instances in Malawi where farmers experienced poor germination of maize planted soon after *Tephrosia* biomass was incorporated. This suggested lack of precision in the recommendations given to the farmers.

- Following the tour and discussions with the researchers and extension workers, it was observed that very little agroforestry research has taken place in the low potential agroecological areas in the region. This was particularly the case in the arid and semi-arid areas of Botswana, Kenya and Namibia.

- Considering that agroforestry is labour intensive, non-adoption of agroforestry technologies could be linked to non-availability of labour during critical periods of the year.

- Several agroforestry tree species and their provenances have proved themselves in Malawi and Zambia. These include *Sesbania sesban, Gliricidia sepium, Calliandra callothyrsus, Tephrosia vogeli* and *Leucaena leucocephala*. The neighbouring countries should access and incorporate these tree species in their agroforestry development programmes.

- Participatory and regular monitoring of agroforestry technologies during testing by farmers in Malawi and Zambia has ensured good feedback to researchers. The feedback has led to the fine-tuning of the technologies.

- Following region-wide collection and screening of a large number of accessions of *Sesbania sesban, Tephrosia vogeli* and *Gliricidia sepium* the SADC-ICRAF Zambezi Basin Agroforestry Project has identified superior provenances for utilisation in agroforestry.

- For maximum effectiveness and impact, agroforestry research calls for multidisciplinary team work that incorporates researchers, extension and farmers. Multidisciplinary collaboration in agroforestry research and development among different government ministries, departments and non-government organisations (NGOs) has been enhanced by the formation of broadly based agroforestry steering committees in the countries participating in the ICRAF SADC Zambezi Basin Project.

- The SADC-ICRAF indigenous fruits domestication programme coordinated from Makoka Agriculture Research Station in Malawi is an important reference centre for the domestication of indigenous fruits.

- Adoption of agroforestry by large-scale farmers (e.g., tobacco and dairy production farmers) demonstrates the relevance of agroforestry to both large- and small-scale farmer problems.

- In order to institutionalise agroforestry in natural resource management practices in Eastern and Southern Africa, it is necessary to involve a broad spectrum of actors, including district and rural councils, that may even provide financial assistance. Tanzania is benefiting from financial support by rural councils.

- The Msekera Agroforestry Team is to be commended for molding researchers, extension workers and farmers into a highly effective agroforestry research and dissemination team in Zambia.

- Funding of research in SADC and East African countries is highly inadequate. The participants pointed out that much of the ongoing agroforestry research was donor-funded, a situation that is unsustainable as donor fatigue sets in. The participants discussed and agreed that provided the research was sound and focused, funding would be easy to come by.

Recommendations

- Involve farmers, especially women, in the design and testing of technologies; encourage them to do their own adaptations and establish information flows in all directions.

- Countries such as Botswana, Kenya and Namibia that have extensive arid and semi-arid areas would learn and gain a lot if they linked up with ICRAF's Sahelian Agroforestry Project.

- There is a need for more socio-economic analysis of agroforestry technologies that includes labour requirements and availability in different socio-economic settings.

- Countries neighbouring Malawi and Zambia should access and incorporate agroforestry technologies developed in the two countries in their agroforestry development programmes.

- On-farm evaluation of agroforestry technologies by farmers and close monitoring of the adoption process are a pre-requisite for the development of appropriate technologies.

5.2 Dissemination and training

Conclusions

- The participants were impressed by the wide array of partners with whom the SADC-ICRAF Agroforestry Project was collaborating in spearheading agroforestry research and development in the region. The participatory nature of the research and the involvement of extension staff, farmers and NGOs ensures the relevance of the technologies and adoption by farmers.

- Agroforestry technologies are knowledge-intensive and therefore require continuous follow-up and support by the researchers and extension staff until farmers are confident enough to manage alone.

- Farmer-to-farmer dissemination of information on agroforestry has been effective in Malawi and Zambia. In particular, use of training of trainers, particularly women, has been highly effective in the dissemination of improved fallows technology in Zambia.

- Although the main effect of agroforestry technologies for soil fertility improvement is to increase productivity, equally important is cost savings and the improvement of soil structure.

- The promotion of agroforestry should be complemented by other relevant technologies such as bee keeping, introduction of fuelwood-saving cooking stoves and the establishment of woodlots.

- Technology dissemination pathways and approaches should be tailored to factors such as type of technology and administrative/political boundaries. For example, the catchment approach renders lends itself to technologies geared towards soil and water conservation.

Recommendations

- Since researchers cannot be expected to effectively handle dissemination single-handed, adequate time and personnel should be allocated for the dissemination of agroforestry technologies.

- NGOs and international agricultural research centres (IARCs) should involve national extension systems in the dissemination process for it to be sustainable over the medium and long term.

- Farmers and extension workers require continuous training in new technologies in order to be able to respond to new needs and enhance dissemination and adoption of the technologies.

- Training of trainers for agroforestry dissemination should target women farmers in particular as they constitute over 70% of farm labour in the region.

- Researchers should provide a basket of options from which farmers can select, instead of pushing a particular agroforestry technology.

- Short- and long-term benefits of agroforestry should be emphasised during the promotion of this land-use system.

5.3 Networking

Conclusions

- Active collaboration was observed in Malawi and Zambia among various actors in agroforestry research and development. Among the collaborators were: research and extension, NGOs, IARCs, community based organisations (CBOs) and farmers. The collaboration was particularly intensive and highly productive in Chipata, Zambia.

- Biophysical research findings are more extrapolable and transferable across countries and regions than socio-economic findings. The latter can vary widely among countries and regions.

- Agroforestry research and development have benefited greatly from networking at local and international levels through the synergy and confidence-building that such networking brings.

Recommendations

- Each country should establish its own research capacity in the field of socio-economics in order to be able to generate appropriate technologies.

- The links among farmers, researchers, extension workers, NGOs and CBOs should be strengthened in support of agroforestry development.

- Eastern and Southern African countries should promote networking among themselves in order to share information on new agroforestry technologies and hence enhance the chances for adoption.

5.4 Seed

Conclusions

- There is a shortage of agroforestry tree seed for most tested species in the two countries visited. Consequently, seed is costly. There is a need to reduce seed costs.

- Most farmers depend on seed harvested from field trials.

- During discussions among the participants, it was agreed that there was a lack of policy in most of the countries regarding seed production and marketing.

- Poor availability of quality seed is hindering the adoption of agroforestry technologies.

- Although giving seed to farmers facilitates adoption of agroforestry technologies, it is not sustainable.

- At Chipata, Zambia one estate had embarked on extensive planting of *Gliricidia sepium,* some of which was to become a seed orchard.

- Potential demand for agroforestry seed in Eastern and Southern Africa is destined to increase considerably as more and more farmers adopt agroforestry.

- In both Malawi and Uganda cooperation between national seed centres and communities in identifiying parent trees has proved effective in accessing seed of indigenous tree species.

Recommendations

- Eastern and Southern African countries should individually and, if possible, regionally develop a strategy for production, processing and marketing and distribution of agroforestry tree seed.

- Seed production strategies should be in-built in any initiative promoting agroforestry technologies.
- Agroforestry tree seed orchards should be established for the production of quality and quantity seed.
- Communities and individuals should be trained and facilitated to establish their own seed orchards/stands.
- Farmers should be trained and encouraged to save their own seed.
- The national tree seed centres that exist in almost all SADC countries should participate in the training of farmer groups and the managers of private nurseries and estates to establish seed orchards for the production of tree seed.
- National tree seed centres should cooperate with communities in the identification of superior trees from which seed of valuable indigenous tree species could be collected.

Annexes

Annex 1: Speech by Dr C. Matabwai, on behalf of the Government of Malawi, at the launch of the agroforestry study visit to Malawi and Zambia, 21 January 2002

Let me start by welcoming you to Malawi most warmly. We are delighted by your visit at it offers us an opportunity to show you what we are doing to address many land-use problems, which I am sure your respective countries are also grappling with. Your visit gives us a window of opportunity to learn from one another and build new links where none existed, as well as strengthening the old ones.

I have been informed that the participants are drawn from Eastern and Southern African countries and that several disciplines in the field of natural resource management are represented in the group. This should enable you to view land-use problems and the solutions thereof in a multidisciplinary manner.

The Ministry of Agriculture and Irrigation, in collaboration with non-government and community-based organisations, the private sector, University of Malawi, various international development and research agencies such as ICRAF, the donor community such as USAID, EU, Rockefeller Foundation and DANIDA, has been involved in agroforestry research and development for over a decade. We are therefore at a stage where we can share our experiences with other experts from outside Malawi and benefit from their observations and constructive criticism. The Malawi Agroforestry Extension Project has played the leadership role in on-farm testing and extension of agroforestry technologies.

The main thrust of our research and development in agroforestry has been focused on:

- Soil fertility replenishment;
- Alleviation of natural resource degradation (soil erosion and deforestation);
- Alleviation of shortage of fuelwood and other tree products such as poles and fruits;
- Provision of fodder, particularly during the dry season;
- Supply of tree seed to farmers and improved propagation techniques to enhance germination and growth;
- Approaches to the dissemination of agroforestry technologies.

Our scientists, extension specialists and farmers will be able to show and discuss with you some of the technologies that have been developed and are at various stages of validation and adoption by farmers. The most promising technologies developed are: contour tree/grass strips for soil and water conservation; tree planting on farm boundaries and homesteads for firewood and poles; relay cropping using *Sesbania* or *Tephrosia*; *Tephrosia* intercropping/undersowing; *Calliandra* fodder banks; domestication of *Uapaca* fruit species; and use of species such as *Ziziphus* for live hedges. Our scientists and their collaborators will give you the details.
Hand in hand with the development of agroforestry technologies, we have been grappling with the problem of providing farmers with high quality seed of recommended agroforestry trees. The MAFE Project has done an excellent job of setting up a system for the collection, processing and distribution of agroforestry seed. No doubt you will take this opportunity to see and appreciate what has been achieved in this initiative. We would really like to learn from other countries' experience on the issue of seed. The group should discuss how best the countries could facilitate the exchange of agroforestry germplasm in order to promote agroforestry development. Without adequate quality seed, extension programmes cannot get started.

In the field of dissemination of information to farmers, MAFE has spearheaded farmer training activities and the development of training materials for both farmers and field technical staff. This is another area where we would like to learn from other countries' experiences. For example, what approaches have you found most efficient and effective in trying to reach the farmer?

Here in Malawi we are reminded that agroforestry is not a panacea for all land-use problems. We are therefore interested in developing solutions that combine agroforestry with other approaches such as inorganic fertilisers to address pressing problems such as soil fertility. In this regard we believe that researchers should not forget to integrate good crop husbandry practices in their technology packages if benefits from agroforestry are to be maximised.

It is my hope that following your field visit and the discussions that ensue, you will all be better informed about agroforestry developments in Malawi and Zambia and that you will have established professional links through which you will advance agroforestry in your respective countries. We also hope that you will actively contribute your own knowledge and ideas so that we in Malawi can gain from your experiences. It is therefore my great pleasure to officially wish you a rewarding visit both to Malawi and to our sister country Zambia.

Annex 2: Study visit programme

Sunday 20 January

Lilongwe, Malawi
Participants registration, briefing meeting, and welcoming dinner

Monday 21 January

MAFE Resource Centre, Malawi
Briefing and opening speeches, tour of MAFE Resource Centre

Bunda/Mitundu area, Malawi
Farm visit: homestead and boundary tree planting, Tephrosia-improved fallows, soil conservation practices

Tuesday 22 January

Chibvala-Chonde and Chembe villages, Malawi
Farm visit: Tephrosia undersowing, afforestation programme, maize/Faidherbia albida

Wednesday 23 January

Chitedze Research Station, Malawi
Legume screening for pest and disease resistance

Njolomole EPA, Ncheu District, Malawi
Tephrosia undersowing, soil conservation practices

Lilongwe, Malawi
Presentations of country reports

Thursday 24 January

Makoka Research Station (ICRAF), Malawi
Briefing on SADC-ICRAF Agroforestry Project in Malawi, tour of on-station nursery and intercropping trials, presentation of country reports

Friday 25 January

Makoka Research Station, Malawi
Fodder banks

Chiradzulu District, Malawi
Farm visit: nurseries for indigenous fruit trees, Tephrosia-based soil fertility improvement, maize intercropping, contour tree planting

Lilongwe, Malawi
Presentation of country reports

Saturday 26 January

Malawi to Zambia via Salima

Sunday 27 January

Chipata, Zambia
Presentation of country reports

Monday 28 January

Msekera Research Station (ICRAF), Zambia
Briefing on SADC-ICRAF Agroforestry Project in Zambia

Tuesday 29 January

Kalungu, Jerusalem and Khapinde areas, Chipata, Zambia
Farm visits (five farms)

Wednesday 30 January

Zambia to Malawi
Final session discussions and evaluation

Annex 3: List of participants

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Distribution of participants in the study visit, according to country and gender

Country	Male	Female	Total
Botswana	–	2	2
Kenya	2	2	4
Malawi	1	1	2
Namibia	1	-	1
Tanzania	3	-	3
Uganda	3	-	3
Zambia	1	-	1
Zimbabwe	2		2
Total	13	5	18

Two participants selected from Kenya dropped out at the last minute

Acronyms

AFRENA	Agroforestry Research Network for Africa
AGRITEX	Agricultural, Technical and Extension Services
ANAFE	African Network on Agroforestry Education
BMZ	Bundeministerium für Wirtschaftliche Zusammenarbeit
BNF	Biological nitrogen fixation
CANAMCO	Canada Namibia Cooperation
CARE	Canadian Aid for Rural Extension
CBO	Community based organisation
CGIAR	Consultative Group on International Agricultural Research
CIDA	Canadian International Development Agency
CTA	Technical Centre for Agricultural and Rural Cooperation
ELDP	Evangelical Lutheran Development Programme
EU	European Union
FAO	Food and Agriculture Organisation of the United Nations
FESD	Forestry Extension Services Division (Kenya)
FRIM	Forestry Research Institute of Malawi (Malawi)
IARCs	International agricultural research centres
ICRAF	International Center for Research in Agroforestry
IITA	International Institute of Tropical Agriculture
KARI	Kenya Agricultural Research Institute
KAWG	Kavango Agroforestry Working Group (Namibia)
KEFRI	Kenya Forestry Research Institute
KWS	Kenya Wildlife services
MAFE	Malawi Agroforestry Extension
MAWRD	Ministries of Agriculture, Water and Rural Development (Namibia)
MPT	Multipurpose tree
NAADS	National Agricultural Advisory Services (Uganda)
NAFRP	National Agroforestry Research Project (Kenya)
NALEP	National Agriculture and Livestock Extension Programme (Kenya)
NASC	National Agroforestry Steering Committee (Malawi)
NGO	Non-governmental organisation
NSWCP	National Soil and Water Conservation Programme (Kenya)
PMA	Plan for the Modernisation of Agriculture (Uganda)
PMT	Priority medicinal tree
PRA	Participatory rural appraisals
PROSCARP	Promotion of Soil Conservation and Rural Production (Malawi)
RAES	Rural Afforestation Extension Scheme (Kenya)
SADC	Southern Africa Development Community
SIDA	Swedish International Development Agency
TAFORI	Tanzania Forest Research Institute
UFSI	Uganda Food Security Initiative
UGADEN	Uganda Agroforestry Development Network
USAID	United States Agency for International Development