AGROFORESTRY FOR DEVELOPMENT IN UGANDA

A Synthesis of Topics Discussed at

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ACRONYMS

ACORD	Association for Cooperation in Research and Development
AF	Agroforestry
AFRENA	Agroforestry Research Network for Africa
ARDC	Agricultural Research and Development Centers
ASDI	Apac Sustainable Development Initiatives
BATU	British American Tobacco Uganda
BFP	Budongo Forest Project
BNF	Biological Nitrogen Fixation
BUCODO	Budongo Forest Community Development Organisation
CARE-DTC	Development through Conservation
CAZRI	Central Arid Zone Research Institute
CBOs	Community Based Organisations
CEFORD	Community Empowerment For Rural Development
DATICS	District Agricultural Training & Information centers
EA	East Africa
EC	European Commission
EPED	Environmental Protection and Economic Development Project
FAO	Food and Agricultural Organisation
FD	Forest Department
FORRI	Forest Resources Research Institute
GEF	Global Environment Fund
GTZ	German Development Agency
HPI	Heifer project International
ICRAF	International Centre for Research in Agroforestry
IRC	International Care and Relief
IRDI	Integrated Rural Development Initiatives
IUCN	International Union for the Conservation of Nature
JEEP	Joint Energy and Environmenat Conservation
KARI	Kawanda Agricultural Research Institute
LVEMP	Lake Victoria Environment Management Project
LWF	Lutheran World Federation
MAAIF	Ministry of Agriculture Animal Industry and Fisheries
NAADS	National Agricultural Advisory Services
NARO	National Agricultural Research Organisation
NEMA	National Environmental Management Authority
NFC	Nyabyeya Forestry College
NGOs	Non-Governmental Organisations
PAF	Poverty Alleviation Fund
PEAP	Poverty Eradication Action Plan
PLAN	Plan International (is an NGO)
PMA	Plan for Modernisation of Agriculture
PWDs	Persons with Disabilities
SAARI	Serere Agricultural and Animal Research Institute
SAFIRE	Southern Alliance for Indigenous Resources
SOCADIDO	Soroti Catholic Diocese Development Organisation
UGADEN	Uganda Agroforestry Development Network
ULAMP	Uganda Land management Program
UNFA	Uganda National Farmers' Association
UNHR	United Nations High Commission for Refugees
URDT	Uganda Rural Development and Training Programme
USCAPP	Ugand Soil Conservation Pilot Project

PREFACE

Agroforestry (AF) is the growing of trees on the farming landscape to improve livelihoods and protect the environment. It has developed over the last two decades from traditional farming methods which have been in practice for generations in Uganda. The earlier promotions of AF as a discipline started at the university level, where promotion of simpler technologies such as alley cropping using fast growing nitrogen fixing shrubs was done. This technology was not widely adopted even in the humid fertile niches because it did not meet the objectives of the farmer of increasing household income, as compared with other alternative farm investments. The concept of Agroforestry as a potential contributor to farming has become increasingly accepted. Agroforestry has been embraced in the national plan for modernization of agriculture (PMA) as a means to improve technologies for increased agricultural production and household livelihoods.

The perception of Agroforestry has evolved to identify technologies and interventions that enhance biophysical conditions, but most importantly, increase household income. The expectations from Agroforestry have also evolved from the earlier exaggerated view of it as the answer to all farming problems, to an understanding that it is part of an integrated approach involving other interventions. Initially Agroforestry was promoted by scientists mainly in the forestry and agricultural disciplines, and was understood as the sum of the two. Now, an understanding of the importance of interdisciplinary approaches involving humanities and economics has developed.

While there is a general agreement that Agroforestry can potentially improve farming practices, enhance soil conditions and livelihoods, the attitude towards Agroforestry has been mixed. Extension has largely targeted women farmers who are the major source of farm labour, but with limited control over the resource base and inadequate participation in marketing. The involvement of men and women in Agroforestry practice has posed a number of challenges to resource base control and division of labour. Another challenge has occurred at community and national level regarding ownership of rights to trees either by the clan, community members or the government. Marketing of timber and other products from trees which are considered to be common or public property is limited by a number of restrictions. Therefore, domestication or management of certain tree species has been avoided. The fast spread of Agroforestry among the public has not been matched by the rate at which its concepts are understood by farmers. Adoption has occurred in places where there is strong extension support. Most natural resource and agricultural based non-governmental organisations have enthusiastically promoted Agroforestry. However, there are few people with sufficient knowledge in the subject to provide the necessary extension support. Therefore, a common understanding among all players in Agroforestry is considered necessary.

Training in Agroforestry in Uganda started at university level and it was supplemented by a number of training workshops. Nyabyeya Forestry College and Bukalasa Agroforestry College have also recently included Agroforestry into their curricula. The proposed trend is to take Agroforestry further to primary schools so that the majority of school leavers have the basic concepts of Agroforestry, and if they continue further in education, they can deal with more complex issues.

The government plans to use a new privatized extension model known as the national agricultural advisory services (NAADS). This form of extension is expected to provide services demanded, and paid for by farmers. For this to happen, farmers must know what advice to ask for, and service providers must have satisfactory answers for their paying clients. This calls for strong human resource capacity building to ensure that the necessary support is provided for, and Agroforestry is properly practiced. In spite of the favourable acceptance of Agroforestry among farmers and government policies, success stories are few and scattered, and a lot needs to be done before a critical mass of farmers start practicing Agroforestry with sufficient knowledge to integrate it with other land management practices for improved income generation and livelihoods. A workshop to determine the status of Agroforestry in Uganda and to develop strategies to increase its impact was convened in September 2001 at Mukono district.

This book is a synthesis of papers discussed during the workshop. It has been arranged into ten major topics of interest to educators, students, researchers, farmers, policy makers and extensionists who contributed to its development through sharing of experiences and participating in forging the way forward for national development of Agroforestry. The objective of this book is to document the status of knowledge in Agroforestry in Uganda for a wider audience and also highlight areas of intervention in research, training and extension. It can also be used as reference book for students, policy makers and researchers.

The first four sections describe the status of the traditional focus areas of Agroforestry: crop and livestock management, tree germplasm acquisition, tree fruit production, and soil and water conservation. The fifth to eighth sections explore how Agroforestry has been influenced by gender, marketing, extension and human capacity building through training. The major focus in these sections is how human livelihoods have been impacted by Agroforestry practices in Uganda.

The final three sections investigate strategies for improving the quality and impact of Agroforestry practices in Uganda through research, capacity building and scaling up through collaborative networks, documentation and awareness creation.

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CROP AND LIVESTOCK MANAGEMENT IN AGROFORESTRY

By

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INTRODUCTION

The tropical agricultural landscape has had woody (tree/shrub) components deliberately retained or planted and managed by farmers for a long time. Currently, Agroforestry is promoted for three major reasons:

- To modernize agriculture by improving and conserving soil fertility.
- To provide forest resources in order to relieve pressure from reserved forests and national parks.
- To improve the welfare of farmers through increased food security and provision of multiple products for sale.

However, these potentials are too general. The specific circumstances optimize through proper species combination and management, and must be fulfilled before such potential can be realized.

Agroforestry interventions begin with the diagnosis of land productivity, farmer's objectives (situation analysis) and evaluation of possibility for Agroforestry practices. The first stage in evaluating Agroforestry intervention is appropriate tree selection, which includes consideration of the suitability of candidate trees for integration into the prevailing farming systems. Trees that are complementary with minimum competition should be selected. Complementary trees usually have a special positive contribution to the microclimate or soil conditions, which may enhance plant growth. Alternatively, such trees may access resources that are inaccessible to crops.

Selection of Suitable Tree/Shrub Species

The first task is usually the selection of suitable tree/shrub species for the particular agro-ecological zone. The following characteristics are most desirable for such multi-purpose tree/shrubs:

i. Easily established from seeds or seedlings;
ii. Rapid growth with high forage productivity;
iii. High foliage harvest index;
iv. Good coppicing capability;
v. Excellent nitrogen fixing capability;
vi. Deep root system;
vii. Good feeding value and high palatability.

It must be emphasized here that not every trees/shrub will be endowed with these favourable characteristics but mixtures of trees/shrubs can easily produce the desirable effects and are discussed under the crop and livestock sections. In Uganda a cropland may carry either annual or perennial crops or both together. Annual crops include maize, millet, ground nuts, cotton, beans, grams and pigeon peas. Suitable Agroforestry species to intercrop with annual crops would include *Acacia abyssinica, Acacia Sieberiana and Cajanus cajan.* Perennial crops stay on the land for several years: tea, coffee, cocoa and banana and these may be intercropped with trees such as Jatropha as support for vanilla, *Ficus natelensisi, Ficus sur* and *Maesopsis eminii* to provide shade and improve soil fertility. Perennials may also be intercropped with fruit trees like pawpaws, and mangoes.

Tree/Crop/Livestock Systems

Agroforestry systems are classified according to their function or the land use type (Nair 1985). There are various classifications of Agroforestry systems. These systems are described according to the components and their arrangement in space and time.

- Trees with agricultural crops – agrisilviculture.
- Trees in pastureland with grazing livestock – silvopastoral.
- Trees with agricultural crops and livestock – agrisilvopastoral.
- Aquaforestry.
- Entomoforestry.

Agrisilviculture

Agrisilvicultural systems can be subdivided into simultaneous and sequential systems. In simultaneous agrisilviculture, trees and crops grow on a piece of land at the same time. The major concern in these systems is the ecological interaction between the components. Examples of such systems vary with geographical location. In the central region of Uganda is the banana coffee system, in eastern region there is the *Borassus aethiopum* millet system, in the northern region there is the Shea tree-millet or groundnut system.

The arrangement of components can also be used for system classification. Hedgerow intercropping is the simplest arrangement of Agroforestry components with trees and crops grown in adjacent bands. When this kind of arrangement is made along contours for soil erosion control, then it is referred to as contour hedgerows. This is a common system in Kabale where the hedgerows constitute nitrogen-fixing shrubs, which may also be good for fodder production for animals. Examples of species grown: *Calliandra calothyrsus, Cajanus Cajan, Sesbania ses*ban and some *Leucaena leucocephala*. Systems with a tree canopy which is discontinuous and above a general crop canopy, are called upperstory systems. The examples are the tobacco, tea and coffee shade systems. In multistorey systems there are more than two canopy levels constituting the crop, tree, shrub and younger tree layers at different vertical levels. The most common example of this is the home garden system, which is common in most rural farming systems in Uganda.

Sequential agrisilviculture implies that the tree and crop components occupy the same piece of land at different times. There might be some overlap between the components. For example, in the relay or taungya system, crops are grown with young trees and then as trees mature, crops are removed from the system. In fallow systems, trees are coppiced during the cropping cycle and left to grow to maturity during the tree cycle. Sometimes trees and crops can exist at the same time, but not on the same piece of land as in the cut and carry system where green manure e.g., *Tithonia diversifolia* is harvested and carried to crop fields.

Silvopastoral system

Trees are put in the grazing system as a means of supplementing animal feed by to providing high quality fodder in times of drought when grass is scarce. Silvopastoral systems can vary with components and arrangement. Some systems have paddocks where animals are moved to occupy a piece of land for a specified time and then moved to allow the land to recover. Some other systems (in Mbarara or Karamoja) are free-range systems. Cattle are moved depending on the availability of grass and water. In these systems trees are few and scattered, and they must be resistant to grazing and fires. Most common are the thorny *Acacia* species. The major animal component is cattle followed by goats. In the zero grazing system as in central Uganda and Kabale, animals are tethered and fodder is carried to them. Trees can be intensively managed in this case as fodder banks with regular harvesting of foliage from them as supplement for animal feed. In these systems the major animal component is diary cattle followed by pigs and chicken.

Home gardening is the most common **agrisilvopastoral system**. The form of components, their arrangement in space and time and the level of management, which is mostly subsistence, determine the variations in home gardening.

The rearing of aquatic animals in association with trees is **aquaculture**. In mangrove forests in Asia, fish are reared and bred. Swamps in Uganda are characterized by shrubs, trees and palms, which contribute food, shelter and cover against high temperatures and excessive surface evaporation.

The two most common forms of **entomoforesty** where insects are reared in association with trees are apiculture (bee keeping) and sericulture (silkworm rearing). When hives are set in trees and bees forage from tree flowers for nectar, then apiculture becomes Agroforestry. This is one of the Agroforestry practices requiring little initial investment, but with high potential for income generation through the sale of honey.

Woodlots planted on farm for provision of various products such as fuelwood, fodder and fruits can also be referred to as **Agroforestry**. An individual farmer or the community may manage these. This is another form of Agroforestry with a high potential to generate household income if well managed, but it can be practiced only if there is surplus land beyond just crop production.

AGROFORESTRY PRACTICES IN CROP PRODUCTION

An Agroforestry practice denotes a specific land management operation of an Agroforestry nature on a farm or other management unit, and usually consists of Agroforestry components such as trees, crops and animals.

Contour hedges

Contour hedges consist of trees/shrubs planted along contour lines, with or without grass strips. The practice is common in highland areas such as Kabale and Mbale. The trees or shrubs planted on steep slopes can significantly reduce the speed of water and soil movement. The most commonly used species are *Calliandra* and *Leuceana*. The prunings from the hedges can be used for feeding livestock if the species planted is palatable to the animals.

Establishment and management of contour hedges

Before planting the hedges, careful planning is necessary. This involves determining the slope of the land, the location of contour lines and the distance between them. There are two types of tools used for locating the contours and determining the distance between the contour hedges. They are the spirit or line level and the A-frame. Only one of them is needed and their use requires some skills. After the positions of the contours are marked, the planting of contour hedges can be done. The spacing between contour hedges can vary from 5 to 20 m depending on the slope of the land. The hedge can either have one or two lines of plants. Spacing between individual plants in the hedge varies form 20 to 40 cm. The contour hedges should be pruned at knee height regularly (at least twice in a season) to minimize competition with adjacent crops. However the frequency of cutting depends on the growth of the shrub species. The prunings can be either used as fodder or green manure.

Benefits and limitations of contour hedges

Benefits of contour hedges include: saving soils from being washed away, provision of tree products (fuelwood, fodder, mulch, stakes and bee forage), contribution to improved crop yields, and they are cost effective and ecologically sound compared to other soil conservation structures. However contour hedges have some limitations such as: hedges can harbour weeds and pests if poorly managed, the hedges can become weeds, and if left unmanaged, they can lead to below and above ground competition with agricultural crops e.g. shading and nutrients competition leading to crop losses.

Improved fallows

Improved fallows are an improvement of shifting cultivation where the fallow period is shortened, and biomass production and nutrient accumulation in the soil increased. It involves the enhancement of natural fallow by use of fast growing trees or shrubs. Fallows are used to revitalize exhausted soils. While natural fallows take long to restore soil fertility, fast growing nitrogen fixing trees or shrubs shorten the fallow period required to restore soil fertility. Leguminous species such as *Sesbania, Leuceana, Calliandra, Crotalaria* and *Tephrosia* are commonly used for this purpose. They are either grown for one season or one year before they are cut and replaced with food crops. Other useful products from improved fallows include fuelwood and stakes.

Establishment and management of improved fallows

Improved fallows are usually established through direct seeding or seedlings alongside a young crop or in newly prepared field. The spacing between individual plants depends on the crop already in the field, but is usually 25 cm, and the shrub is planted in between the crop lines. For a newly prepared piece of land, spacing between rows of plants can vary from 50 to 100 cm, while the spacing between plants can vary from 20 to 40 cm. The fallow is usually weeded as the crop is also weeded. Once the crop is harvested it is important to protect the fallow from browsing animals. Prior to the planting of a crop in the following season, the fallow is cut down after flowering but before it seeds. This is the stage at which the fallow has attained maximum biomass and nutrients concentration. The harvested material is spread out in the field and left to shed the leafy biomass. The woody parts of the trees or shrubs are removed from the field after the leafy parts have decomposed. The crop is normally planted two weeks after the harvesting of the shrub.

Benefits and limitations of improved fallows

The advantages of using improved fallows are:

- Shortening of the fallow period while increasing the yield of subsequent crops.
- The trees and shrubs restore nutrients to the soil.
- Suppression of weeds, pests and diseases.
- Provision of essential basic needs such as food, medicines and fodder.
- The closed nature of the fallow stands helps reduce erosion caused by wind or water.

Limitations of improved fallows include: high labour requirements for planting, sowing, and protection from browsing animals (some of the species are palatable to animals.

Rotational woodlots

Rotational woodlots are used to revitalize exhausted soils, while at the same time, providing large quantities of wood products such as fuelwood, stakes and poles. The trees are usually grown for 1-3 years, after which, they are cut and replaced with a food crop. The species that can be used are *Calliandra, Leuceana, Alnus* etc.

Establishment and management of rotational woodlots

In this practice the trees are established at close spacing such as 2 by 2 m spacing. This encourages quick production of large amounts of biomass and at the same time suppresses weeds. Usually the trees will establish faster if protected from animals. Initial weeding is necessary to give the trees an advantage over the weeds. The trees are clear-cut after 2-3 years after which a crop can be planted at the site.

Benefits and Limitations of Rotational Woodlots

The rotational woodlots are beneficial in that tree fallows are able to improve on soil fertility, and hence increase food production. The tree fallows also produce large amounts of fuelwood, stakes and poles, and they conserve soil and water in sloppy areas. Limitations of rotational woodlots are:

- Tree stamps are labour intensive to uproot where the fallow has been growing,
- The fallows can harbour weeds and pests,
- Fallows attract birds which can destroy crops,
- Fallows can become weeds, since most of the species seed profusely.

AGROFORESTRY PRACTICES FOR WOOD AND ENERGY PRODUCTION

Boundary planting

This is an Agroforestry practice where trees are planted along field edges to demarcate either external or internal boundaries. In some cases, trees can also be planted along roads and water canals. The tree species used in the practice are those that are compatible with adjacent crops but also provide multiple products such as building poles, timber, firewood, fruits etc. The trees can also act as windbreaks. Tree species commonly used in this practice include *Grevillea, Markhamia, Casuarina, Maesopsis, Melia, Senna* etc.

Establishment and management of boundary planting

Trees for this practice should be planted initially at 5 m spacing between individual trees along plot boundaries, contours or roadsides. The trees can be thinned to improve on stem form, and the final spacing may be 10 m between trees. The thinned trees can provide poles, but the tree branches have to be pruned regularly to avoid shading and also improve the quality of tree products. The prunings can be used for firewood or stakes

Benefits and limitation of boundary planting

The advantages of boundary planting include: increased availability of various tree products to farmers (fuelwood, fodder, mulch, stakes), trees planted along contours help control soil erosion and stabilize terrace bands, trees planted on boundaries also act as boundary markers which help reduce land related conflicts between neighbours, and these trees can also act as windbreaks.

Limitations of boundary planting are conflicts with neighbhours arising from the negative effects of trees on crop yields, competition with, and shading of, crops by trees if chosen wrongly or if not properly managed. The trees might also harbour pests and diseases.

Trees scattered in cropland

It is common practice in most parts of Uganda for farmers to deliberately plant or retain trees in cropland with little or no regard to tree spacing or planting pattern. The trees are either planted or retained from natural regeneration and left to grow. They are grown for the production of various products such as poles, firewood, fruit, timber, fodder and medicine. The tree species commonly used in this practice include *Albizia, Grevillea, Ficus, Maesopsis, Markhamia, Jackfruit, Avocado, Mangoes* etc.

Establishment and management of trees scattered in cropland

It is recommended that if trees are being introduced, they should be planted 10 m by 10 m apart. This leaves room for land clearing, planting and weeding of crops. Competition between trees and companion crops is also reduced. Naturally growing trees should be reduced to the recommended spacing. At this spacing, 100 to 200 trees can be planted in 1 ha of land. These trees are individually managed to obtain products and services desired by the farmer. They will also need to be protected from animals, and when young, the trees need to be spot weeded.

Benefits of trees scattered in cropland

Scattered trees in cropland can:

- Provide shade for crops such as coffee and bananas.
- Maintain and improve soil fertility, and farm microclimate.
- Provide tree products (fuelwood, fodder, mulch, and stakes).

Limitations of trees scattered in cropland

Trees scattered in cropland can have the following limitations:

- There can be competition and shading of associated crops if tree management is not practiced.
- The trees can harbour pests and diseases and attract birds.
- Most of the trees take long to mature and this can discourage farmers.
- When harvesting these trees, associated crops can be destroyed.

Woodlots

Woodlots are established usually for fuelwood, poles and sometimes timber, and can consist of either a single tree species or a mixture of species. They are usually established in areas that are not suitable for crop production on the farm. Because a woodlot keeps the soil surface covered, it is also a soil and water conservation measure. The common species used are *Eucalyptus, Senna, Acacia's* etc. They are common in areas where land is abundant or where crop production has failed and is not profitable.

Establishment and management of woodlots

A woodlot should be located on the less productive parts of the farm such as on steep slopes or on land with poor soils. When planted near homesteads, it is advisable to plant the trees against the direction of wind as this protects homes from destruction by wind. Establishing a wood lot requires a lot of resources, especially tree seedlings, labour for planting and weeding. The seedlings can be raised in the farm or they can be bought from another source. The trees can be established by planting seedlings on a cultivated field, and initially they should be spaced at 2 m by 2 m. Thinning of the trees over the years can increase the tree spacing. Weeding, pruning and thinning are the three most important management activities that need to be done on a woodlot. Different trees grow at different rates and therefore, the period from planting to complete harvesting (rotation cycle) of the woodlot differs for different species.

Benefits and limitations of woodlots

Benefits of woodlots include: increased availability of poles, fuelwood and timber; increased cash incomes through the sale of products from the woodlot; land that is not productive for cropping purposes is put into use; improved security of tenure for both land and trees; improved microclimate; and woodlots can serve as windbreaks and boundary markings.

However woodlots have limitations which include: requirement of fairly big piece of land of more than 1.0 hectare, they need sufficient resources to establish and maintain, no crops can be planted where they are found, it is difficult to remove tree stumps after harvesting of woodlots, marketing of products is difficult especially in remote areas, and they need protection from fires.

AGROFORESTRY PRACTICES FOR LIVESTOCK PRODUCTION

The commonly used fodder trees in Uganda are *Leucaena leucocephala* and *Gliricidia maculata.* Among browse plants the tree legume *Leucaena leucocephala* is one of the most tremendous fixers of nitrogen known, and it is used as a feed for ruminants in the tropics. It has been used as cut and carry forage to supplement pen-fed animals, and it can support high growth rates with highly digestible roughages, and lesser rates when fed with poor quality roughages. Its greatest value is as a grazing supplement for beef cattle on grass pastures in the tropics. *Leucaena leucocephala* leaf material is also an excellent source of Beta-Carotene, which could be a valuable characteristic particularly during the dry season when *Leucaena* is able to retain green leaf better than most other pasture species.

On the other hand, *Gliricidia maculata* is a medium size deep-rooted legume tree. It grows well in wet warm weather conditions and in a variety of soil types, including the less fertile acidic soils on eroded lands. It is fairly tolerant of drought conditions but does not appear to grow well in water logged soils. Extreme and prolonged dry weather conditions may result in leaf shedding from older branches.

Fodder banks

A fodder bank is an Agroforestry practice in which fodder trees/shrubs are planted in a block on their own or in a mixture with fodder grasses for cut and carry. This is a common practice in areas where grazing land is scarce due to high population density or in peri-urban areas. It can also be defined as an enclosed area of forage legumes reserved as supplementary feed during dry seasons or acute shortages of pastures.

The main objective of establishing fodder banks is to overcome the problem of protein deficiency of many grasses of low quality besides being unavailable due to limited grazing space or due to weather conditions. Legumes are usually higher in protein and minerals than many grasses, and they are more palatable and have a higher digestibility than other associated grasses. The common tree legumes used in Uganda include *Leuceana species, Sesbanaia spp, Gliricidia sepium, and Calliandra callothrysus.*

Establishment and management of fodder banks

Fodder banks should be established on well-prepared land. They can be grown in pure stands of grasses, shrubs and trees, or mixed trees and grasses. Fodder banks that are well managed can be harvested at different intervals and thus maintain a continuous supply of feed to the animals. In a fodder bank, spacing between rows of the trees or grass is normally 90 cm, while the spacing of Napier grass along the row is 60 cm and the trees is 50 cm. The size of cuttings of Napier grass is 30 cm with three nodes. During the planting process, cuttings of Napier are inserted into the ground in a slanting position. They should neither be too old or too young. In a tree/grass mixture, for every row of grass, there should be one or two rows of tree/shrubs planted in a zigzag manner especially in slopping lands.

Fodder banks should be managed properly establishment to ensure high productivity. Fodder grasses and trees or shrubs for zero grazing are usually managed in a cut-and-carry system. For good yields, weed control even if by hand picking is required. Cutting heights are specific to different types of fodder and should be followed. For example, Napier grass is cut at 1.5 cm and *Calliandra* at 15 cm during the first cutting to allow forking, and later on at 0.5 to 1m height for good re-growth and supply of fodder material. The first cutting should be done at least six months from time of the planting of grasses. Manuring of the fodder banks is important for returning nutrients to the soil.

Calliandra is first harvested 9 -12 months after planting. A well-established stand can be harvested up to 5-6 times a year, with shorter intervals during the rainy season. The cutting height should be less than 1 m above ground in order to minimize the shading effect on crops. Napier grass is harvested when it is 90-120 cm tall. Enough grass is cut to feed the animals for one day starting progressively at the end of the row.

Benefits of fodder banks

Well managed fodder banks can have the following benefits:

- Enable animals rearing in areas with high population densities.
- Increase crop yields through increased land productivity due to the use of animal manure which is easier to collect in zero grazing.
- Different types of fodder in the farm ensure adequate and balanced supply of nutrients for the animals.
- Fodder fed to the animals enhances their health and increases milk production thereby improving incomes and nutrition of families.
- The fodder legumes act as supplements for dairy meals thereby saving farmers money.
- When grown as fallows, forage legumes and shrubs improve soil structure and fertility.
- Fodder banks established from drought resistant varieties provide animal feed in times of severe dry seasons.
- Fodder banks save time and energy, as family members are not required to herd or graze animals.
- When grown along the contours, fodder hedges control soil and water erosion and later on lead to formation of natural terraces.

Limitations of fodder banks

Fodder banks can however have the following limitations:

- It is costly to establish a good stand of trees and shrubs for fodder.
- It is difficult and expensive to change a fodder bank to other crop production systems.
- Some fodder trees like *Leuceana leucocephala* are susceptible to pests (*Leuceana* psyllid) although some are resistant (*Leuceana diversifolia*).
- The trees, shrubs or grasses used for fodder banks can become weeds if not well managed.
- Fodder trees planted along the hedges requires regular pruning to eliminate competition with agricultural crops.

Trees in rangelands and pastures

In this practice, trees are either scattered randomly or arranged according to some systematic pattern on established pastures or rangelands. The trees usually provide shade and fodder for livestock. Grasses also tend to grow better under trees in pastures or rangelands. Some of the common species used are *Acacia spp, Ficus, Alnus, Albizia spp, Combretum, Prosopis, Alnus spp.* etc. The practice is common in areas of extensive grazing lands.

Establishment and management of trees in rangelands

In this practice trees can either be planted or deliberately left to grow from natural regeneration. The trees or shrubs may be used primarily to produce fodder for livestock or they may be grown for other tree products. The spacing of trees or shrubs can vary greatly. They can be planted as isolated trees, in strips, clumps or clusters depending on the farming system. The trees require protection by fencing and spot weeding when they are still young. The trees also require management in order to produce maximum products.

Benefits of trees in rangelands

The following benefits can be got from trees on rangelands:

- Trees planted maintain the stability and fertility of grazing lands.
- Trees help to maintain fodder reserves through dry seasons.
- Trees help meet wood demands.

Limitations of trees in rangelands

Trees on rangelands have the following limitations:

- If not well managed the trees can become weeds as most of them seed profusely.
- The trees can harbour pests and diseases and attract birds.

Homegardens

A home garden is an Agroforestry practice that is common throughout Uganda. Home gardens consist of a diverse mixture of vegetables, fruits and medicinal plants and also fodder grasses and shrubs in small intensively cultivated plots in and around home compounds. Different types of products and services are obtained from the various tree species and crops grown in a home garden. They have been found to be a good way of using land for a long time without using a lot of labour.

Establishment and management of homegardens

The establishment of home gardens requires a lot of time and labour. This is because trees in home gardens may be planted or may be managed after they have grown naturally. But after establishment, home gardens require less time for maintenance. There are three main methods for establishing home gardens: by adding new species to an existing garden; adding vegetables, fruits and root crops beneath open canopy of existing trees; and planting desired tree species and crop combinations on clean prepared plots.

Home gardens are a complex land use practice whose management varies from farm to farm. Although home gardens are an Agroforestry practice known to farmers, information that can provide general management guidelines is limited.

Benefits of homegardens

Homegardens have the following benefits:

- Trees planted provide a variety of tree products (fuelwood, poles, fodder etc).
- Increase incomes to the farmers through sale of tree products.
- They enhance the availability of tree products such as fuelwood and poles for household use.
- They minimize risks of total crop failure because many types of crops are grown.
- They save time and energy because the garden is near the home.
- They improved crop yields.
- They improve nutrition for the family.
- Due to closeness to the home, they are easy and convenient to manage.

Limitations of homegardens

Home gardens have the following limitations:

- Identification of the right tree/crop mixtures for the home garden is difficult
- Management is intensive and therefore it is labour demanding.
- There is no particular type of management due to the various tree/crop mixtures found in various farms.

BUFFER ZONE AGROFORESTRY

Buffer zone Agroforestry is a form of Agroforestry practiced around forested areas that are mainly for conservation purposes rather than production. In Uganda, technologies used vary depending on the agroecological zone (Table 1.1). Buffer zone Agroforestry contributes to the conservation of biodiversity by the purposeful integration of trees on farmlands so as to reduce pressure on the forest for tree products. Usually buffer zone Agroforestry enables farmers to achieve food and wood security and generate income through the integration of trees on farms in the forest buffer zones. It is a common practice in forested areas that have a lot of pressure from the surrounding population. Various Agroforestry technologies described above can be used in implementing buffer zone Agroforestry.

TABLE1.1: *Agroforestry practices in four selected agro-ecological zones in Uganda*

Agro-Ecological zone	Eastern lowlands	Northern	Southern Highlands	Lack Victoria crescent
AF Practices				
Improved fallows	*	*		*
Rotational woodlots	*	*	*	*
Boundary planting	*	*	*	*
Scattered planting	*	*	*	*
Fodder banks	*	*	*	*
Apiculture	*	*	*	
Fruit production	*	*	*	*
Woodlots	*	*	*	*
Aquaculture				*

Note * implies the AF practice exists in that agro-ecological zone

Experiences and status of Agroforestry knowledge

Agroforestry research in Uganda has concentrated on a few exotic fast growing nitrogen fixing trees, which are grown for more than one purpose. However, adoption of these has been successful mainly in Kabale; where there has been active NGOs and research institutions working together to support farmers in the use of these tree species. These trees have the potential of providing fuelwood, controlling soil erosion, replenishing soil fertility and improving soil structure. In other parts of Uganda, these species are apparently, not a priority.

Although most trees are multipurpose, many farmers normally keep trees for one major reason, and the other values are considered as secondary. The value of Agroforestry starts with listening to the needs of the investors (farmers).Therefore, giving due regard to the priorities of farmers strongly enhances the adoption and management of Agroforestry systems for farm gain. In most of central Uganda upper story trees grown in form of woodlots and managed for pole and timber production, are more attractive.

Although the largely subsistence agricultural farming system in Uganda seems to hamper wide-spread adoption of Agroforestry, current focus on agricultural modernization through the Plan for Modernization of Agriculture (PMA) which is aimed at promoting new technologies that enhance farm productivity, provide a good opportunity for enhancing the application of Agroforestry practices by many farming communities. Therefore, it is time to look at high value trees by considering their potential to financially enhance livelihoods, rather than as sources of basic products that farmers may need. Extension should therefore, concentrate on getting farmers to evaluate potential tree species and assist in the selection and management of such tree species.

Case Studies

Case study 1: The Heifer project International (HPI) - Uganda program

The main goal of the Heifer project International (HPI) was to alleviate poverty and hunger by improving food security, increasing rural household incomes using integrated, sustainable and environmentally friendly practices. This study was done in Mukono district, where a loan is given to a needy family and the family is also trained in animal care and environmental protection. Each beneficiary was required to "pass on a gift"- the first female off spring and animal care knowledge to another needy family. In this case, each beneficiary becomes a donor and the benefits of the HPI are replicated, sustained and enjoyed by all the community. This project is assisting 33 grass-root projects in 21 districts of the country. HPI uses a holistic and agro-ecological approach to issues of development whereby, the beneficiaries, the livestock, crops and environment have all been integrated. A part from the above, other benefits include:

- Introduction of fodder trees as a source of protein for animals.
- Introduction of fruits for balanced diet and income.
- Improved soil fertility and reduction of soil erosion.
- Increased supply of firewood, and use of windbreaks.

Case study 2: Agroforestry development activities in Soroti, Kumi, Katakwi, and Kaberamaido districts.

This project covered four districts in eastern Uganda, and its objective was to improve the nutritional well being and livelihood of the rural people self-sufficiency in food, income levels; and amelioration of environment degradation through tree planting. The project introduced 15 institutional nurseries in the named districts and seedlings were available to farmers at a reasonable cost. The seedlings grown included: fruit trees, medicinal trees, timber and poles tree species, hedges, fodder and ornamental species. The project also encouraged establishments of private nurseries, and by the time of writing this report, there were 50 private nurseries. The project also provided extension services in Agroforestry technologies such as crop/livestock management, tree selection, etc. The project is collaborating with NARO, SAARI, KARI, Makerere University (FFNC), Arapai and Bukalasa agricultural colleges, and Nyabyeya Forestry Colleges. Table 1.2 summarises highlights of this project.

TABLE 1.2: *Highlights of Agroforestry development activities in five districts of eastern Uganda*

Achievements	Constraints	Future strategies
• Farmers have adopted a variety of Agroforestry practices like woodlots, orchards, and live fencing. • Improved livelihoods • 50 private nurseries established as means of sustainability • Energy saving technology are in place i.e., Lorena cook stoves. • Improved knowledge and skills in AF • Multiplication and dissemination of improved sweet potato varieties	• Wild fires are a hazard in the dry season, destroying many trees. • Pests attack especially termites • Inadequate extension services • Land tenure limitations - some women are not allowed to plant trees • Insecurity especially in Katakwi.	• Lobby for the establishment of fruit processing plant. • Establish pole preservation plant • Market surveys for Agroforestry products. • Encourage institutions to use energy saving devices.

Conclusions and Way Forward

The major problems for the slow development of Agroforestry in Uganda are:

- The culture of tree planting is not very common.
- Most trees in the landscape are retained, but not deliberately planted.
- Very little is known about the propagation of high value indigenous trees species.
- Lack of tree management skills like tree establishment, pruning, weeding, and tree protection against diseases, fires and animal damage.

Trees are taken for granted and are not given as much care as agricultural crops. This stems mainly from lack of a definition of the major purpose(s) for managing the tree. Consequently, the full value of the tree component is lost yet farmers have to wait a long time before they can obtain tree benefits. In promoting Agroforestry, farmers should be assisted in stating the primary and secondary purposes of tree management. Farmers should also be aware of the cost of tree management so that they make informed decisions. The following will also be useful during the promotion of wider application of Agroforestry on farms:

- A clear understanding of the interactions between components of the potential Agroforestry practices to be promoted.
- Researched answers to the commonly asked questions like added benefits from mulching with Gliricidia or *Leucaena* foliage regarding water infiltration into soil.
- Clear strategies for scaling up of Agroforestry impact from plot to landscape level, and from short-term interactions to a longer time scale.
- Research on the domestication and propagation of the indigenous trees species.

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2

TREE GERMPLASM ACQUISITION

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INTRODUCTION

The improvement of Agroforestry trees is as much a social and political challenge as a biological one. To develop and promote a tree planting culture among a diverse client group of resource poor farmers, there is a need for better understanding of many diverse issues, ranging from germplasm demand and supply to the way that farmers manage trees and crops on their farms. According to Simons *et al.* (1994), tree domestication efforts need to focus first on priority species that have been determined following rigorous characterization methodologies, as well as those that farmers themselves see as most valuable and profitable, remembering that priorities can vary tremendously among farmers, and even over time for an individual farmer.

Tree domestication involves selection and management of trees by humans and is not only about breeding *per se*. Tree selection can be deliberate or inadvertent. Tree management is also linked to the genetics of the tree because the ability of a tree to respond in a certain way to management regimes is genetically controlled. This is a type of "genotype x environment" interaction resulting from the "management" environment. The direction and speed with which domesticated trees diverge from their wild progenitors often depends on the physical environment, size of the population, heritability of trait under selection and inherent variability of the traits.

Box 1: Trees as God-given
In many parts of Africa, trees are generally still viewed as God-given and the fruits harvested seen as nature's gifts. With increasing pressure on natural stands of trees, there is a need to engender a tree-planting culture among farmers – but first there must be good delivery of good germplasm.

Vegetative Propagation

Vegetative propagation (cloning) is the ultimate means of complete capture of useful genetic variation because it does not involve recombination or segregation of genes. But there is a need to screen large numbers of individual trees to identify clones with superior traits. Vegetative propagation, however, is not genetic improvement in itself, and regular testing and introduction of new material is strongly advocated. For Agroforestry trees that have not been conventionally propagated this way, this method should be considered initially only for those that produce high value products, for instance fruit or timber.

Despite the long-term use of clonal technologies in agriculture and horticulture and for very few forest trees, it is only recently that the concept has been widely accepted as a means of improving a broad range of trees and domesticating them for Agroforestry systems (Leakey & Jaenicke 1995; Leakey & Newton 1994; Leakey *et al.* 1994).

Regenerating plants from vegetative parts of a stock plant is possible for several reasons. First, every living cell of a plant is initially totipotent, meaning that it contains all the genetic information necessary to regenerate the entire plant. Second, cell division continues to occur during the normal growth and development of most plants. Third, cells can reform a meristem, which divides and produces the missing part. So clones of all the individuals produced by vegetative propagation from a single original stock plant, are genetically identical, unless rare somatic mutations occur and are perpetuated.

Vegetative propagation of trees can be done using a variety of techniques - rooting stem cuttings, grafting, budding, layering and in vitro tissue culture systems.

Rooting of stem cuttings is the most common vegetative propagation technique used for commercial forest trees and in the domestication of Agroforestry trees species. For this, a portion of a stem with a leaf and axillary bud is cut from the parent plant and then set in an environment where humidity is high. A simple, practical tool for this is the non-mist propagator described by Leakey *et al.* (1990). This simple and low cost technology is well adapted to rural areas of developing countries. It does not require a central water supply or electricity, and it can be constructed locally.

After several weeks in such a propagator or other humid environment, roots may form on the cutting, and a new, independent plant can then develop from the stem section. Most propagation by cuttings is done with material from seedlings or from coppice shoots, because these parts of the plant are succulent and tend to grow vigorously. In trials in Niger, more than 85% of the single-node leafy cuttings of *Bauhinia rufescens* rooted after six weeks under a non-mist propagator (Tchoundjeu 1996)

Grafting and budding are techniques that join parts of plants together in such a way that they will unite and continue their growth as a single plant. These techniques are used to perpetuate clones that cannot be conveniently reproduced by other asexual methods. Grafting is often used to multiply mature material that is difficult to root as cuttings; it is mainly used for high-value fruit and ornamental trees.

Layering, the oldest method of vegetative propagation and the form that often occurs naturally, is the development of roots on a stem while it is still attached to the parent plant. The rooted stem is then detached to become a new plant growing from its own roots.

ICRAF, working with its national partners and with farmers, has already set priorities on several species in several ecoregions. Studies are under way in Kenya *with Markhamia lutea, Melia volkensii* and *Prunus africana.* In Malawi, *Sclerocarya birrea, Uapaca kirkian, Vangueria infausta* and *Ziziphus mauritiana* are being studied. In Peru, *Bactris gasipeas*, and *Inga edulis* are being propagated. In West Africa, *Dacryodes edulis* and *Irvingia gabonensis* are being studied in the humid zones of Nigeria and Cameroon, while *Bauhinia refuscens*, *Prosopis africana* and *Pterocarpus erinaceus* are the focus of propagation work in the Sahel.

EXCITING OPPORTUNITIES

Vegetative propagation leading to the domestication of Agroforestry trees offers exciting opportunities for research and for the sustainable development that can come from it. As Leakey and Simons point out (in press), this technique allows tree improvers to multiply, test, select from and use the large genetic diversity present in most trees species. There is evidence from simple tests that majority, probably over 90% of tropical trees, are amenable to propagation by juvenile stem cuttings (Leakey *et al.* 1990). The selected, highly productive but unrelated clones can then be used commercially for reforestation and Agroforestry. In the same paper, Leakey and Simons point out that 10 well-selected and unrelated clones may contain as much genetic variation as a narrowly based, sexually reproducing population - even more!

The technique can be used to circumvent problems of poor and erratic seed supply or production. Stocks of planting material can be multiplied and then the best clones can be selected from field trails to produce genetically superior trees with increased yield and quality. Such a strategy can produce clones that will grow and do well in a particular environment. These can then be mass produced and made available to farmers in the region.

However, clonal propagation is not without its risks, especially when practiced on a large scale. Clonal populations may have little resistance to sudden environmental changes, such as insect attack or drought. Some clones deteriorate over time because of the accumulation of pathogens over a number of vegetative generations, particularly viruses (Hartman and Kester 1983).

Experience has shown that successful domestication programmes can only be carried out together with the concerned farmers. This is particularly important for the development of clonal propagation strategies. A clonal programme must not develop only new clones; it must develop several traits but different genotypes, simulating as much as possible the diversity and flexibility of a natural population. This means there is a need for repeated cycles of collection. Leakey and Simons (in press) discuss a strategy that involves the continuous release of different mixtures of superior or improved clones to help reduce the danger of a narrow genetic base.

As it is not unusual for superior clones to appear from poor provenance, it is not essential to use only selected superior provenance. By spreading the clonal selection over the full geographic range, the genetic diversity encompasses most of the adaptation to different soils, rainfall and altitude (Leakey 1991) in the same way. Leakey and Simons (in press) point out that for species without an existing trees improvement programme, clones for field testing should originate from seed collections spanning the natural range of the species, particularly including those on the edge of the range or any isolated sub population. The identity of plants within collections of this sort should be maintained and new materials should be brought into the gene bank whenever possible, to maintain and increase genetic diversity. Vegetative propagation is a unique and powerful means of capturing existing traits and fixing them so that they can be used as the basis of a genetic variety or cultivar.

The desirability of using clonal varieties or cultivars in preference to genetically diverse seedling populations varies depending on the situation and the type of trees to be propagated (Leakey and Simons, in press). The advantages of clonal propagules for both forestry and Agroforestry outweigh those of seedlings when the products are valuable, when the tree has a long generation time and when the seeds are scarce or difficult to store e.g. *Prunus africana*.

The use of vegetative propagation and clonal selection together in this strategy for domestication work, opens new and promising avenues for resource poor farmers throughout the tropics. Increasing the number of valuable trees on farms can improve nutritional security in rural households and provide the farmers with new or increased sources of income, all the while contributing to sustainable development and improving the management of natural resources - the ultimate goals of Agroforestry research and of Agroforestry itself.

Box 2: Defining the terms
Axillary bud: a performed, undeveloped shoot in the axil a leaf.
Genotype: the genetic constitution of an individual; the whole of the genes in an individual or group.
Grafting: joining pieces of stem (scion) to another plant (root-stock) to provide root systems for detached pieces from a selected tree.
Maturation: the processes of ageing in a plant including physiological ageing, chronological and antogenetic ageing.
Meristem: tissue that continues to undergo cell division and differentiation throughout the life of a plant, often found in root and shoot tips.
Phenotype: an organism distinguishable from others by observable features; the sum of the attributes of an individual that result from the interaction of the genotype with the environment.
Root cuttings: where shoots are encouraged to form on a piece of root, so that it becomes an independent plant.
Rooted cuttings: where roots are encouraged to form on a piece of stem, so that it becomes an independent plant.
Somatic mutations: genetic changes that pertain to or affect the body of a plant as opposed to changes controlled by environment.
Vegetative propagation: the production of new plants directly from vegetation parts of existing ones, not from seeds.

TREE DOMESTICATION

Once the germplasm has been collected, vegetative propagation can proceed as a part of the domestication process for Agroforestry trees. Vegetative propagation - reproducing selected plants from vegetative organs such as stems, roots leaves, buds and even single cells - offers a range of benefits for any domestication programme of tropical trees, as well as in conservation efforts. By capturing the genetic variation of trees in natural stands, researchers are able to select for desirable characteristics found in wild tree populations. Eventually, the aim is to produce large numbers of improved propagules. This ancient art has been turned into a science that can produce planting material for resource poor farmers.

Domesticating desirable plants using vegetative propagation is nothing new; in fact it goes back not just centuries but millennia. Theophrastus, writing his inquiry into plants in about 300 BC, was already talking about the propagation of trees by means of cuttings and grafts. And almost 2000 years ago, in Roman times, Pliny in his Historia naturalis talked about propagating plants from suckers and cuttings or by layering (Jaenicke 1979). It was also in this period that the wine grape cultivar Cabernet Sauvignon was first propagated vegetatively (Mullins & Srinivasan 1976) Fitness of purpose of Agroforestry trees still remains the prime objective of tree domestication (Box 3), and this is best ensured by providing a choice of priority species to farmers. From surveys of both buyers and suppliers of Agroforestry germplasm, it is clear that the market is imperfect. There is no reducing paid for quality, whether physical or genetic, and there is little appreciation of intraspecific diversity.

Germplasm, almost without exception, is marketed under the species name only. Greater awareness of differences among individual trees of the same species and attachment of names to such differences would help improve the situation. Above all, domestication of Agroforestry trees must be farmer centered. For improved Agroforestry trees for reducing deforestation and environmental degradation there must be both adequate delivery of germplasm and an engendering of a tree planting culture among farmers. An understanding of marketing by farmers is also required. A study conducted in Cameroon in 1995 found that farmers selling Agroforestry tree products were not aware of the prices that prevailed in urban markets due to lack of market information system.

Box 3: Domestication means many things to many people

- To domesticate is to settle as a member of a household; cause to feel at home; naturalize – especially a plant or an animal (Oxford English Dictionary)
- Domesticating Agroforestry trees involves accelerated and human-induced evolution to bring species into wider cultivation through a farmer-driven or market-led process. This is an iterative procedure involving the identification, production, management and adoption of desirable germplasm. Strategies for individual species vary according to their functional use, biology and target environments. Domestication can occur at any point along the continuum from the wild to the genetically transformed state.
- Domestication is a two-stage process in plants; the bringing into cultivation of wild plants and exposing them to some form of management, and subjecting these to differential selection.
- The idea of domestication is closely linked to the idea of selection, for fitness of purpose, of pushing nature into a higher gear and in a particular direction.
- Domestication is human-induced change in the genetics of a plant to conform to human desires and agroecosystems, culminating in the plant's loss of its ability to survive in natural ecosystems.

AGROFORESTRY TREE PROPAGATION OPPORTUNITIES AND CONSTRAINTS IN UGANDA

In the current Government Plan for Modernization of Agriculture (PMA) and Poverty Eradication Action Plan (PEAP), Agroforestry has been identified as an important means of improving the livelihood of farming communities in Uganda. Multipurpose trees have the potential to improve soil fertility, increase agricultural productivity and contribute to food security. Multipurpose trees can be used to rehabilitate degraded areas, control soil erosion, provide food, fodder, medicine, dyes and protect the environment. Trees on farms can meet people's needs for wood and wood products, poles, fuelwood and hence contribute to conservation of ecosystems and biodiversity. Trees on farms can play an important function of absorbing atmospheric carbon (carbon sequestration) and enhancing environmental stability.

On farm tree planting is expected to increase, as more farmers become aware of the benefits of Agroforestry. The success of any future Agroforestry activities will depend on sustained provision of adequate quantities of good quality seed. During recent years there has been a shift in the demand for seed from traditional industrial species to multipurpose/Agroforestry tree species. Demand for Agroforestry seed exceeds supply, a situation that has encouraged trade in Agroforestry seed. Sale of Agroforestry seed has therefore become an important rural enterprise and a livelihood opportunity for rural communities. Supply of Agroforestry seed in Uganda has encountered a number of problems:

- The national tree seed center has not been able to supply adequate quantities of seed for many multipurpose tree species.
- Inadequate physical infrastructure has hindered efforts to produce and distribute good quality Agroforestry seed.

- Degradation of many seed sources has hampered efforts to produce and distribute adequate quantities of Agroforestry seed.
- Many farmers cannot afford to buy good quality seed for multipurpose tree species.
- The origin and quality of seed, which has been supplied by the private sector, is not known.
- Lack of regulations on production and distribution of Agroforestry seed and germplasm has resulted in indiscriminate use of seed. Hence the full potential of Agroforestry has not been realized.
- Marketing and distribution channels for Agroforestry seed are not well developed.
- Private seed collectors lack knowledge on seed procurement and handling methods that can improve the quality of Agroforestry seed.

Many tree seed users have imported seed to supplement local seed supply. It is possible that considerable quantities of bad quality seed have also been imported.

Large areas are needed to multiply germplasm for Agroforestry species to meet demand. There is a need for farmers to have access to good quality Agroforestry seed and they should be encouraged to multiply and sell Agroforestry seed and germplasm. Marketing and distribution channels should be developed to enable farmers to market and sell Agroforestry seed. Moreover, it is important to carry out research to identify appropriate species and provenances that are most adapted to different agro-ecological conditions in the country.

Importance of Agroforestry

Uganda has very good conditions for plant growth. For a long time, the country has had abundant natural resources including tropical forests that covered nearly 40% of the total land area before independence. However, these have been reduced and degraded because of increased human population, overgrazing, increased demand for wood and wood products and urbanization. FAO and the National Environment Action Plan (1995) estimates indicated that forest cover had been disappearing at the rate of 50,000 – 200,000 hectares annually. Figure 1 presents a summary of decline in forest cover from 1890 to 2000 (Kaumi & Esegu 2000).

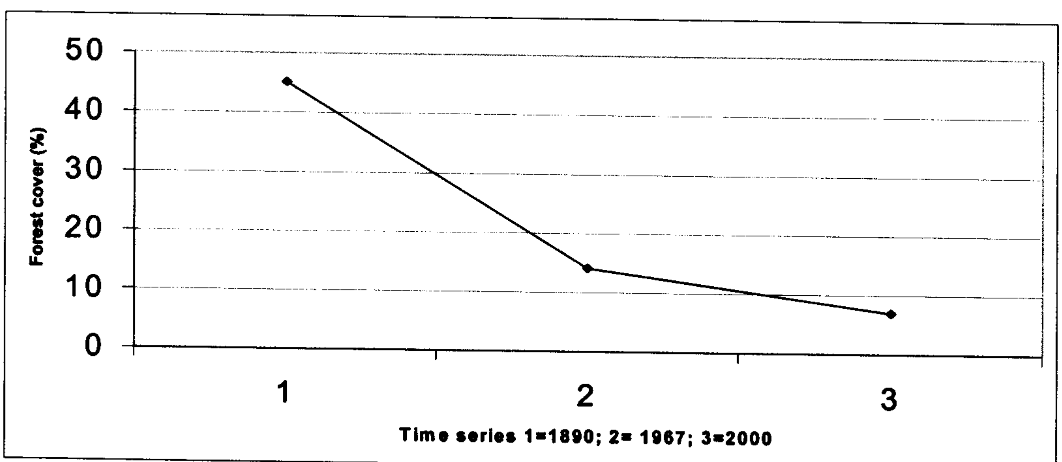

FIGURE 2.1: *Deforestation trends in Uganda 1890 – 2000*

Loss of forest cover has had many adverse effects. For example, it has resulted in loss of biodiversity, agricultural productivity and food security. Forests are known to influence environmental factors such as climate which are tied to agricultural production. Forests and trees protect water catchment areas, reduce soil erosion and maintain fertility all of which contribute to sustainable agriculture. Planting of multipurpose trees on farmland would restore soil fertility, rehabilitate degraded areas, and provide fodder and shelter for animals, food, fruits, dyes and medicine for rural communities.

Uganda is an agricultural country, with more than 75% of the total land area (19 million hectares) available for farming and pastoral activities. Agriculture is basically subsistence with households producing crops and raising livestock on small land holdings of about 2 ha each. The farms are characterized by having numerous individual trees and small woodlots interspersed with food and cash crops. Traditionally farmers practice Agroforestry on small land holdings. In order to improve Agroforestry practices, research has been undertaken to identify suitable tree species and their management in various farming systems in the country.

The Government of Uganda has recently approved a Plan for Modernisation of Agriculture (PMA). The plan 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. Planting of multipurpose trees on farms will play an important role in the realisation of the objectives of PMA (Forest Sector Co-ordination Secretariat 2001).

Multipurpose trees can play a significant role in nutrient cycling and organic farming. Trees can provide nitrogen inputs in Agroforestry systems by biological nitrogen fixation and deep nutrient capture. Giller and Wilson (1991) noted that trees could fix 150 kg of nitrogen/hectare. Species such as *Senna siamea* are known to be highly efficient in accumulating nitrogen in their leaves (Garrity and Mercado, 1994). In Zambia for instance, nitrogen content of 4 tones of leguminous leaf mulch produced in alley cropping produced 60-150 kg of nitrogen/ha while *Sesbania sesban* can replace nitrogen fertilizer applications (Sanchez and Palm 1996). On farm tree planting has increased considerably during recent years because more farmers have become aware of the benefits of practicing Agroforestry. This has resulted in a shift in demand for tree seed from industrial species to multipurpose Agroforestry tree species (Figure 2). Forecasts indicate that there will be a shortage of timber and other wood products in Uganda in the coming 10-15 years (Forest Sector Co-ordination Secretariat 2001). There will also be an increase in demand for wood biomass energy with increased population growth, economic development and urbanisation. Planting trees on farmland will provide income to farming communities and will help avert shortage of wood and wood products.

Tree planting of the envisaged magnitude will require a reliable supply of adequate quantities of good quality seed and plant material. During recent years, demand for Agroforestry seed and planting materials in Uganda has increased many fold. A recent review of forestry initiatives in Uganda has identified "insufficient high quality tree seeds of appropriate species" as one among the constraints, which will affect implementation of the Plan for Modernization of Agriculture (Forest Sector Co-ordination Secretariat 2001).

Tree Seed Demand for Agroforestry Species in Uganda

Knowledge of tree seed demand for Agroforestry in Uganda is important because it is the basis for developing strategies for provision of good quality seed for tree planting activities. It is important to have knowledge of the most important tree species used for Agroforestry, the main users for Agroforestry tree seed, specific location in Uganda where Agroforestry is practiced, the purpose for planting and the quantity and quality of seed used for tree planting activities. It is also important to understand the current and future demand for Agroforestry tree seed in order to prepare strategies to produce adequate quantities of seeds to meet demand. Recent studies have revealed that Uganda has a potential tree seed demand of more than 20 tons of seed annually (Kaumi and Esegu 2000). A summary of different tree planting activities and their seed requirements are presented in Figure 2 and Table 2.1. The study on seed demand and supply situation by Kaumi and Esegu (2000) covered 24 districts in Uganda. This implies that demand for Agroforestry tree seed could be higher

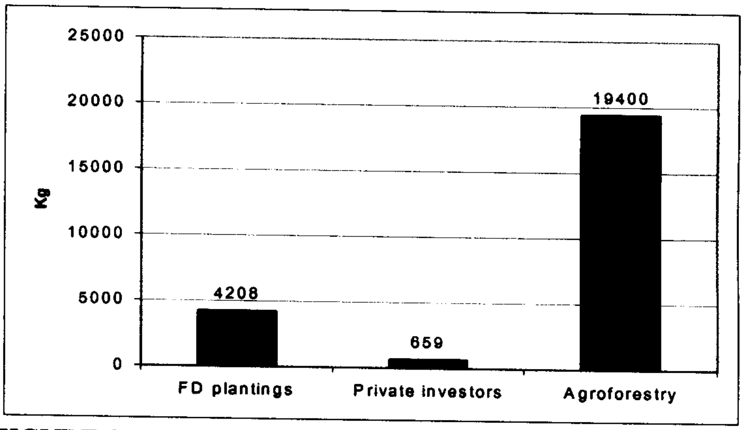

FIGURE 2.2: *Seed demand for different categories of tree planting*

TABLE 2.1: *Tree planting initiatives and estimated seed demand in Uganda*

Name	Category	Available land for planting	Species and quantity of seed (kg/annum)
Planting activities in the Forest Department: Industrial plantations Rehabilitation Peri-urban plantations National Tree Planting Agenda	Government	Unspecified	*Pinus caribaea* (118 kg), *Pinus oocarpa* (68kg), *Pinus patula* 19 kg, *Cupressus lusitanica* 11 kg, *Eucalyptus* species 52 kg, Mixed species (3,880kg);
Bukaleba Peninsula Development project Busoga Forestry Company	Private commercial Industrial plantings	500 ha/ year	*P.caribaea* 20kg, *P.oocarpa* 10kg, *Eucalyptus grandis* 6kg, *Maesopsis eminii* 125kg
Private investors Compensatory timber plantations	Private sector	49,182 ha	*E.grandis* 20 kg, *P.oocarpa* 50kg, *P.caribaea* 80kg, *P.tecunumanii* 40 kg, *C.lusitanica* 8 kg , *M.eminii* 300kg
Lake Victoria Environment Management Project	Government	100 ha/year	*P.caribaea* 3 kg, *P.oocarpa* 3 kg, *M.eminii* 50 kg, *E.grandis* 1kg,*Grevillea robusta* 1 kg, *Markhamia lutea* 1kg, *Milicia excelsa* 1 kg.
Agroforestry	Private farmers	Unspecified	14.4 tons of seed of various MPTs
Social forestry, NGOs, Community based projects	Private	Unspecified	Vi Masaka alone has a demand of 5 tons of seed.

Private small scale tree planting on homesteads	Private	Unspecified	Various

Source: Kaumi and Esegu (2000)

than what is shown above. There is a need to carry out further studies to clearly understand the extent of seed demand for Agroforestry tree species in the country. Figure 2.2 demonstrates a shift in demand for tree seed from industrial species (mainly planted by the Forest Department and private investors) to multipurpose Agroforestry tree species planted on farm. This trend has been observed in other countries in the region. A summary of Agroforestry tree seed demand for the most important multipurpose tree species is presented in Figure 3. The data do not include MPTs produced and distributed by Vi Masaka and other NGOs, Community Based Organisations and the private sector.

Seed supply

It is important to understand how the tree seed market operates in Uganda and key players on the tree seed market in order to design strategies which will ensure sustained provision of good quality seed for Agroforestry in the country.

Seed supply by the National Tree Seed Project

The National Tree Seed Project was initiated in 1992 to provide good quality seed from selected seed sources of indigenous and exotic woody species, to meet the growing demand (Figure 2.3) for tree planting programs in the country. Good quality seed refers to seed of known origin with desired physiological and genetic quality. Physiological quality of seed has to do with viability, vigor, health, condition of morphological structures as well as specific gravity of the seed. Genetic quality of a viable seed population is closely related to genetic superiority of mother tree population, which is potentially inherited in the seed population and the degree to which the genetic composition of the mother population is represented in the seed population (Lauridsen 1995).

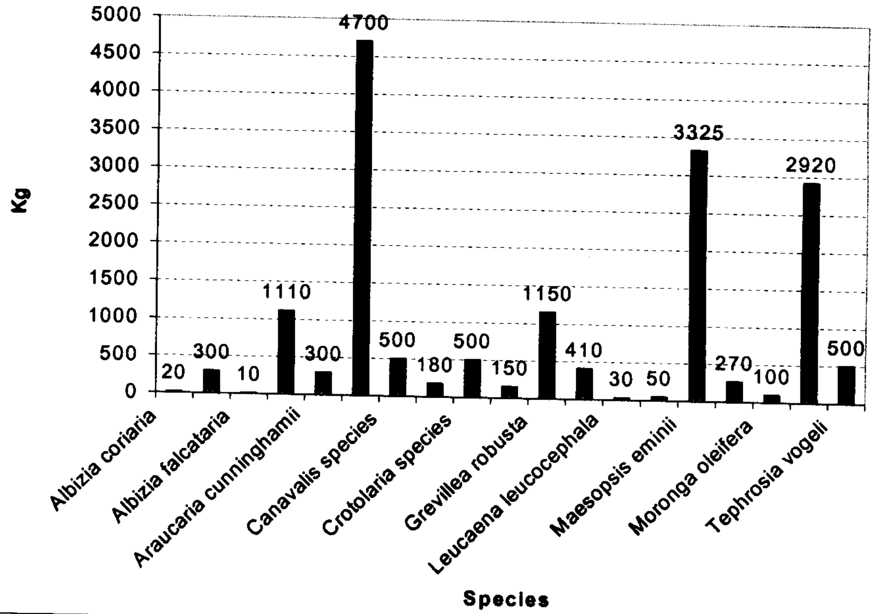

FIGURE 2.3: *Summary of annual agroforestry seed demand*

Figure 2.4 presents a summary of seed produced by the Tree Seed Project from 1992. Between 1992-2000, the Tree Seed Project produced and distributed 4.2 tons of seed mainly for industrial tree species. Figure 4 indicates a significant decline in seed production between 1995-1998. The decline created a shortfall in seed supply not only for industrial species but also for Agroforestry tree species. A recent survey has revealed that during the last 9 years, the seed center supplied less than10% of seed needed for planting in the country (Kaumi & Esegu 2000). Experience elsewhere has revealed that whenever there is a short fall in seed supply, tree seed users resort to producing their own seed or buy it from anywhere they can get from. This seems to have been the case in Uganda.

Following a review in year 2000, the Tree Seed Project will receive support from the Government of Uganda and NORAD during the coming 3-5 years to improve production and distribution of good quality seed mainly for multipurpose tree species to meet a significant proportion of seed demand.

The seed center will employ both central and de-centralized strategies to produce seed. In the central strategy the seed center will identify adequate seed sources and produce seed (collect, process, test, store and distribute seed) to meet a significant proportion of seed demand for priority Agroforestry species in the country.

In the de-centralized strategy, the seed center will recruit and contract motivated individuals who are willing to produce and sell seed to the tree seed project. The contractors will be trained to enable them to produce good quality seed. The tree seed project will do joint seed source identification and description with the contractors for the species they will be contracted to produce. The seed center will supervise collections especially for long rotations species. This strategy is expected to increase seed production, reduce costs of seed production and prices of seed to levels that are affordable. The strategy will promote participation of the private sector in the production and distribution of seed for Agroforestry species. It will also promote conservation of seed sources. Seed distributed by the seed center will bear a certificate showing the quality of seed.

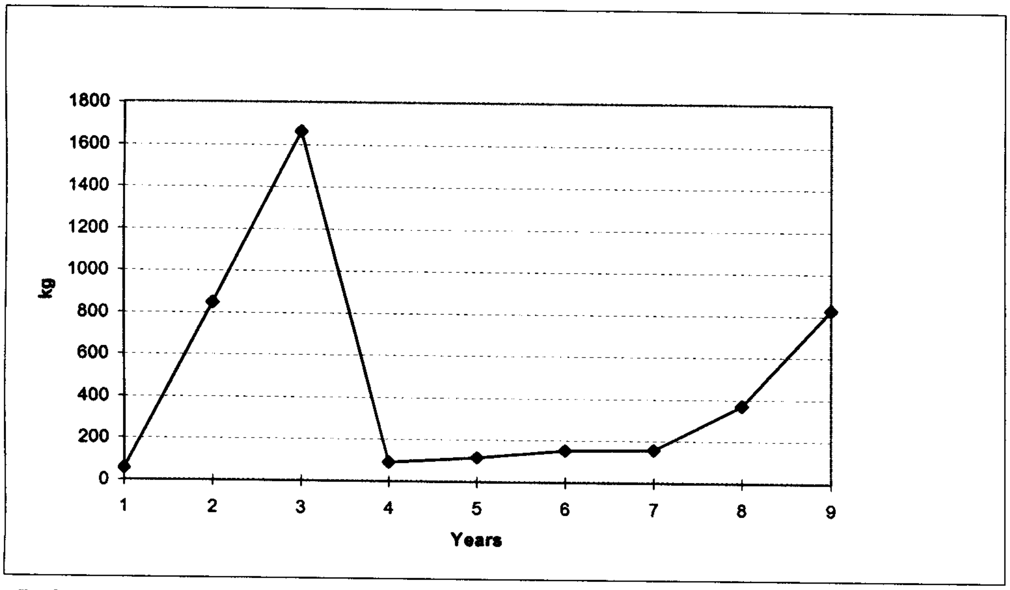

FIGURE 2.4: *Seed supply from Tree Seed Project 1992 - 2000*

It is envisioned that even after all these interventions, the tree seed project will not be able to produce enough seed to meet the demand for Agroforestry species in the country. Private initiatives are therefore needed to complement efforts by the National Tree Seed Institution.

Agroforestry Seed Supply by the Private Sector

The private sector (NGO's, CBOs, and private individuals) have collected and distributed most tree seed for Agroforestry in the country (Omondi 1997; Kaumi and Esegu 2000). ICRAF has supplied most Agroforestry seed in the areas they have been operating. Amongst the NGO's, Vi- Masaka has supplied significant amounts of seed needed by farmers not only in Masaka and Rakai districts but also in other parts of the country. However, there is lack of data on actual quantities of Agroforestry seed distributed by individuals and the private sector because there has not been a well-coordinated effort in this field. However, Vi- Masaka alone has been distributing on average of 5 tons of seed annually.

The private sector lacks facilities to conduct routine quality tests for seed. As such, there is limited knowledge on the quality of seed used for Agroforestry in the country. Most often, large quantities of seed have been distributed to make up for low germination encountered in the field. It is therefore possible that the high seed demand scenario depicted in Figure 2 may not represent the actual seed demand. Regional Land Management Unit/SIDA (1998) has documented the short falls for seed supplied by the private sector including:

- Lack of seed origin data and hence difficulties in matching seed sources and planting sites.
- Poor quality seed resulting from harvesting premature seed and poor handling methods.
- Lack of knowledge on seed production methods that can improve quality of seed.
- Wrong labels on species due to failure to have verified true identity of species collected.

In conclusion, it can be said that there has been indiscriminate use of Agroforestry seed in Uganda. Most Agroforestry seed distributed is not documented. There is lack of information on the origin of seed, genetic quality of seed and the number of trees contributing to seed lots. Lack of knowledge that would lead to matching seed sources to planting sites could result in sub-optimal growth. There is a need to monitor the performance of Agroforestry trees planted with seed from different sources in order to avoid use of poor seed sources. Use of poor quality seed can lead to low productivity, prolonged rotations and economic losses.

Experience elsewhere has revealed that most subsistence farmers may not afford to buy good quality seed from tree seed centers. Yet subsistence farmers should be beneficiaries of good quality seed if they are to realize the potential of Agroforestry as a means of enhancing their livelihood. As an alternative, small-scale farmers have to own seed collections or trade amongst themselves. In addition, there is a need to provide good quality seed to farmers at affordable prices and encourage them to use their resources (land and labor) to multiply Agroforestry germplasm. This will guarantee that farmers have access to good quality seed and will ensure sustained provision of good quality Agroforestry seed and planting material in the country.

Recent surveys on seed demand/supply in Uganda have confirmed that insufficient supplies of tree seed have hampered Agroforestry activities in the country and the following constraints have featured prominently in hampering provision of enough and good quality Agroforestry seed in Uganda:

- Limited seed sources.
- Poor marketing and distribution channels.
- Inadequate seed production facilities.
- Limited research and dissemination.
- Lack of legislation.

Therefore there is a need to develop strategies to improve both the quality and quantity of Agroforestry seed to meet the demand. Given these constraints, the next section makes several recommendations for the way forward, especially in terms of interventions that will improve provision of good quality Agroforestry seed in the country.

RECOMMENDATIONS

Strategies to improve provision of good quality Agroforestry Seed

The following measures are expected to improve provision of quality seed.

Baseline studies on seed demand and supply situation

There is a need to:

- Carry out detailed studies on demand and supply of seed used for Agroforestry activities in the country. This will provide data for planning strategies for production and distribution of Agroforestry germplasm.
- Monitor demand and supply of Agroforestry seed in the country because this keeps on changing over time.

Seed sources

Available data on demand and supply of Agroforestry seed in Uganda suggests that it is no longer possible to meet Agroforestry seed demand from traditional conventional seed sources. Large areas are required to produce adequate quantities of Agroforestry seed in the country. As such, it is important to procure and distribute good quality Agroforestry seed to selected farmers who are willing to participate in a country-wide seed source establishment program for Agroforestry species.

Develop marketing and distribution channels for Agroforestry seed

There is a need to:

- Develop marketing and distribution channels for Agroforestry seed to encourage farmers to participate in the mass production of Agroforestry germplasm. Farmers involved in the production and distribution of Agroforestry germplasm will need guarantees on marketing opportunities of their seed as an incentive to encourage them to mass produce Agroforestry germplasm. One could link up with agricultural seed distribution channels.
- Promote use of good quality Agroforestry seed. During good seed years efforts should be made to produce adequate quantities of Agroforestry seed and ensure that there is a good buffer stock of seed to meet demand.
- Promote trade on Agroforestry seed as a means of enhancing livelihood for the rural communities.

Improve facilities for handling Agroforestry seed

There is a need to:

- Review seed handling facilities available in the country and improve them to ensure that there is adequate capacity to produce, store and distribute adequate quantities of good quality seed needed for Agroforestry activities in the country.
- Utilize fully seed handling facilities at Namanve to monitor the quality of Agroforestry seed used for tree planting in the country.

Training of suppliers of Agroforestry seed

There is a need to:

- Undertake an inventory of all individuals involved in the production and distribution of Agroforestry seed in the country. These groups should be trained to enable them to produce good quality seed. A mobile training unit could be established to carry out this training in all sub-counties. The training could cover seed source identification, planning seed collection, crop assessment, seed collection, processing, testing, storage, distribution and seed documentation.
- Hold regular workshops with users of Agroforestry seed to exchange views on seed demand and supply and ways on how to improve provision of good quality Agroforestry seed in the country.

Applied species and provenance research

There is a need to carry out applied research to screen out Agroforestry species and provenances most adapted to different agro-ecological conditions in the country and promote use of the best provenances on planting sites.

Legislation to regulate movement of tree seed and plant material

At the moment there are no regulations which guarantee production and distribution of good quality tree seed and plant material in Uganda. This has resulted in unplanned collection and movement of tree seed and plant material in the country. This practice could result in low productivity and one may fail to realize the potential of forestry and specifically Agroforestry.

- It is important to have a National Tree Seed Committee that will address matters related to production, distribution and use of Agroforestry germplasm in Uganda. All those engaged in trade of Agroforestry seed and germplasm should be registered and trained so that they can produce good quality seed.
- The committee should advise the Government of Uganda (GOU) on measures to be taken to regulate production and marketing of tree seed and planting materials in the country.
- It is necessary to introduce standards to be followed by all involved in the production and distribution of Agroforestry germplasm in the country. The standards should be complemented by regulations that will protect both producers and users of Agroforestry seed. Only those who comply with regulations should be given a trading license for Agroforestry seed.
- It is important to ensure that seed suppliers of Agroforestry seed provide adequate information on both genetic and physiological quality of seed they distribute.

Collecting Germplasm from Trees – Some Guidelines

The process of domestication began with the farmers. The farmers are the ultimate users and beneficiaries of improved Agroforestry trees and are therefore the only ones who can tell researchers which trees they value most, why these are their 'priority species, what tree products benefit them most and how they would like to see the trees 'improved. It is only after these priority species have been identified that germplasm collections can have the impact they should.

There are many reasons for collecting tree germplasm. Immediate distribution of planting material to users – farmers or horticulturists or extension workers, is one of them. With the rapid rate of deforestation throughout the tropics, many species of trees – and their genetic wealth – are endangered. Therefore, the collection may conserve their germplasm for posterity. In addition, germplasm may be collected because it is needed for tree improvement programmes.

Germplasm collection is a key step in any process to domesticate trees; the genetic variation of a species should be present in the collected germplasm, and this is needed for the selection and improvement that are part of domestication. Many tropical trees have undergone little or no domestication at all and therefore the best source of germplasm for improvement of these species is wild populations. Collection is often done in exotic stands, since they are relatively easy to get at, and they provide a good comparative base in trials to assess the performance of different sources of germplasm.

There are as many strategies for collecting germplasm as there are reasons for doing it. Finding the right strategy will depend on the purpose of collection, the biology of the species and the ability to select for desirable characteristics during sampling. Normally, the aim of collection is to sample germplasm that is as genetically representative as possible of a population (or provenance). This is called systematic sampling, and it means collecting seed from many trees in an individual population. This is the strategy that national partners and ICRAF used to collect germplasm of *Calycophyllum spruceanum* and *Guazum crinita* in Peru and *Prunus africana* in Cameroon (see Ian Dawson's article p 15-17). In addition to systematic sampling within populations, the researchers also collected from several populations for each species, the idea being to get germplasm that represented the geographical ranges of the three tree species.

Sometimes in the course of collection, if researchers decide that important characteristics have high heritability and can therefore be selected for at the time of sampling, they can do phenotypic selection of trees within populations. This increases the chances of capturing superior material for improvement programmes; a method referred to as 'targeted collection.' This is the approach researchers used for their collections of germplasm of *Sclerocarya birrea* and *Uapaca kirkiana* in Southern Africa (see news item p.28) for both species, researchers collected seed from trees that villagers identified as producing fruit with superior characteristics. In addition, the collection team systematically sampled seed from a number of populations so that they could assess, in subsequent field trials, whether this kind of phenotypic selection during collection was efficient.

Occasionally, collectors may also do vegetative sampling to collect superior phenotypes, because trees do not bear seed at the time of sampling. This approach may be useful for the targeted collection of fruit trees such as *Sclerocarya birrea* or *Uapaca kirkiana*, or for endangered species such as *Prunus africana*, for which mature, seed-bearing trees can be difficult to find in some locations.

Although germplasm is sometimes collected in these targeted or vegetative ways, we recommend these in only very specific cases. This is because these approaches have potential disadvantages – they can lead to a narrowing of the genetic base of collected populations.

Generally, therefore, the best approach will be systematic sampling of seed. Below are a few standard guidelines for the systematic sampling of seed from an individual population. These guidelines are summarised into appropriate steps before, during and after collection. Although certain steps alter for targeted seed sampling or vegetative collection, many considerations remain the same. For more details on collecting germplasm from trees, see FAO, Forestry Resources Division Guidelines (1995).

Before collection

- Decide on the purpose for which germplasm is required.
- Find out if suitable and well-documented germplasm is already available from other sources.
- Inform others of your plans, to avoid duplication of effects in collecting from the same area.
- Develop a collection strategy – determine the where, when and how of collection.
    - Where? Find out the geographical and ecological areas where a species grows and from what areas it can be collected (literature, herbaria, field exploration).
    - When? Decide on the best time for collection. This may require a prior visit to a site to identify the period when seed is mature. Herbarium specimens often give dates of fruiting or collection. Trees may seed only in certain years and the timing of seed production may also vary between years and regions. For species with a prolonged fruiting season, more than 1 sampling time might be needed to avoid collecting only the early fruiting trees.
    - How? Estimate the quantity of seed required from the collection, to help determine the appropriate sampling strategy. In addition, decide if seed from individual trees should be kept separate during collection or bulked to form a single population sample. For research trials, individual tree collections are sometimes needed, while in other cases a bulk collection from a population suffices. If material is being collected for immediate distribution to farmers or other users, a bulked collection strategy may make handling easier.
- Find out the requirements for handling seed of a species being collected, including necessary seed treatments to ensure maximum seed viability. If seed is orthodox and kept under the appropriate storage conditions after collection, it may remain viable for many years before being planted. If seed is recalcitrant, however, it is necessary to prepare for immediate planting after collection.
- Ensure that all necessary equipments for collection are available. Collection from trees may require specialist tools, such as pruning saws and tree-climbing equipment. Use open-weave collection bags other than plastic ones, to allow aeration.
- Ensure that the necessary permission for collection is obtained. If collections are to be from communal or private land, it is necessary to obtain the permission of the land-owner. For large-scale collections, permission must also be sought from the relevant government bodies. If collections cross national boundaries, permission for the export of germplasm between countries may be required.

During collection

- Develop a sampling strategy-to ensure representative sampling of a population, the following guidelines should be adopted:
  - Number of trees sampled and their selection - collect seed from at least 30 trees. If possible, collect from more individuals. No selection criteria should be used, although normally only those trees producing reasonable quantities of seed are chosen.
  - Collection from crown - for each tree, sample different points in the crown, especially if the species is insect pollinated. This is because individual pollinators carrying pollen from different potential fathers may visit only part of a tree crown. So seed from different points in the crown may be different genetically. If it is not possible to sample directly from the tree canopy, seed or fruit that has fallen naturally and is lying underneath trees may be collected.
  - Spacing - ensure a reasonable spacing between sampled trees to reduce the likelihood of collecting closely related individuals. Ideally, individual trees should be spaced by a distance greater than that associated with normal seed dispersal - usually at least 50 m apart.
  - Bulking of seeds - if seed from individual trees is bulked during collection, each tree should contribute roughly the same amount of seed. Bulking can always be done later so it may be worth keeping seed from individual trees separate.
  - A pragmatic approach - although the above represent ideal sampling criteria for a population, be pragmatic and realistic when in the field.
- Ensure that, wherever possible, physiologically mature seed is collected. Otherwise, the viability of seed may be very low.
- Do not collect so excessively from a population that its survival through natural regeneration is threatened.
- For tree species with associated microsymbionts, e.g. mycorhiza or rhizobium, take soil or root samples - or both - during seed collection. This is particularly important for nitrogen-fixing legumes or pines.
- Document the work - ensure that accurate and adequate records are kept during collection. A collection form designed prior to collection is useful. Documentation is essential, for example, in relocation of populations that trials show to have useful characteristics, and for identifying gaps in conservation collections. As a minimum, the following should be recorded for a population:
  - Species name.
  - Collection date.
  - Individuals carrying out the collection.
  - Population location, including name of location and directions to reach the site (where possible, accurate latitude and longitude measurements should be recorded from maps or by using a Global Positioning System receiver).
  - Number of trees collected from at each site.
  - The approximate average distance between site.
  - The approximate average distance between trees.

- A unique identifier for each collected sample (normally a number, which should be used to label seed during and after collection) Other data that should be recorded for research and conservation collections include:
  - Altitude, soil type and depth of water table for dry areas (the latter can be determined from a well near the collection site),
  - Morphological characteristics of trees in the population,
  - Density of trees in the collected stand,
  - Status of the population (natural, naturalized or planted),
  - Abundance of the species in the area,
  - Type of vegetation (primary or secondary),
  - Associated species,
  - Human disturbance (if any),
  - Local guides,
  - Local name of the species,
  - Local uses,
  - Maturity of collected seed,
  - Presence of any pests or diseases.

After collection

- Back at base, ensure seed is correctly processed and placed under storage conditions that maintain optimum viability, until required for planting. Normally, the viability of seed is tested before it is placed in storage.
- Keep a record of the collection exercise. Distribute this report to individuals involved in collection and others who may require a record of, or be interested in, the collection exercise. The collection records should include:
  - Objectives of the collection.
  - The approach used
  - All documentation taken
  - Recommendations for follow-up work.
- For large-scale collections, duplicate germplasm at additional storage sites for safety purposes.

The above strategy will provide collections of germplasm that should be representative of population and have the widest possible genetic base. The former is important because it means that future collections of the same population, using a similar collection strategy, should result in seed that is similar genetically in its characteristics. A wide genetic base is particularly important for trees because the majority of species are preferentially outcrossing. A wide base can therefore prevent in-breeding depression in future generations, as germplasm is distributed to users. In addition, a wide genetic base for Agroforestry trees provide an adaptive capacity to changing user requirements and varying environmental conditions (Simons *et al.* 1994).

Box 4: A glossary for germplasm collection

Exotic: a tree growing outside its native range, normally as a result of planting by people. Such populations often have a narrow genetic base.

Germplasm: genetic material, which can be seed, pollen, vegetative propagules or other material, though normally seed.

Genetic base: the amount of genetic variation in a species or population. During collection, maximizing the genetic base sampled can prevent in breeding depression in future generations.

Heritability: the proportion of the total variance of a characteristic that may be accounted for by genetic factors. If a character is not highly heritable, most variation can be accorded to environmental factors. Phenotypic selection cannot be usefully practiced on such characters during collection.

Inbreeding depression: a decline in the vigour of a species as a result of decreased levels of heterozygosity at individual loci. This may occur in species that are preferentially outcrossing when their genetic base is reduced. This negative effect may be prevented by maintaining the widest possible genetic base during the collection of populations.

Microsymbiont: bacteria or fungi associated with a tree, existing in a relationship that brings benefits to both. For many trees, such organisms are essential for good growth.

Orthodox seed: seed that can remain viable for long periods if processed and stored in the appropriate manner (normally seed should have a low moisture content and be kept at low temperatures.

Outcrossing: the production of off spring by the transfer of pollen between individuals rather than by self-pollination. Outcrossing often results in high levels of heterozygosity in populations. Many trees are preferentially out crossing.

Phenotypic selection: the choice of individuals based on their physical appearance, which may or may not reflect their genetic make up, depending upon the heritability of characters; sometimes referred to as targeted collections.

Population: normally a group of individuals growing in the same general location, which are potentially interbreeding.

Provenance: a term generally used interchangeably with the term population, although it relates to geographic rather than genetic confines.

Recalcitrant seed: seed that loses its viability if stored for any length of time, even under conditions that are normally conducive to seed longevity.

Seed viability: the proportion of seed that can produce viable plants. Often this is estimated by testing levels of seed germination.

Systematic sampling: collecting seed from many randomly selected but well-spaced trees in an individual population. Such collection provides representative sampling of a population and the widest possible genetic base.

Vegetative sampling: the collection of vegetative material, such as stems or root cuttings, from a species.

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Susan Tumwebaze, lecturer Faculty of Forestry and Nature Conservation made some editorial contribution.

Articles by several authors have been used to compile the above information especially a paper presented by Kalaghe, A.G., Esegu, F.O. & Kaumi, S.Y.S. at the 2nd National Agroforestry Workshop in Mukono, Uganda, in 2001, and articles by Ian Dawson & James Were, and Zachary Tchoundjeu, Joris de Wolf & Hannah Jaenicke published in Agroforestry Today. A.G. Kalaghe is a Technical Advisor with the Uganda Tree Seed Project, F.O. Esegu is the Director of Forestry Resources Research Institute, Uganda, and S.Y.S. Kaumi is Forestry Consultant. Ian Dawson is a germplam specialist with ICRAF. Were is a seed physiologist at ICRAF. Zachary Tchoundjeu is a forester doing tree improvement work with ICRAF's Agroforestry network in the semi-arid lowlands of West Africa. Joris de Wolf is a Belgian associate scientist with ICRAF in Kenya. Hannah Jaenicke is a propagation physiology specialist at ICRAF and lead scientist of its propagation systems project.

3

FRUIT TREE PRODUCTION

INTRODUCTION

Fruits are undoubtedly mankind's oldest food and apart from their high nutritional value, they also a source of pleasure because of their flavour and taste. The history of fruits is perhaps as old as that of Adam, Eve and the forbidden apple. In pre-agricultural days, our early ancestors lived on wild game, fruits and succulent herbage. Most of our common fruits have their origin in the parts of the world that were inhabited by early man. When man took to modern agriculture there was a shift to cultivation of mainly grain crops and also some fruit trees in his back yard. It is possible that some fruit plants might have been cultivated even before the cereals, and that grapevines, dates and figs were among them (Kochhar 1981).

Archaeological findings give definite clues about the primitive diet and gradual change that occurred with the domestication of plants. The backbone of Mesopotamian agriculture consisted of crops that are still important to the world's food supply. Cultivation of fruits is now a highly profitable enterprise. There is a growing realization among people that fruits should no longer be considered a luxury, but a necessity for sustaining human nutritional needs.

THE ROLE OF FRUIT TREES IN AGROFORESTRY

The role of fruit trees in Agroforestry has gained worldwide recognition. In Kenya the efficacy and potential adoption of fruit crop based Agroforestry was studied and found to be satisfactory either as understorey trees in cashew-coconut plots, or an understorey of food crops (Aiyelaagbe 1994). In the Mangwende area of Zimbabwe 82% of the households planted and managed mango trees in the home fields as multipurpose trees grown in association with herbaceous crops (Musvoto & Campbell 1995). In Tanzania highlands, deciduous fruit trees are widespread in field and homesteads, and fruits are a major source of family income, eaten as part of the diet, a symbol of land ownership and soil erosion control (Delobel *et al.* 1991). In the highlands of Java, fruit-based Agroforestry in the form of commercial production of apples and oranges was well established in localized areas in the 1990s.

Nair (1984) noted the potential of fruit trees as components of Agroforestry systems and the need to look beyond conventional monoculture research. Fruit-based Agroforestry systems have been placed in a broader Agroforestry classification structure generally described as an agrisilvicultural production oriented system, used on sloping lands in the highlands of moist tropical ecological zones. Novel Agroforestry systems were developed as an alternative form of land use in many temperate and industrialized countries. In Europe, fruit trees were traditionally grown on agricultural land undersown with crops or managed grassland.

Of the crop options available to highland farmers, fruit cropping appears to be attractive. Apart from providing wood and services (recycling nutrients, protecting soils, serving as wind breaks, providing shade and easing pressure on forests), fruit-based Agroforestry contributes fruits that are important for their nutrients, oils and nuts. Therefore, the economic potential of fruit-based systems is more than that of the usual Agroforestry. In addition, due to the many crop components and combinations possible, the fruit-based Agroforestry system is highly adaptable and applicable to a wide area and range of physical and social conditions worldwide.

FRUIT TREES IN AGROFORESTRY: THE KIGEZI HIGHLANDS CASE STUDY

In the Kigezi highlands of western Uganda, fruit trees have been successfully planted on terraces as a strategy for improved nutrition and incomes as well as for soil and water conservation. Moreover, the highlands are characterized by cool temperatures that are suitable for growing temperate fruit trees such as apples, pears and peach. Because of the high population density (230 persons per km^2), the land tenure is such that land has been highly fragmented, thus making it impossible to introduce large-scale commercial farms. It was felt by AFRENA-Uganda project that there was a need for the highland farmers to change to intensive agriculture in order to maximize the utilization of land. A shift in farming practice means that farmers have to move gradually away from subsistence farming dominated by growing of food crops to a more commercially oriented farming that emphasizes production of cash crops. A similar change has been reported in the fruit-cropping and fruit-based Agroforestry systems in other highland areas such as northern Thailand (Poffenberger & McGean 1993; Rerkasem and Rerkasem 1994; Turkelboom *et al.* 1996; and Whithrow *et al.* 1999).

Box 1: Varieties of fruit trees introduced in Kigezi highlands

Varieties of apple, avocado, fig, plum, tree tomato, nectarine, pear, peach, almond, guava and loquat were introduced into the montane farming system in the Kigezi highlands by AFRENA-Uganda project in conjunction with National Agricultural Research Organisation (NARO) and Kawanda Agricultural Research Institute (KARI). On-station trials were carried out and the best performing varieties of fruit trees were selected. As a result of the trials and selections, six avocado, two apple and two pear varieties were taken for on-farm trials. After about 18 months avocado, apple pear fig, and tree tomato started fruiting. Farmers and extension officers were trained by KARI/NARO/AFRENA staff on nursery and orchard establishment and management. Some farmers have established their own fruit tree nurseries and orchards and have developed deep interest in on-farm fruit tree cultivation for income generation and food security.

Key Lessons Learned

- Temperate fruit trees can be combined easily in highland farming systems and fruit production can become a profitable enterprise.
- Fruit tree growing as an Agroforestry component can be sustainable as fruit trees also help to improve the nutritional status of rural households.

Recommendations for Way Forward

From the foregoing, it is apparent that there is a very high potential for development of both indigenous and exotic fruit trees in Uganda. The benefits of such development include cultivation of fruit trees in Agroforestry systems for improved nutritional value, incomes, as well as a sustainable soil conservation strategy. The next section gives examples of indigenous fruit trees with a high potential for successful propagation in Agroforestry systems in Uganda and beyond.

INDIGENOUS FRUIT TREES WITH AGROFORESTRY POTENTIAL

Mangabeira *(Hancornia speciosa)*

This is a delicious and nutritious fruit that grows wild in various regions of Brazil, and is being domesticated by researchers at the Brazilian fruit research agency. The fruit has the size of a plum, is red with a thin skin and sweet flesh containing one seed. It can be eaten fresh, but is also used in syrup, wine and vinegar. Its elastic gum serves well in ice-cream recipes. The tree grows between 2 and 10 m high and likes a warm and humid climate.

Morula *(Vangueria infausta)*

This fruit is also known as wild medlar or African chewing gum. Morula is an indigenous fruit tree of southern Africa fully adapted to local and sometimes harsh and dry conditions. Although it may not be a famous fruit as oranges, pineapples and mangoes, it is however, tasty, healthy and valuable.

Masau fruit *(Ziziphus mauritiana)*

Masau fruit or 'ber' as it is known in India, is no stranger in many African, Caribbean and Pacific countries. The tree is believed to originate from south Asia, but can be found throughout Africa (Kenya, Ethiopia and Zimbabwe), and in the Caribbean on Barbados, Guadelupe, Jamaica and Mauritinique. Despite its name, some of its properties are not widely known. The masau is a multipurpose tree, used for hedges and intercropping. Its leaves serve as animal fodder and its hard wood is well suited for agricultural implements, building and charcoal.

PLATE 3.1: *Ziziphus mauritiana fruits.*

Relatively unknown is the fruit's high vitamin C content – much higher than citrus – and its high phosphorus, carotene and calcium content. The leaves also provide an excellent source of vitamins C and A. The tree is drought resistant, salt tolerant and thrives on poor soils. Rural communities in Zimbabwe have started to grow the tree commercially for its fruit, with support of the Southern Alliance for Indigenous Resources (SAFIRE). Masau jam is already sold in Zimbabwean super markets, through the company Tulimara Speciality Foods of Africa Ltd. The company started producing masau jam some years ago with fruit from pickers but will now also use semi-processed fruits from the Rushinga communities. Trained by SAFIRE, they clean the fruit and extract juice, thus earning more than they were selling it raw. For fruit production, *Zizphus* requires annual pruning, and the pruned wood makes good fuel or fencing material.

Propagation

Vegetative propagation is required for multiplication of improved cultivars, budding being the best method. Rootstocks should be selected from hardy local plants in the wild. In India, the most commonly used rootstocks come from *Ziziphus rotundifolia*. In Africa, the best rootstocks probably come from *Ziziphus spina-christi*. Scion wood is taken from improved cultivars, which can be imported from other countries.

The seeds of the rootstock are sown in pits where plants are to be raised; budding is done in the following year. The survival rate is high (more than 90%) and the plants are drought resistant because the taproot is not disturbed as it is in transplanted individuals. This is the most workable method if *Zizphus* plants are to be raised in rain-fed situations. Existing *Z. spina-christi* trees can also be converted into improved cultivars by top working or grafting. The trees are headed or cut back and the budding is done on the new shoots. Such top-worked trees start bearing fruits from the second year onward because of the well-developed root system. This method has proved ideal for raising mother plants to obtain bud sticks for large-scale multiplication. For large-scale multiplication of plants, nursery raising is the only answer. The technique developed at the Central Arid Zone Research Institute (CAZRI) in Jodhpur has revolutionized *Zizphus* cultivation in India. The technique has reduced the time needed to raise budded plants from 1 year to 4 months. The root stock seedlings are raised in polythene tubes, and they are ready for budding in 90 days. The buddings are ready for transplanting after one month of budding. When these budded plants are planted out, they need to be watered until they are well established.

Planting and Soil and Water Management

The desirable density of planting is related directly to canopy development, which in turn is affected by the climatic conditions of the given location. In places of relatively high rainfall (> 750 mm) and high humidity, canopy development is vigorous so planting should be kept at 7 x 7 or 8 x 8 m. However, if the plantation is rained and there is less than 500 mm of rainfall a year, the density can be reduced to 6 x 6 m. Where water is limited, yields can be increased if rainwater is harvested and stored near root zone to ensure that there is water even at critically dry times. This can be done by ridging up the soil on either side of tree rows so that rainwater collects near the root zone. Research done at CAZRI more than a decade on *in situ* water harvesting in *Ziziphus* has shown that fruit yield can be doubled using this technique. In arid and semi-arid regions, water harvesting is important in the cultivation of *Ziziphus* as it can increase both fruit yield and biomass production.

Other techniques can be used to save water at the time plants are established. Mulches that reduce evaporation losses can be made from local flora provided these are not affected by termites. Double-walled pots can reduce water loss by 75% - the Ziziphus is planted in the inner pot that is open at both ends; the outer pot that is sealed at the bottom, is filled with water. Since the pot is made of clay, water seeps through the wall of the inner pot and is thus available to the plant. Plants grown in such pots show better growth than plants planted directly in a pit.

The *Ziziphus* plant must be trimmed during the first three years. Any shoots arising from the root stock portion should be removed frequently, and branches should be kept at an appropriate distance to keep the plant balanced. Two branches should be allowed to grow out of a single point to make a crotch. The first three years of trimming will provide a strong frame for the plant. Regular pruning is required for fruit production. As flowering and fruiting occur on the current year's growth, pruning should be done when the plant is dormant. Depending on the availability of soil moisture and on canopy development, 50-75% of the biomass can be removed in pruning. However, the amount of pruning can be adjusted to meet local conditions. After pruning, the cut ends should be painted with copper fungicide paste to avoid infection.

Pest management

Measures to protect *Ziziphus* will depend on pest incidence, which may vary at different locations. However, the insect pests that seem to cause the heaviest losses are various species of fruit fly. In India it is the species *Carpomiya vesuviana*, whereas the species that affects *Ziziphus* in Israel is *Carpomiya imcompleta*. The flies infest the fruits at the 'pea' stage. Spraying with a systematic insecticide is advised at this stage, and repeating the spraying three weeks later. Once again management for pests will depend on local conditions.

Disease Management

Powdery mildew disease (*Oidium* spp.) can appear from the time of flowering onwards. If the infection takes hold during flowering, it adversely affects fruit set. It may appear during fruit development, causing white powdery patches on fruits, which develop into necrotic spots on the mature fruit. In either case, spraying 0.1% Karathane can save the crop from damage.

Ziziphus and Agroforestry

Ziziphus starts producing fruits in the third year. Under rained situations with annual rainfall ranging from 300 to 600 mm, the fruit yield varies from 30 to 50 kg per 5-year-old tree. Rainfall, atmospheric humidity, and water holding capacity of the soil affect the yield. In severe drought (100-125 mm rainfall), when even the pearl millet crop fails, *Ziziphus* can provide subsistence income with 10-15 kg fruits, 3-5 kg of leaf fodder and 8-10 kg fuelwood per tree. With irrigation, a tree 5 years old or more can yield 100-150 kg of fruit in a year.

Since *Ziziphus,* like other trees, produces fruits and the subsequent income after 3 years, it is best to grow the tree with other crops until the canopy fills out. Local needs will govern the choice of intercrops. Leguminous crops help to enrich the soil in addition to providing income. The rule of thumb is that the intercrop should not be taller than the *Ziziphus* plants. Moreover, the area immediately around the *Ziziphus* plant should be kept free of other plants. In irrigated situations, vegetable crops can be grown in between the rows of *Ziziphus*.

Resource-poor farmers living on the edges of Africa's great deserts stand to gain plenty from the cultivation of *Ziziphus* on their farms. The tree can survive drought while remaining productive, providing fruit for human consumption, leaf fodder for goats and sheep, and ever-scarce fuelwood needed in the household.

The life span of the tree is 50-75 years, so once it is established and producing fruit, its benefits can be enjoyed by people in arid regions for three generations – or more.

Bush Mango (*Irvingia gabonensis*)

Farmers in Cameroon have started cultivating the bush mango (*Irvingia gabonensis*) with the help of ICRAF and its partners. The farmers are experimenting with vegetative propagation technique called marcotting. A section of branch is debarked and wrapped with a rooting medium to encourage rooting. The section is then secured tight in a container, such as a polythene bag and once the wrapped section develops roots, the stem is undetached and is planted in the field, after some hardening period in the nursery. When planted from seedlings, bush mango can take 10 to 15 years to produce fruit. But with marcotting, that time can be reduced to 3-5 years. This is remarkable considering the high importance that resource poor farmers attach to the bush mango.

Found throughout the humid forest zone of Cameroon, the bush mango is commonly called 'dika nut'. The pulp of the flesh is eaten and the nut is cracked open to reveal the real treasure – the kernel, which is the most valued part of the tree. The kernel is used as a delicious condiment for soups and is pounded into paste that is used as both a substitute and a complement for groundnuts. A sauce made from the kernel keeps for several days without refrigeration. The dried kernel can be stored for up to a year, as can the paste if it is thoroughly dried in the sun. This is a vital consideration where refrigeration is often not available.

The fresh bark of the tree is also an important and versatile product. It is sometimes used to add a flavour to locally made palm wine and is considered to be a powerful antibiotic for scabby skin, a cure for diarrhea when mixed with palm oil, and a toothache remedy. The fruit and kernel of the bush mango can fetch a good price at the local markets – a powerful incentive for farmers to plant more of these and other high value trees on their farm.

Shea Butter Tree *(Vitellaria paradoxa)*

The shea butter tree, *Vitellaria paradoxa* is a major component of the woody flora of the Sudan and Guinea savanna vegetation zones of Sub-Saharan Africa. The species forms an almost unbroken belt approximately 5,000 kilometers wide from Senegal to Uganda. *Vitellaria paradoxa* is an important source of many non-timber products. The nutritious fruits are eaten, the bark is used for traditional medicines and the latex is used for making glue. The wood is used for production of charcoal, construction, making furniture and carved into utensils and tool handles. Of all the products from the shea butter tree, the most valued is the shea butter/oil. The butter/oil is widely used for local domestic purposes such as cooking, as a skin moisturizer and as an illuminant. Commercially it is utilized as an ingredient in cosmetic, edible products and pharmaceuticals.

General Description

Many descriptions of mature *Vitellaria* have been published, but there is much variation in the level of detail, and few relate strictly to material from individual countries. *Vitellaria* is a promising Agroforestry fruit tree. It is normally a small to medium sized tree, its shape apparently controlled by external conditions. In savanna areas subject to regular fires, height rarely exceeds 10-15 m. Heights of 15-20 m are more common in annually cultivated fields. In protected areas, individuals may be as tall as 25 m while in severe environments, mature trees do not exceed 7m The shape of mature *Vitellaria* trees is variable: round, spindle and umbrella or bottom-like crowns.

The indehiscent fruit is an oblong, subglobose or ellipsoid berry borne on a pedicel 1.5-3.0 cm long. The fruit length is most commonly 4-5 cm and the diameter slightly less (2.5-5.0 cm). The weight varies from 10-57 g but is usually 20-30 g. The nut shape mirrors that of the fruit and is usually globose or broadly ellipsoid. Individual nuts are 2.8-5.0 cm long and 2.2-3.5 cm in diameter. The testa is lignified, sclerotic and brown in colour, with a broad, pale adaxial helium almost covering one side.

PLATE 3.2: *Fruits of Vitellaria*

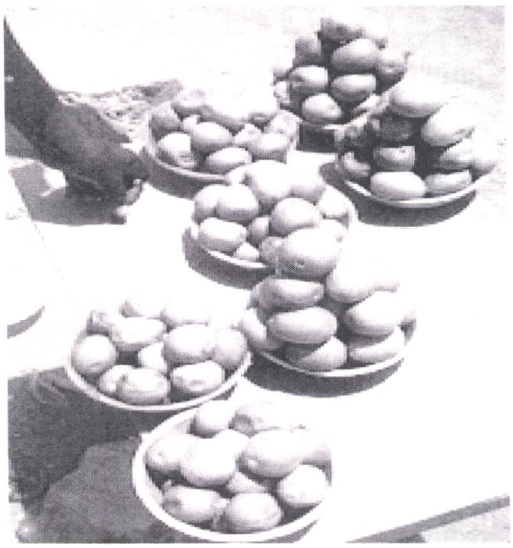

PLATE 3.3: ***Nuts of Vitellaria***

Cultivation and Management

Because of its role as a source of oil, *Vitellaria* trees have long been treated as integral components of wooded farmland agriculture. It is under these circumstances that the tree is protected even under shifting cultivation. In the cultivation phases it is common that young regenerating seedlings are removed even though large individuals are protected. When two or three fallow phases have been completed there is normally too much shade for the cultivation, and the communities tend to move and farm a different area, but they retain the stand as a resource where fruits are gathered.

Scattered *Vitellaria* trees in fields are rarely subjected to formal management. Only occasionally are young trees protected in order to rejuvenate an ageing parkland area. Sometimes multiple coppices that develop from a cut stump are thinned out in order to favour the growth of a single, main stem. The latter is then later pruned and staked to encourage upright growth. The crowns of trees show evidence of lopping in some areas, and farmers give the following reasons for the practice: the removal of dead branches, the reduction of crown size and the need to increase fruit production. A survey of 2,000 shea butter trees in Burkina Faso showed that 56% of the trees showed signs of pruning of one or more branches up to 15 cm diameter. This had been done with obvious care to reduce impact on crops. However, other farmers in the same country believed that any pruning of shea butter trees would be detrimental to fruit production, which suggests that practices vary with local cultural beliefs.

Impact of Vitellaria on Agricultural Crops

Nair (1984) recommends *Vitellaria* as an Agroforestry tree for the drier savanna regions, where there is a definite 4-6 months dry period. In West and Eastern Africa, *Vitellaria* grows in association with annual crops such as millet, sorghum, groundnuts, cotton, cassava, yams and vegetables as well as around and within settlements. Combinations with these crops provide the basis for Agroforestry involving *Vitellaria.*

Fruit Production

Productivity rises rapidly in the age range 40-50 years before finally declining. Fruit yield appears to be dependent on adequate soil moisture at the time of flowering and fruit set, and soil fertility has a strong influence on fruit production. Fruit production fluctuates considerably for one particular tree from year to year. Average yield per tree has been conservatively estimated at 15-20 kg per year. Trees growing on very poor and rocky soil may not produce any fruit at all. Caterpillar damage reduces fruit yields, and severe infestation by *Cirina butryospermi* causes reduction in both individual fruit weight and fruit yield per tree, as well as inhibiting normal flower and fruit production.

Propagation

Vitellaria is readily propagated from seed. In some areas obtaining seed for planting is difficult, as the fruits are nearly all collected for butter production. But in other areas, seed is readily available from the stands where fruit collection is neglected in favour of cultivated or recently fallowed lands. Like many seeds with high oil contents, nuts have a short period of viability. With fresh seed, germination rate can be over 90%, though considerable variation has been observed. Some seed sources have been found to give only 40% success. As germination potential falls very rapidly, seed should be sown as soon as possible after harvesting, preferably within the first week, but at most within a month. Short viability means that seed cannot be stored for any length of time, which is a problem when it comes to the collection and dissemination of 'improved' seed. Seed may be sown directly or in nursery bed. Wildings may also be planted, but the seedling should be 0.5-0.75 m in height, with large root ball in order to minimize damage to the taproot and hence stress to the plants and lower survival rate. *Vitellaria* may also be raised through coppice and root suckers, budding and grafting, and from stem cuttings.

Rural Processing

It is generally stressed in literature that the traditional, labour intensive processing of shea fruit for the extraction of shea butter is a task performed solely by women. Regional variations exist in the traditional methods of oil extraction, even within the same ethnic groups, but there are several basic steps involved. Oil extraction begins with roasting the nuts, a process which causes the latex to coagulate. This technique appears to be the most commonly adopted by ethnic groups across *Vitellaria's* range. The techniques are summarised in the sub-sections below. It is estimated that the production of 1 kg of shea butter takes one person 20-30 hours, from collection to final product. It has also been estimated that 8.5-10.0 kg of fuelwood are needed to produce 1 kg of shea butter.

Collection

Women and children are principally responsible for the collection of shea fruit. However, in Uganda and, under exceptional circumstances in parts of West Africa, the involvement of men has been recorded. Picking rights vary in accordance with land tenure arrangements and in some cases, are strictly controlled. In northern Nigeria, for example, trees are often inherited, except in areas where they still occur in large numbers. In northern Burkina Faso, land rights are acquired primarily through relatives (from previously cultivated land) or spontaneous clearing, but also by requesting uncultivated plots from village chiefs. In Mali, everyone in the village is allowed to collect from crop fields, regardless of who owns them. In Ghana, women pick from their husbands' plots, and the oldest wife regulates in polygamous marriages. Fallow plots are for the wives of the previous owners, whilst uncultivated plots are open to all women. Pickers wake up early in the morning and trek up to 15 km, then carry the loads back in head pans of 20-25 kg (sometimes over 40 kg). Hazards include scorpions and snakes, especially beyond cultivated areas.

Vitellaria fruits are harvested from May to September, depending on the latitude of the location. This coincides with the early wet season, when the edible fruit pulp forms a welcome addition to the diet. Fruit are collected mainly as windfalls. The harvest season coincides with the planting of the main crops such as groundnuts, cotton, sweet potatoes and cassava, and inevitably coincides with a shortage of labour. Several strategies have been developed to deal with this problem. Among the Hausa, for example, and many other ethnic groups, fruits are piled or buried in shallow pits for processing later.

The heat of fermentation resulting from the piling-up of fruit (very effective in pit storage) is relied upon to destroy the germination potential of the nuts. However, fruit collection is not always discriminating, especially among certain ethnic groups, and germinated fruit may be collected as part of the harvest. This can cause a decline in subsequent oil quantity and quality, as germination leads to a fall in oil content and may be associated with the development of a bitter taste in the butter. These changes result from the hydrolysis of fat into glycerin and fatty acids by lipolytic enzymes, a process which produces an increase in free acidity as well as a decrease in oil content. Also, once the shell becomes punctured through the process of germination, there is contamination with the growth of fungi and rapid deterioration in the quality of the kernel.

Boffa (1995) calculated that the average value of unprocessed shea nuts collected on family fields in southern Burkina Faso was 2035 FCFA (US $4.20) per year, in 1993. The time taken for collection varies from year to year, depending on how far collectors have to walk and on the abundance of fruit. In Mali, women and children collected shea fruit daily for about 3-4 months, within a 1-3 km radius of their homes. In Benin, it was estimated that a poor harvest could be gathered within one month, whereas several months would be required in more productive years. At the start of the shea fruit season, women made two harvesting trips per day but, with the start of the rains, this was reduced in line with increased pressure from agricultural activities. The first few trips tended to be made to trees growing beyond fields and fallows nearby, in areas where competition from other collectors was highest. Trees within family fields and fallows, where harvest ownership was guaranteed, were left until later. Towards the end of the season, groups of two or more women occasionally ventured further a field to find unharvested trees. Excluding journey time, the time taken for one woman to collect a head load of fruit of 25 kg, in a good year, was, on average, 40 minutes. Although head loads of 25 kg were most common, some women carried as much as 47 kg of fruit on their heads.

In Ghana, it was found that women collected, on average, 20 kg of fruit per day, including a round trip of at least 16 km on foot. It has been reported that a man was said to be able to collect approximately 45 kg in one day, whereas women were only capable of collecting approximately 4.5.-9 kg in a morning, but this is not substantiated by more recent reports. About 22 kg head loads were regularly carried for a distance of up to 19 km. Other studies found that women in northern Benin were able to collect 2-3 calabashes of 10 kg per day, building up to 1 tone of fruits per season. From a study in the same country, it was found that quantities of fruit collected by one person varied between ethnic groups. In 1993, the general average was 160-290 kg, but there were extremes of 63 kg and 1,035 kg.

Depulping

Fermentation facilitates the removal of the fleshy mesocarp. If this is not achieved by burying for at least 12 days, boiling the fruit may be necessary. Among the Yoruba, the flesh is eaten directly off the fresh fruit by pickers and their families, or chewed off by sheep. The nuts are then boiled to remove the remaining flesh and to kill the embryo. Boiling also has the effect of causing the kernel to shrink and become detached from the shell, which facilitates subsequent dehusking.

Drying of nuts

Among some ethnic groups such as the Hausa and Yoruba, nuts are sun-dried for 5-10 days until the kernel rattles inside. At this point, the moisture content is 15-30%. If the weather is not suitable for sun drying, boiling may be necessary. Special kilns for drying the nuts are used by other ethnic groups, such as the Otamari in Benin. The Gwari in Nigeria also build kilns, which hold up to 45 kg of dried nuts. The drying process takes 10 days at 50°C. The Nupe build larger kilns, holding around 70-90 kg of dried nuts. The kiln is only fired when it contains 130-180 kg of wet nuts, because of the scarcity of fuel. It may take up to two months to accumulate this volume, as fruit collection has to compete with the crop planting season. Drying the nuts takes 4-5 days at a temperature of approximately 56°C, which reduces the moisture content of the kernels to 6-7%.

Dehusking

Children or old women may be given responsibility for this stage. A variety of methods are used, including trampling, pounding in a pestle and mortar or cracking between two stones. It has been estimated that women could crack and winnow 125 kg of nuts in a day using a pestle and mortar, but this method has the disadvantage of producing more broken kernels. Other reports indicate that among the Yoruba, in Nigeria, a man could reportedly decorticate 113 kg of kernels per day, and women could crack open and separate 13 kg of nuts per hour.

Drying and Smoking of Kernels

Boiling (Blanching) or baking is necessary in order to inactivate enzymes responsible for the build-up of fatty acids and prevent the growth of fungi (e.g. *Aspergillus spp.*) The moisture content must be less than 7% for safe storage. Smoking the kernels for 3-4 days at this stage facilitates storage for up to nine months. Kernels dried to 7% moisture content could be stored for up to two years. For sun drying, kernels require approximately 5 days spread out in the open, after which, with consistently good weather, the moisture content should be reduced to 10-15%. If heavy rains at the beginning of the season make these difficult, freshly cracked kernels at 40% moisture content may be used directly for the next processing stage. The Nupe roast shea nuts in a clay oven at 150°C for 1-2 hours, depending on the moisture content. The process is considered complete when the kernels become a dark colour, glisten with oil and begin to crack. Care is taken to avoid charring as this greatly reduces the fat content. In Mali and Benin, a special oven is also used to dry the kernels, but this process takes 12-24 hours. The oven requires a large quantity of timber, pieces of large diameter being favoured for their slow burning. Estimates of the labour required for the smoking process show little variation between sources and range from 1-2 hours.

Pounding and Grinding

This is generally done in large wooden mortars or between a stone and an iron bar or stone and wooden roller. The product may be heated during and/or after this process. In Mali, and among the Yoruba and Nupe in Nigeria, the kernels are crushed in a mortar whilst still warm from baking and are pounded until a thick, porridge-like substance is produced. This is then ground on a special stone with a little water until a smooth paste is formed. It takes 4 women 25 minutes to pound 7-8 kg of kernels to a coarse meal, and an hour for 2 women to grind 7 kg.

Mixing with Water, Treading, Kneading and Churning

Kneading is the most crucial step in determining the quality of the shea butter finally produced. Its success depends on the recognition of changes in temperature, consistency and appearance, which can only be assessed correctly with experience. The product may be heated again at this stage. Among the Yoruba and Nupe, hot water is poured into an earthenware pot sunk into the ground, the paste and more hot water are added, and the mixture is then allowed to rest for 20 minutes. Once cool, the mixture is trodden by a woman until a grey spongy dough is produced. This takes approximately half an hour for 7 kg. The same result may be achieved by kneading by hand and churning, but this method may take longer, from 30 minutes to three hours. The residue which is left in the bottom contains solid particles and impurities, and may be used to make soap.

Floating, Washing and Refining

Small amounts of dough are worked with the fingers in cold water. This vigorous mixing breaks the emulsion, causing a grey, oily scum to rise. In Ghana, adding the juice of *Ceratotheca sesomoides* ENDL to the boiling pot may accelerate the rate of separation of the fat. The oil is skimmed and washed repeatedly in a basin with clean water to eliminate residues and is then made into balls. One woman is said to be able to process the fat from 45 kg of roasted kernels in half an hour. The butter is clarified by melting and boiling the solid fat in a pot until it is clear and bubbly. The fat is then poured into a basin where it is left to solidify. Among the Yoruba, the fat is refined by melting the balls gradually into a large pot and boiling for two hours (which causes the water to evaporate), then leaving overnight for sedimentation to occur. A thin scum is then removed from the surface and may be kept for use as an illuminant, whilst the remaining fat is poured into basins ready for the final processing.

Solidifying and Moulding

The Yoruba further process their butter by agitating it with a stick in large calabashes in a cool place. Over the period of an hour, this gradually causes the liquid to thicken; it is then spread out for 15 minutes before the process is repeated several times. After another hour, a semi-solid substance is produced. Finally the butter is moulded into characteristic shapes and then packed in leaves for preservation, ease of storage and transport. Shea butter is often sold as loaves, in shapes characteristic of particular villages, weighing usually 2.2-2.7 kg. The deeper the colour, the stronger the odour and taste of shea butter. This has been linked to the presence of decomposed proteins which occur in proportion to the degree of fermentation of the nuts and as a result of over-roasting. Hausa butter is sometimes tinted with yellow dye extracted from the root of *Cochlospermum tinctorium*. Research has suggested that this may help in delaying the onset of rancidity. The dye is destroyed during cooking.

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4

SOIL AND WATER CONSERVATION

BY

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INTRODUCTION

As population growth increases, available land for individual agricultural production decreases, especially in rural communities with traditional tenure systems. Most of the land in Uganda that could be classified as suitable for cultivation is already under cultivation. Such pressures are forcing farmers to utilize marginal lands or intensify their agricultural production, risking land degradation through deforestation, water erosion, leaching, and physical and biological degradation. Soil degradation not only lowers crop yields obtainable on the basis of intrinsic soil fertility, but it can also substantially reduce response to fertilizer or other inputs (Young 1997). Continued cultivation of marginal land to meet the ever-increasing demand for food production will only be possible through intensification of existing farming systems.

Uganda has vast areas of degraded agricultural land with infertile soils that cannot sustain agricultural production. It has been hypothesized that traditional agricultural production systems and technologies promote soil fertility depletion and land degradation, and cannot sustain high crop yields on smallholder farms. The hypothesis is based on (i) average levels of crop productivity, (ii) broad soil genesis and inherent soil fertility descriptors, (iii) available soil and plant tissue analytical data sets, and (iv) extrapolated nutrient budget and balance data. Ugandan farmers have applied several technologies in the management of agricultural land, including traditional systems of fallowing, crop rotation and use of organic fertilizers. These have not helped to overcome Uganda's food needs. Some of these technologies have been researched and modified to constitute potential alternative soil management systems that could be deployed in many agro-ecosystems to sustain or extend crop and animal production.

Current agricultural production in Uganda

Uganda is characterized by diverse agricultural systems that are typically low input and based on subsistence farming. Traditional shifting cultivation and rotational systems have been disbanded as population and pressures for land use increase. To meet the ever increasing demand for food, more land has been brought into production often at the expense of dwindling forest reserves and marginal lands. Such practices increase the risk of degradation through erosion, leaching and physical and biological degradation, if the reclaimed land is not put to an appropriate use. For example, there has been a decline in the proportion of land under natural forest between 1960 and 1996 (National Biomass Study 1996).

Continuous cultivation, especially on steep slopes, has accelerated soil erosion. Annual soil losses in Uganda have been estimated at >70 kg of nitrogen, phosphorus and potassium (NPK), which is one of the highest rates in sub- Saharan Africa (Stoorvol and Smaling 1990 cited in Kakuru *et al.* (2001). In Kigezi highlands, soil erosion rates ranging from 20 to 150 ton ha-1 yr-1 are reported (Twesigye and Bagoora 1991; Kakuru 1993). Expanses of central and northern region of Uganda covered by coarse sandy loams are susceptible to interrill erosion culminating in gullies. Similarly, signs of advanced soil erosion have been reported on the rolling topography of south and central Uganda with exposed subsoil and reduced crop yield becoming apparent (Tumuhairwe 1986). Where there is no more land to bring into agricultural production, there has been a notable increase in the frequency of cultivation. Recent AFRENA - Uganda Project studies indicate that 10% of formerly arable land in the Kigezi highlands 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. Such deterioration of farmland increases rural poverty, malnutrition and inability to meet other basic needs.

Presently, grain yields per unit of land in Uganda are low, hardly 30% of the potential production levels depicted by those obtained on research stations (Table 4.1). The low yields can be attributed to several factors including political instability and conflict, poor governance, erratic weather, poverty, agricultural failure, population pressure and fragile ecosystems (including soils). Soils are one of several elements that interact at a particular time and location to ensure sustainable agricultural systems (Young 1997). Therefore there is a need to have a good knowledge and understanding of these elements as removing one constraint will not result in increased productivity unless other problems are also addressed.

Use of inorganic fertilizers to replenish soil nutrients lost in Uganda has been constrained by low, and often negative, returns to fertilizer investment. Organic materials available on-farm are of low quality and often produced in insufficient amounts to meet crop demand. Traditional soil erosion control strategies such as stone barriers and terrace benches are labour intensive and often not sustained for long due to lack of stabilization.

TABLE 4.1. *Potential and current yields of selected staple and cash crops grown in Uganda*

Crop	Units	Potential yield[1]	Current yield[2]
Banana	t $ha^{-1}yr^{-1}$	40-60	5.7
Maize	t ha^{-1}	5-7	1.6
Beans	t ha^{-1}	2.5	0.8
Cassava	t ha^{-1}	50	8.5
Coffee (Kiboko)	t $ha^{-1}yr^{-1}$	2	0.5

Source: Bekunda 1998. [1]yields obtained at Research Stations in the country; [2]average national yields obtained from the agricultural census data 1995/6.

SOIL CHEMICAL STATUS

Soil characteristics are the key element in determining the productivity of the land, and these differ widely as a result of different parent materials and pedogenesis. Uganda's soils are predominantly old soils, the major ones being orthic ferralsols, ferric acrisols (Anon 1973) that form 70% of farmed land. The soils have lost their weatherable minerals due to exposure to weather elements, resulting in acidic or poorly buffered soils that are difficult to manage under long-term cultivation, because their fertility is stored in the fragile organic matter fraction. The rating of these soils using the Land Suitability Assessment of the FAO's Agro-ecological Zoning procedure (FAO 1978) is, at best, marginally suitable (S2) for major staple crops grown in Uganda.

The most readily available basic soil data sets are those collected from approximately 1700 fertilizer trials conducted at 62 centers in Uganda and analyzed by Foster (1981). Most of the soils sampled then, had not been subjected to intensive agricultural use. Some of the major conclusions of this analysis were that (i) total nitrogen, organic phosphorus and CEC were low and closely related to soil organic matter (ii) indices of available phosphorus and base saturation were related to soil pH (iii) there were high phosphorus sorption losses and (iv) many soils were low in magnesium. Increased smallholder agricultural activity over time could have led to loss of soil fertility.

Nutrient studies have confirmed that different nutrients limit the productivity of land in different locations. Studies in the Kigezi highlands, for example, have shown that out of 56 sites, Nitrogen, Phosphorus and Potassium were limiting in about 90%, 40% and 50% of the sites respectively (Siriri, D., unpublished data). Phosphorus limitation was predominant in soils derived from volcanic action. Nitrogen limitation was found to cut across the major soil types of the Kigezi highlands.

NUTRIENT AUDIT STUDIES

It has become evident that resource flows within and beyond farms are important indicators of the rate of depletion of soil fertility. One study on organic material flows within a smallholder farming system in Kabale District (Briggs and Twomlow 1998) revealed that the net loss of fresh organic materials from one cropping system (annual hillside crops) resulted in a net gain to banana plantations and annual fields close to the homesteads. However, this is not a sustainable system as continued nutrient mining from the hillside soils eventually lead to reduced organic material availability for the receiving systems. Another study, based on nutrient balances in farming systems of eastern and central Uganda (Wortmann and Kaizzi 1997) confirmed that the current farming systems with minimal external inputs, results in nutrient losses, despite the low productivity (Table 4.2).

AGROFORESTRY FOR SOIL AND WATER CONSERVATION

Agroforestry land use systems offer an opportunity to improve soil nutrient status and control soil erosion within small-scale farmers' framework. In Uganda, research and dissemination on this aspect has mainly been conducted by the National Agricultural Research Organisation (NARO) through the Forestry Resources Research Institute (FORRI) and several non-governmental organisations (NGOs). The NGOs include AFRENA, Vi Agroforestry Project, World vision (Uganda), Africare, Africa 2000, and the Soroti Catholic Diocese Integrated Development Organisation (SOCADIDO). During research in Agroforestry, several lessons have been learned about the contribution of Agroforestry to land management.

TABLE 4.2. *Nutrient balance estimates (kg ha^{-1} yr^{-1}) for selected crops grown separately in four locations in eastern and central Uganda*

Location	Nutrient	Crop		
		Banana	*Maize*	*Beans*
Pallisa	Nitrogen	-13.2	-105.2	-40.4
	Phosphorus	1.2	-13.6	-8.9
	Potassium	-35.7	-82.4	-42.7
Iganga	Nitrogen	27.2	-84.2	-25.2
	Phosphorus	22.1	-8.9	-8.2
	Potassium	13.1	-53.8	-35.2
Mpigi	Nitrogen	-9.1	-84.2	-25.2
	Phosphorus	5.7	-8.9	-8.6
	Potassium	-56.0	-61.7	-33.3
Kamuli	Nitrogen	7.1	-93.7	-20.0
	Phosphorus	6.3	-9.4	-8.3
	Potassium	-50.3	-81.4	-28.0

The Potential of Agroforestry for Soil Physical Conservation

Maintenance of good soil physical properties is important in soil management for its direct effects and efficient use of nutrients and improved water management. Hillside arable farming is often constrained by soil erosion and runoff rendering the topsoil and water less available for crop production. In the Kigezi highlands, the terrace scouring phenomena caused by upslope hoeing and soil erosion leads to formation of hard compacted soils on the upper terrace section, which is less productive than the lower part (Siriri 1998). Agroforestry systems have the potential to improve or maintain the soil physical environment (Young 1997). Improved fallows of *Sesbania sesban* can lower soil bulk density and increase water infiltration (Torquebiau and Kwesiga 1996). In the Kigezi highlands, hard compacted soils on the upper part of terraces are broken lose following a two year *Calliandra, Alnus* or *Sesbania* rotational woodlot/improved fallow. According to Raussen *et al.* (1999), this results in increased water infiltration, which more than doubles under tree based land use systems (Table 4.3).

TABLE 4.3. *Average field saturated hydraulic conductivity on degraded parts of bench terraces under different land use systems*

Land use system	Water conductivity K_{sf} (mm hr^{-1})
Alnus acuminata	81
Calliandra calothyrsus	100.8
Bush fallow	46.2
Continuous cropping	45
SED	16.8

Source: Raussen *et al.*, 1999

Contour hedgerows on sloping land have been observed to effectively control soil erosion and runoff while increasing water infiltration. In Machakos in central Kenya, contour hedgerows of *Senna siamea* increased water infiltration from 8 to 69 mm hr^{-1} in the wet season, and from 44 to 135 mm hr^{-1} in the dry season (Keipe 1995). In Uganda improved soil and water conservation under contour hedgerows has been reported. In Kabale district where soil erosion ranges from 10 to 500 ton ha^{-1} $year^{-1}$, contour hedgerows of *Calliandra calothyrsus, Leucaena diversifolia* and *Alnus acuminata* have over 65% efficiency in controlling runoff (AFRENA, unpublished data). The impact of *Calliandra* hedgerows was recently assessed on farmer's fields in Kabale. Good topsoil accumulation behind hedges was observed after 3 to 6 years of hedge establishment. However, the effect was evident on 66 % of the sites, indicating that the effect of contour hedgerows can be site specific. Where the hedgerows were established, the topsoil layer was about 14 cm thicker than on fields without hedges (Table 4.4). With an average width of 7 m per field, this is equivalent (at a bulk density of 1.2 and an efficiency of 68% of the farms) to 80 tons of soil accumulation per 100 meters of hedge.

TABLE 4.4. *Soil depth under on-farm contour hedgerows in Kabale*

Treatment	Average top soil depth (cm)
No hedge	66
Hedge	80
SED	4.2

(Source: Siriri *et al.*, 2000)

The Potential of Agroforestry for Soil Nutrient Replenishment

Low external input Agroforestry practices like; improved fallows, rotational woodlots, biomass transfer and hedgerow intercropping are known to improve soil nutrient supply. Improved soil is attributed to tree enhanced processes like deep capture of nutrients beyond the reach of crop roots hence reduced leaching, biological nitrogen fixation, and input of organic materials (Buresh and Tian 1998). Improved fallows of *Sesbania sesban* when grown in soils where nutrients are easily leached to depths beyond the reach of crops to tap, make such nutrients available to crops through leaf litter decomposition (Hartemink *et al.* 1996; Mekonnen *et al* 1997). *Sesbania* fallows can tap about 148 kg of mineral nitrogen per hectare (Mekonnen *et al.* 1997).

Most trees used in Agroforestry systems are leguminous and therefore able to fix atmospheric nitrogen in their biomass. The nitrogen becomes available to crops through decomposition of below and above ground biomass of trees. For instance, the % nitrogen derived from the atmosphere and fixed in soil ranges from 37% to 74% in *Leucaena leucocephala* and from 26% to 68% in *Gliricidia sepium* (Sanginga *et al.* 1990, 1991). *Gliricidia* and *Leucaena* can potentially fix up to 200 and 250 kg of N ha^{-1} respectively. This represents a fertilizer equivalent of 100 and 180 kg of N ha^{-1} for *Gliricidia* and *Leucaena* respectively. *Calliandra* grown for 12 months will derive about 80% of its nitrogen from biological N fixation, resulting in about 300 kg of N ha^{-1}, with prunings alone providing between 80 to 220 kg of N ha^{-1} (Peoples *et al.* 1996). *Crotalaria ochroleuca*, tested in Central and Eastern Uganda, can produce 2.5 to 9 t ha^{-1} of above ground stover containing 35 to 290 kg of N ha^{-1}, the residual effect on crops representing a fertilizer equivalent of 90 kg N ha^{-1} (Fischler 1997). Tephrosia can potentially produce about 6 to 8 t ha^{-1} of stover yield, which can supply about 112 to 200 kg of N ha^{-1}. The residual effect of *Sesbania sesban* on crops, one of the shrubs most frequently used for soil fertility replenishment is estimated to be equivalent to 150 kg of inorganic fertilizer ha^{-1} (Mathews *et al.* 1992).

Experiences from Uganda also indicate high nutrient turnover from improved fallows. In Kabale, soils sampled at fallow clearance showed that on the upper degraded terrace sections, nitrogen levels were significantly higher in the tree systems than the continuous cropping or natural fallow systems (Table 4.5). Total mineral nitrogen was highest in *Sesbania* plot followed by *Calliandra* while the continuous cropping and natural fallow plots had the lowest level.

TABLE 4.5. *Green manure production and nitrogen status following improved fallows in Kabale District, Southwestern Uganda*

Land use system	Green manure production (ton ha^{-1}]	Mineral nitrogen levels (mg kg^{-1})
Sesbania sesban	2.22	17.23
Calliandra calothyrsus	4.94	13.13
Alnus acuminata	5.36	9.97
Tephrosia vogelli	0.82	9.87
Natural fallow	-	9.50
Continuous cropping	-	9.00
SED	0.35	1.66

(Source: Siriri and Raussen, in press).

Crop Performance under Agroforestry Systems for Soil Management

Improved fallows

Improved fallows involve the planting of nitrogen fixing leguminous trees/shrubs on poor soil which are often cut after a season or two when the trees/shrubs have attained maximum biomass. The trees/shrubs are then allowed to shed their leaves, which together with the roots are dug and incorporated into the soil. An important merit in the use of trees/shrubs for improved fallows to replenish soil fertility is that, farmers can multiply their own seed for further fallowing, making the system appropriate and sustainable. However, it should be noted that poor and food insecure households may not afford to invest in land improvements that put some portions of land out of crop production for an extended (2 -3 years) period. In addition, ease of decomposition is a key issue when timing nutrient release from the fallow materials to peak with crop nutrient demand. Short-living crops will, for example, require materials that decompose quickly. The challenge is to merge the peak of nutrient release with that of nutrient demand by crop. Different plant residues possess different decomposition rates. Hence, nutrient release from each plant material will peak at different times. Agro-ecological zones also influence decomposition rates and, hence, nutrient release patterns. Therefore, there is a need to identify tree/shrub species, which are suitable for improved fallows in the various agro-ecological zones of Uganda.

In the highlands of southwestern Uganda, cumulative maize yield following improved fallows significantly increased from 1.6 ton ha^{-1} in the continuous cropping to 3.5, 4.1, 5.9 and 6.2 ton ha^{-1} in the *Tephrosia, Alnus, Calliandra* and *Sesbania* fallow systems, respectively. The technology has become attractive to farmers who value the additional firewood input of 27, 26, and 24 ton ha^{-1} from *Sesbania*, *Calliandra* and *Alnus*, respectively. The improved crop yields coupled with good wood production results in attractive net benefits and returns to labour in the tree fallow based land use systems but not in the continuous cropping and natural fallow systems. Parallel results were reported in Zambia where one-year *Sesbania* fallows raised the annual maize production from 1.6 ton ha^{-1} in the continuous cropping system to 3.5 ton ha^{-1} in the fallow system. Increasing the fallow period to two years increases annual maize production from 1.6 to 5.3 ton ha^{-1} (Kwesiga and Coe 1994). In western Kenya, a 15 month fallow of *Sesbania sesban* increased maize yields from 2 to 4.5 ton ha^{-1}, where neither the fallow treatment nor the control of continuous maize were fertilized, and from 5 to 7 ton ha^{-1}, where phosphorus fertilizer was added to both (ICRAF 1995).

Hedgerow intercropping

In an acid infertile soil in Burundi, there was no yield increase in the first two years under contour hedgerows but yield ratios (yield in contour hedgerow divided by yield in no hedge system) rose substantially above 1 in years 3 and 4 (Akyeampong and Hitimana 1996). In western Kenya, yield ratios under six hedgerow species averaged 1.6 and remained almost constant over years 4-6 (Heineman 1996). In Uganda, there is scanty information on crop response to contour hedgerows. A long-term experiment at Kachwekano in Western Uganda shows yield improvement under *Leucaena diversifolia*, *Calliandra calothyrsus* and *Alnus acuminata* hedges spaced at 4 m apart (AFRENA unpublished data).

Biomass transfer

This system involves growing trees and cutting prunings to be spread and incorporated in soil on another site. The trees are usually grown on poorer sites or along roadsides or field boundaries and easily decomposable materials are used in biomass transfer. The materials are usually referred to as green manure because of their straight application without composting. One potential promising shrub for biomass transfer is *Tithonia diversifolia*. In western Kenya maize yield increased from 0.8 ton ha^{-1} to 1.5 ton ha^{-1} after application of about 2 ton ha^{-1} of *Tithonia*. It is reported that farmers can obtain a maize yield from application of 5 ton ha^{-1} of *Tithonia* that is comparable to yield obtained from applying the recommended rate of fertilizer application (ICRAF 1997).

Management of Agroforestry systems for soil fertility replenishment

Agroforestry systems in Uganda have probably been practiced for as long as the existence of agriculture although comparison of their contribution to soil fertility improvement has not been an area of extensive research. In the banana-cropping systems, for example, *Ficus* trees are very common components of the system serving several purposes including soil conservation. This is a "simultaneous" Agroforestry system whose management necessitates random spacing of a few trees within the crop so as to minimize competition for light, water and nutrients. One improved form of simultaneous Agroforestry is alley cropping where trees and shrubs are established in hedgerows at spacing dictated by different land conditions on arable cropland with food crops in the alleys (Wilson and Kang

1981). Management of this system requires that hedgerows are oriented to minimize shading within alleys and soil erosion. For soil fertility replenishment, fast-growing N_2 – fixing leguminous species are often preferred in alley cropping systems. Periodic pruning prevents shading of the companion crop; the prunings incorporated to the soil as green manure or used as mulch help to maintain soil fertility for crop production. The prunings may also be fed to livestock and later added to the soil as livestock manure.

Sequential Agroforestry systems are more robust; trees are planted in place of colonization by natural vegetation in a crop-fallow rotation, so as to improve the rate of soil amelioration. In such a system, there is a progressive build up of soil carbon and nitrogen. The other nutrients are released to the soil upon clearance or through litter fall (Young 1997). These systems tend to have more positive influence on soil physical conditions.

Water Harvesting

Water harvesting refers to the collection and concentration of water run off for the production of crop, pasture and trees for livestock or for domestic water supply. It is used where rainfall is inadequate to meet crop requirements mainly in arid and semiarid environments where rainfall is erratic and water is lost as runoff. The most common systems of water harvesting include: harvesting from roof tops, runoff harvesting from ground surfaces and flood water harvesting from water courses. In Uganda, rainfall is fairly well distributed and most parts of the country experience bimodal rainfall pattern with one rainy season from February to May, and a shorter one from September to November. Rainfall totals range from 1000 mm to 1500 mm per year. However, the semi-arid area of North Eastern Uganda (Karamoja region) experiences unreliable distribution of rains ranging between 250 mm and 800 mm per year. Such areas merit water harvesting.

Factors Influencing Water Harvesting

For any comprehensive water harvesting project to take root, socio-economic factors, including farmers' priorities and needs, gender equity, area differences, land tenure, and water harvesting technologies and approach to be adopted should be considered. In addition, knowledge of soil physical and chemical properties is important for successful water harvesting. Soil in the catchment area (area for collecting run off from outside the cropped area) should have a high runoff coefficient i.e. should have a low infiltration rate, whereas soils in the cultivated area should be deep with good infiltration capacity. Where conditions of the cultivated and catchment area conflict, the requirement of the cultivated area carry more weight. Soil texture, depth, salinity/sodicity, and construction characteristics (ability of soil to form stable earth bunds) are particularly important soil properties in water harvesting.

Approaches in water harvesting include the use of under ground tanks, sand dams, earth dams, rock catchments and rainwater catchment tank. Methods that can be used to harvest water for crop use include contour ridges, contour bunds, microcatchments for tree e.g. V-shaped bunds, and retention ditches and basins, which are mainly used for trapping runoff. Floodwater can be harvested by intercepting it using large earth bunds across a flat valley floor in an arid area.

CONCLUSIONS AND RECOMMENDATIONS

Land degradation is attributed to low and unsustainable agricultural production in Uganda. Several technologies that have been applied by farmers in the management of agricultural land have not been sufficient to overcome Uganda's food needs. Agroforestry holds promise for soil and water conservation while providing essential products such as firewood and fodder to the predominantly resource poor Ugandan farmers. On-station and on-farm evaluation of Agroforestry soil conservation technologies, particularly improved fallow and contour hedgerows have shown significant improvement in soil physical and nutrient status, and attractive crop and wood yields to farmers. However, such evaluations have been done mainly in the highland farming systems and low land areas in the Lake Victoria basin, using limited range of tree/shrub species. There is little or no Agroforestry experience in the drier parts of Uganda, particularly the dry savannas of northern Uganda and the cattle corridors of western Uganda. The following aspects should be considered in countywide scaling up of Agroforestry for soil and water conservation:

- Agroforestry soil and water conservation technologies should be developed and promoted for the dry areas of northern Uganda and the cattle corridors of western Uganda.
- More tree/shrub species, both indigenous and exotic, for soil and water conservation should be evaluated in the different agro-ecological zones of the country with the aim of increasing suitable species range and germplasm.
- Ecologically and socially proven soil and water conservation technologies in the Kigezi highlands and the Lake Victoria basin should be scaled up in areas of similar farming systems.
- There is a need for more detailed analyses of farmers' resources, needs, priorities and perceptions of soil and water conservation in the different agro-ecological zones of Uganda.
- A database on soil and water conservation in Uganda should be developed. This will not only facilitate networking between stakeholders in soil and water conservation, but will also be a positive step towards modeling soil and water conservation in the country.

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5

QUALITY AND IMPACT OF AGROFORESTRY RESEARCH
BY

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INTRODUCTION

Agroforestry, which involves the application of a vast array of biophysical and socioeconomic disciplines, is a scientific art. The implication is that researchers have a dual obligation of developing better solutions to land management problems and advancing the science of Agroforestry (Nair 1998). In Uganda, Nielsen (1995) presents evidence that Agroforestry has been practiced for more than 5000 years while formal Agroforestry research dates back to 1935. Recommendations for Agroforestry (mainly shade trees) were developed with regard to cash crops, especially coffee in particular. Contour hedgerows were recommended in the Kigezi highlands in 1937.

Interest in Agroforestry research increased in the 1980s, spearheaded by non-governmental organisations (NGOs) and the Forestry Department. In 1986, the Agroforestry Research Networks for Africa (AFRENA) was established as a collaborative initiative between the International Centre for Research in Agroforestry (ICRAF) and various research organisations in African countries. In Uganda, it is now implemented by the Forestry Resources Research Institute (FORRI) of the National Agriculture Research Organisation (NARO). Agroforestry is one of the four research programmes of FORRI and Agroforestry curricula have been established at tertiary education institutions.

The main categories of Agroforestry research in the early 1980s were methodological investigations and system/component descriptions, but their relative importance later declined when empirical (quantitative and experimental) research became more dominant. Empirical research has involved mainly soil improvement by trees and soil management, screening and evaluation of multipurpose trees/shrubs, and development and evaluation of Agroforestry technologies in relation to local land use systems. Early experiments concentrated on hedgerow intercropping and screening of tree species for upperstory Agroforestry in Kabanyolo Makerere University Farm, Namulonge and Kifu.

Over the last decade the interest of farmers, professionals, local and national leaders in Agroforestry has greatly increased in Uganda. Recommendations by the parliament, ministers, donors and professionals at an Agroforestry symposium (September 2000) to make Agroforestry a platform for development are evidence of the increased profile of Agroforestry. Consequently, the blueprint for the development of Uganda's agriculture, the "Plan for the Modernization of Agriculture" (PMA) highlights the importance of Agroforestry, whereby "Agroforestry will be treated like other crop commodities and be provided with extension services at farm level as a decentralized function" (GOU 2000).

Agroforestry in Uganda's development

Strategic and adaptive research on farms in Uganda has confirmed the great contributions Agroforestry can make to the livelihood of rural households and the rehabilitation of ecosystem functions (AFRENA-Uganda 2000; AFRENA-Uganda 2001, Raussen *et al.* 1999). Promotion of Agroforestry through government extension services and NGOs is successful in various parts of the country, although still only a fraction of the potential impact of Agroforestry has been realized. The impact of Agroforestry research and dissemination may largely increase if the rather fragmented efforts could be interlinked. Making Agroforestry innovations available to at least a quarter of Uganda's rural households over the next decade would be a tremendous but achievable task.

A new and promising pathway for the adoption of Agroforestry in Uganda is through farmer-based organisations supported by the recently decentralised and empowered local governments which were democratically elected in 1998 (Raussen 2000; Raussen *et al.* 2001). A similar 'Landcare' approach has been very efficient in Australia, Southeast Asia and is beginning to emerge in various parts of Africa (Garrity 2000). However, targeting the most important areas and vulnerable farming systems is often not easy for local planners. Modern tools like GIS could provide better decision support. Using geographical features, for example, local watersheds rather than administrative boundaries should be considered an opportunity to enhance research adoption rates (Raussen *et al.* 2001).

Learning from successes and failures of various research and dissemination approaches will be essential to design an efficient and cost-effective partnership program for scaling up Agroforestry in Uganda. Hence, a monitoring system should be designed to provide insights in the adoption of Agroforestry practices and on the efforts (costs) of the dissemination approach. Given the size of Uganda, its farming population and the diversity of its agroecological zones and farming systems, high-quality research and dissemination of Agroforestry innovations will only be feasible as a multi-institutional initiative. This may be achieved through a framework for a partnership approach based on agro-ecological zones.

Agroforestry adapted to Uganda's agro-ecological zones and farming systems

Climate, soil and terrain interact with farmers' traditions, preferences and the local socio-economic situations, resulting in varied agricultural systems and land-use practices. For Agroforestry innovations to be adapted to the local situations the above factors are important. More than two decades of Farming Systems Research and Extension have confirmed the importance of locally adapted innovations for successful scaling up. "Blanket recommendations" have generally not worked.

It is useful to define areas that share common natural features and agricultural characteristics, the so-called "agroecological zones" and to convey their similarities and differences (Worthmann and Eledu 1999). Various delineations of agro-ecological zones have been proposed for Uganda. Recently a detailed study has been produced by Worthmann and Eledu (1999) which, based on 25 variables, proposes 33 agro-ecological zones. The information is detailed although may still have to be combined with local knowledge and local studies for planning at the district or sub-county level. At national level an aggregated delineation with 12 agro-ecological zones has been proposed by NARO and is the basis of the planning at the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF). The zones are Eastern, Eastern Highlands, Karamoja Drylands, Lake Albert Crescent, Lake Victoria Crescent, Mid Northern, Northern, South East, Southern Drylands, Southern Highlands, West Nile, and Western highlands.

NARO has begun to establish an Agricultural Research and Development Centre (ARDC) in each of these zones. These 12 ARDC will serve as centers for adaptive research and dissemination. District Agricultural Training and Information Centers (DATICS) will support the dissemination. It is proposed that the partnership program for scaling up Agroforestry would use the same broad delineation to ensure congruence in planning, adapted technology development, and better dissemination through improved technology targeting. Furthermore, the size of the zones appears to be appropriate to combine short distances for information exchange and a critical mass of organisations for joint planning. Such a decentralised approach is in agreement with the research strategies of the PMA, which aim at addressing the "unique constraints faced by subsistence farmers in the different ecological zones of Uganda" (GOU 2000).

Accelerating the adoption of ecologically and economically sound Agroforestry innovations, requires: (a) The intensification of Agroforestry dissemination in areas where such work has been ongoing for some time, and (b) developing a national Agroforestry strategy that would also cover areas where such work is still in its early stages. Promoting the latter (b) at the expense of the former (a) would likely result in the loss of very valid experiences and studying ground regarding the development, adaptation and dissemination of Agroforestry innovations.

Agroforestry information dissemination

Agroforestry information is a very important component since economic development is underpinned by the application of scientific knowledge and new technologies. Consequently, access to relevant, timely and appropriately re-packaged Agroforestry information is an important prerequisite for conducting effective research and rural development. Lack of access leads to comparative isolation and limits the speed of progress. Therefore, there is a need for equitable access to core Agroforestry information. Modern information technology and in particular, the Internet, has the potential to improve the quality and timeliness of Agroforestry information, the efficiency of its management, and the relevance of presentation methods. With efficient dissemination, more users can be reached simultaneously and in real time.

A missing link between research and extension is the translation of findings into simpler, usable reference and dissemination materials. Research tends to target journal publication, which reaches only the academic category. Translation of established fact into fact files, posters or other well illustrated practical messages is rarely undertaken. Perhaps this is a precaution against undue implementation. However, preventing farmers from accessing or implementing research findings 'too early' precludes their sensible contribution to knowledge generation and testing, and restricts them to being only receivers.

It is therefore imperative before any research and development activity is undertaken to access information to establish what has already been achieved or taking place. A balance between published journal/book material and grey literature in extension project reports from a number of relevant organisations (preferably in the intended zone), is an invaluable spring board for the subsequent decisions. Recorded knowledge helps in choosing the most promising topics for research and development projects. It can be used as a standard of comparison for judging the quality of a variety of methodologies and technologies from which to select the most appropriate to specific research or development needs. Similarly, information in a form of feedback from the farmers is very vital in assessing whether or not the technologies are meeting the farmers' needs to enable the researchers, planners and policy makers to adjust accordingly.

On the other hand, information is one of the outputs of research and development activities. A lot of valuable information is generated and accumulated in scientific journals, workshop papers, annual reports, technical papers/ notes, pamphlets, newsletters, institutional reports and many more. The AFRENA progress report and Newsletter (Agroforestry Trends) are valuable publications for Agroforestry development. Such information should reach all stakeholders of Agroforestry. To achieve this, all the information should be systematically organised and managed to enhance timely access.

Agroforestry information has the potential to contribute effectively to poverty alleviation and environmental sustainability by enabling all stakeholders in Agroforestry to make informed decisions. However, the full potential of Agroforestry to provide these important goods and services from various initiatives undertaken, has not been realised. This has been attributed to lack of an appropriate information base and systematic dissemination of the research findings, and absence of the systematic feedback from the farmers. Farmers should readily access information. This requires translation of Agroforestry information into language(s) best understood by farmers.

Main information dissemination constraints

The major constraints in the flow of Agroforestry information in Uganda include the following:

- Limited timely access to the scientific and technical information vital in planning and executing research and development activities.
- Poor communication infrastructure.
- Limited capacity to effectively harness information.
- Failure to exploit modem information technology.
- Lack of effective budget for information.
- Lack of awareness about relevant sources of information.
- Lack of Agroforestry information strategy.
- Insufficient knowledge base to promote Agroforestry research and development.

GENERAL AGROFORESTRY RESEARCH OUTLOOK

Generally, the gains and developments in Agroforestry research over the last few decades are impressive, but a number of questions are still to be answered. For example, what direction should Agroforestry research take? The charter of ICRAF's 1977 mandate states that research in Agroforestry would and should lead to alleviation of hunger and poverty, reversal of environmental degradation, reduction of deforestation, and enhancement of fuelwood and fodder supply. To what extent have these expectations been fulfilled? Deforestation, shortage of fuelwood and fodder, and soil erosion are the land management indicators that are likely to be most influenced by Agroforestry. The situation in respect of any of these is not satisfying (Nair 1998). Because improvement has been so slow or non-existent, ICRAF's main goals for Agroforestry remain basically the same today as they were 20 years ago: alleviation of poverty, increasing food and nutritional security, and enhancing environmental resilience.

On-farm Agroforestry research is promoted although it is expensive, slow, difficult to control or replicate, challenging to design and analyze its data, and it is also prone to loss of focus. However, it is multidisciplinary and enforces a systems approach to problem solution. It also results in practical deductions, the applicability of which, is clearer than that from field stations. Although on-farm research complicates work for researchers, it simplifies implementation for farmers. However, participating farmers bear substantial cost in terms of land, especially when results differ from desired hypotheses.

It is accepted that the main focus of Agroforestry research should be to generate technologies for solving land management problems and that research should be a means rather than an end in itself. In the era of dwindling research support, it is imperative to priorities the research agenda of Agroforestry for the 21st century. Lists of research topics that appear in many publications need to be combined, co-coordinated, and prioritised according to well-thought-out directions. Some general areas and topics which ought to be considered while setting the Agroforestry research agenda for technology generation in the future, have been discussed by Nair (1998), some of which, are highlighted below.

Indigenous under-exploited trees

Traditionally people throughout the tropics have depended on indigenous plants for a variety of basic household needs. Exploitation of these indigenous trees through domestication and improvement was recognised as one of the most promising opportunities in Agroforestry. Systematic efforts in this direction, however, have not been undertaken until recently. Most tree selection and improvement efforts have often involved popularisation of exotic species. Domestication, improvement, and exploitation of indigenous trees should be a major focus of Agroforestry research in the 21st century. Domestication of these tree crops could increase yields, provide higher quality products, enhance commercial potential, and above all, contribute to the food security of the local population.

The 'agro' part of Agroforestry

In most discussions of development efforts, and research initiatives, Agroforestry is perceived as more a part of forestry than agriculture. In reality, Agroforestry is an aspect of neither agriculture nor forestry. Agroforestry has (or should have) an identity of its own. For several reasons, all discussions on component improvement or research tend to center around trees. However, the 'agro' component of Agroforestry is important too, at least from the production point of view. Usually, in Agroforestry experiments, the crop component is considered as 'given'. In most cases, the varieties used are improved genotypes that have been developed for high performance under conditions of optimum supply of light, nutrients, and water, and freedom from pests and diseases. Paradoxically, Agroforestry is expected to do well under conditions that are far from optimal for the performance of agronomic crops. Thus crop varieties that are adapted to less-than-optimal growth conditions are essential in Agroforestry. However, breeding/selection of crop varieties adapted to sub-optimal conditions such as low light has rarely, if at all, been attempted.

Impact assessment and evaluation procedures

A major problem facing Agroforestry research is the lack of a comprehensive, robust, and widely applicable methodology for realistically assessing the benefits and impacts of Agroforestry practices. It is essential that the development of appropriate methodologies that embody economic, social, and environmental costs and benefits of Agroforestry should be a priority item in the Agroforestry research agenda for the 21st century.

Policy environment

Analysis of the experience of several countries in Latin America and Asia has shown that rapid and dramatic expansion of agriculture and plantation occurred when supportive public policy was put in place through appropriate subsidies, national investment, and adequate extension programmes. Major policy research issues that ought to be addressed in Agroforestry include: (i) land and tree tenure, (ii) assistance to farmers when trees in Agroforestry systems are not productive, (iii) evaluation of environmental externalities, (iv) improving the institutional structures governing marketing of Agroforestry products, and (v) provision of information and extension needs. Focus on how the legal framework can facilitate formation of cooperatives or common commodity farmer groups, which is the only way Agroforestry farmers can obtain significant benefit from markets, will also be very helpful.

Spatial issues: the need for larger-scale perspectives

Agroforestry field research has so far focused on smaller spatial scales, or research plots in experimental stations or farmers' fields. Publications that appear to take broader scales (global, regional, or even watershed scales) usually address the issues in a conceptual generalised manner, with little data from empirical investigations. Consequently, the importance of Agroforestry in issues that need to be assessed on a much larger scale than individual fields or plots - for example, carbon sequestration, water quality improvement, biological conservation and biodiversity, and extraction of non-timber forest products, has received little attention.

Gender issues

If implementation of Agroforestry depends on gender issues, gender constraints have only been identified, but no solutions or circumventing strategies have been generated or tested.

CONCLUSIONS AND OUTLOOK

Although Agroforestry is a traditional practice in Uganda, its science is relatively recent. Empirical research has confirmed the great contribution Agroforestry can make in the livelihoods of rural households and ecosystems functions. However, the full potential of Agroforestry to provide important products and services countrywide from various initiatives is yet to be realised. More emphasis should now be placed in harnessing the science of Agroforestry to develop and disseminate technologies applicable to the specified ecological zones of the country.

Operationalising this is a multi-institutional task. Networking is proposed to enhance synergies and to integrate the many local Agroforestry initiative into a countrywide programme. The following recommendations will particularly facilitate the flow of Agroforestry information.

- Building a sound information base by identifying existing Agroforestry information, organising it, and making it easily accessible to users.
- Developing Agroforestry information strategy to be able to put in place critical information services including: bibliographic databases, selective dissemination of information, literature searches, current awareness, document delivery, e-mail and internet connectivity
- Capacity building in Agroforestry information management, re-packaging information for various stakeholders, sources of Agroforestry information, modern information techniques, such as designing a website, information retrieval form the internet and CD ROM.

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6

MARKETING OF AGROFORESTRY COMMODITIES IN UGANDA

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INTRODUCTION

According to the Forestry Policy (2001) of Uganda, 90% of national energy demand is met from firewood and charcoal. An estimated 550,000 m^3 of wood is used for building, fencing, furniture making and other manufactured goods. Yet an unspecified amount of other products are used as non-wood products (medicine, crafts, nuts, etc). FAO (1991 1992) estimated that fuelwood accounted for 60% of the total energy used in Africa in the early 1980s. It is further indicated that 24 countries in Africa obtained more than 80% of their energy needs from fuelwood. In Uganda, it is estimated that 96 % of the households use firewood for energy purposes (Kyaroki and Tunyareeba 1999; Ministry of Water Lands and Environment 1999). This demand has increased tremendously due to a number of factors, including a fast rate of population expansion and increased rate of urbanization (Boserup 1965). It is now estimated that fuelwood in Africa accounts for 90% of the total energy use (Mnzava 1981). This increased demand has shifted fuelwood from being a "common property good"(where it was consumed without payment of any money, from existing forests), to being a marketable commodity (Hosier 1981; Scheer 1995; Tomich 1996).

Post harvest marketing, the major concern of this paper, involves bridging of the gap between producers and consumers of Agroforestry (AF) products and services. It therefore involves covering space (transportation), time (storage), changing raw products into final products (processing), releasing when it is needed (creating time) and retailing (buying and selling). Marketing is therefore a very complex system involving numerous channels (paths), activities, stages, human beings, and institutions (Ministry of Finance and Economic Planning 1998; Taylor *et al.* 1996; Tomich 1996). It works efficiently if there is market information (what prices are available for the products, where, who wants what and how much). Market information is needed by all concerned (producers, technology developers, traders, processors and consumers). Once what is needed is known, the quantity and quality, and when and it is needed, scientists developing Agroforestry technologies can come up with the appropriate technologies that would meet the marketing characteristic of various AF products. Marketing therefore adds value to products from rural areas. It is also a source of income, which rural communities can use for purchasing food and other consumer goods that are not produced on farm. It therefore enhances food security and general welfare of rural farming communities.

The main consumers of forest/tree commodities are the farming communities, wood and non-wood industries (furniture makers), institutions, agro-processing industries (local brewers, fruit and food industries) and households in urban areas (Forest Department 1992; Ministry of Water, Lands and Environment 1999; Mrema *et al.* 2001; Mwebesa 1998). However, very little information is available on the quantity and the type of each product consumed, and the quantity supplied at any particular period. Such information is necessary for long and short term planning by both the producers and marketers of AF products and services (Gorretti and Tsigas 1994).

The bulk of forest products exchanged in marketing come from natural, community, farm and urban forests (Gombya-Ssembajwe 1985, Ministry of Water, lands and Environment 1999). The forests provide both direct and indirect products and services. The direct products could be perishable (fruits, medicines, etc.) or non-perishable (timber, building poles, fencing posts, firewood, charcoal, etc.). AF services include increased yields of crop produce from increased soil fertility, shelter and increased milk from fodder (Kyeyune 1999).

Unprecedented increase in demand for AF products has resulted, in many instances, in over harvesting of the products or harvesting in an unsustainable manner. This has resulted in the disappearance of many species of trees and shrubs (Mander *et al,* 1996). Over-harvesting actions, resulting mainly from lack of awareness and training of the suppliers, and low remuneration on the part of the harvesters (Banana 1996), have prompted many governments to set up policies to ensure that harvesting of such products is done sustainably (Ministry of Water, Land and Environment 1999; Mwandosya and Luhanga 1985; Scheer 1995; Taylor *et al.* 1996; Tomich 1996). Such policies include declaring some natural forests as reserves, aforestation, reforestation (Fleuret 1983) and the promotion of private plantations by local industries and communities. This is where Agroforestry (AF) can significantly contribute towards meeting some of the needs for direct and indirect, perishable and non-perishable, woody and non-wood forest products and services.

Agroforestry interventions contribute to the satisfaction of subsistence needs (fuelwood, food, and building materials (Gombya-Ssembajwe 1985; Mgeni 1996; Mrema *et al,* 2001). In addition, such interventions provide substitutes for purchased farm inputs, such as fencing poles, animal feeds, green manure, herbs (Hosier 1981; Mwandosya and Luhanga 1985), and opportunities for supplementing cash income through sale of raw or semi processed agroforestry products (Mgeni 1996; Taylor *et al.* 1996). The cash income can be used for the purchase of non-farm goods and services (Melynk 1996).

IMPORTANCE OF AGROFORESTRY COMMODITIES TO UGANDAN LIVELIHOODS: MABIRA CASE STUDY

For more than two decades "modern" AF has been introduced on farm to meet farmers' demands for fuelwood, building poles, fencing posts, fruits for nutritional purposes, timber for sale, and services such as hedge row planting for soil fertility and fodder for increased milk yields (Kyeyune 1999; Scheer 1995). This is because communities were perceived to be the major users of tree and forest products, and the major degraders of natural forests. A survey done in the Mabira forest buffer zone, revealed in fact that this is not always the case. While a rural household of an average size of 10 members (80% of which are children below 18 years of age) use about 33 kgs of charcoal and 30 bundles of 20 pieces of fire wood per month mainly for cooking, brewing and ironing, 63% of the firewood and 7% of the charcoal came from the trees growing on the farm. Only 25% of firewood, but up to

66.7% of charcoal were obtained from the surrounding Mabira forest (Mrema *et al.* 2001).

Fuelwood from farmlands and the forest is sold to sugar and tea factories. Sugar factories use 350 tones of fire wood per day to produce a total of 150 tonnes of sugar, for 44 weeks in a year (Mrema *et al.* 2001), while tea factories use 1 tonne of firewood to dry 3-5 tonnes of tea leaves (Wajja-Musokwe *et al.* 1999). Other industries that were found to hardly produce any fuelwood but purchased from the farms and traders cutting fire wood from the forest are brick and charcoal burners. Due to increasing demand for construction in the 4 urban areas surrounding the forest (Kampala, Mukono, Lugazi and Jinja), each brick burner was found to burn an average of 67,000 bricks a year, using lorries, tractors and pick ups to transport tree trunks from farmlands or the forest to their work places. A 7-tonne lorry accommodates 10 large trees (20 meters tall) or 15 medium size ones (10-15 meters tall). It takes one such lorry full to burn 20,000 bricks. Each charcoal burner on the other hand produced 120 sacks of charcoal (70 kg/sack) per annum with 15 medium-size trees yielding 15-20 sacks (Mrema *et al.* 2001).

Although sugar and tea factories grow *Eucalyptus* trees in plantations, products from such plantations are kept for emergency use only. Much of the firewood used in these factories still comes from the nearby forests and farms. This is done through contracted farmers who cut and load the trunks onto the various transport sources. The market therefore does the work of meeting the needs of the factories and brick burners. While charcoal burners usually purchase trees in the forest enclaves on farms or illegally cut from the forest.

A lorry load of firewood costs between Uganda Shs 40,000-60,000 depending on the distance and the type of firewood (tree species from which the firewood was cut). This means that if the trees come from private small farmers, then part of this income generated is transmitted to the farm. In this case marketing, although is still at a very primitive level (only tasks performed are cutting down of trees, chopping them into manageable billets, loading, transportation and offloading them) adds value to the trees grown. However the amount of income farmers generate from firewood depends on the number of trees harvested, the frequency of harvesting and the prices for the trees offered at the farm. The sustainability of tree production is important. Currently, the communities surrounding the Mabira forest are planting several tree species including *Ficus natalensis, Markhamia lutea* and *Maesopsis eminii* to ensure sustainable fuelwood production (Mrema *et al.* 2001).

While local industries have been found to have very high demand for fuelwood, households in the urban areas and institutions surrounding the forest have been found to have greater needs, which also keep growing. Table 6.1 shows the average energy purchased by each household, of an average size of 7 members, in four urban areas of Kampala, Mukono, Lugazi and Jinja that surround Mabira forest buffer zone. The prices of charcoal in the urban areas are substantially higher than Ug shs 3,100 offered per sack of charcoal at the farm. The difference in price is the value added by the market (cost of employing labour for various activities, processing transporting and retailing, etc.).

TABLE 6.1: *Energy needs of households in four urban centers surrounding Mabira forest buffer zone*

Type of Energy	Monthly household energy consumption			
	Kampala	Mukono	Lugazi	Jinja
Household size (average)	7	7	6	6
Firewood (bundles)*	9.2 (500/=)	23.4 (460/=)	6.3 (652/=)	14 (600/=)
Charcoal (70 kg sack)	1.3	1.5	1.6	1.7
(Price/sack)	(7950/=)	(6860/=)	(5090/=)	(6700/=)
Electricity (in shs)	13000	Not available	Not available	15000
Gas (67 kg cylinder)	0.8	Not available	Not available	Not available
Paraffin (litres)	2.9	5.2	2.9	5.2

Source: Mrema *et al.*(2001) * a bundle contains between 20-25 pieces - split or whole pieces

The most popular energy source in urban households surrounding Mabira forest is charcoal (Table 6.2). This confirms the importance of fuelwood to urban households. It also confirms the importance of marketing as a bridge between production sources in the rural areas and the consumption centers in urban areas. The marketing activities are therefore a source of income in the rural areas.

TABLE 6.2: *Energy consumption in urban centers surrounding Mabira forest*

Type	Energy consumption (%)			
	Kampala	Mukono	Lugazi	Jinja
Charcoal	97	81.8	88.2	93.9
Firewood	18.2	59.1	70.6	30.3
Gas	6.1	0	0	0
Electricity	21.2	27.3	17.6	51.5
Paraffin	36.4	63.6	52.9	57.6

Source: Mrema *et al.*(2001)

Households in Mukono, Lugazi and Jinja which are nearer to Mabira forest consume more firewood and charcoal from the forest than Kampala households which may supplement fuelwood with petroleum products (paraffin and gas) and electricity. While the transportation of fuelwood to Kampala is mainly done using large lorries carrying, for example, more than 100 bags per trip, those near Mabira forest use tractors, pick ups and bicycles.

A survey of the schools, a prison and a hospital around Mabira forest established that 100% of the energy, mainly for cooking, was firewood purchased mainly from private farms or brought in by traders from the forest. Schools use 1.5 7-tonne lorries of firewood per month, mainly for cooking for an average of 752 children (some boarders and others day scholars), 3-4 meals a day. Some of the schools however (50%) conserve energy by using energy saving stoves. They also supplement the firewood with an average of 126 sacks of charcoal per month. The prison in Mukono, buys 1.3 lorries of firewood to cook 2 meals for 25 prisoners while Kowolo hospital, with 2400 patients /month, use 1 lorry full of firewood per month for cooking 2 meals a day. The quantity of fuelwood used per institution depends on the method of cooking used. Apart from some schools, the institutions were using open fire to cook. The amount of fuelwood is also high because in all these institutions, the type of food cooked and the high cooking frequency (beans 79% of the times, matooke 77% of the times, etc) require a lot of energy. The institutions spend Ug Shs 175 000-180,000 per trip for firewood (Mrema *et al.* 2001).

Some of the income spent by institutions and households on fuelwood goes back to the farmers and some remains with the traders. According to Mnzava (1981), 30% of the household budgets are used to purchase fuelwood. The need for fuelwood continues to grow and can not be controlled (Mrema *et al.* 2001; Mnzava 1981). Therefore, the questions to be asked are: how much can AF contribute towards these needs, how much of the income generated goes back to farmers in rural areas and how much harvesting of the products is done in a sustainable manner?

FACTORS AFFECTING THE DEMAND FOR AGROFORESTRY PRODUCTS

It is important to note that demand for some AF products may affect the availability of others if sustainable methods of harvesting are not employed. For example, it has been observed in settlements surrounding Kampala City and the Mabira forest buffer zone areas that fruit trees are being harvested for fuelwood thus causing shortages in the supply of fruits such as mangoes and jack fruits (Nabanoga and Gombya-ssembajwe 2001; Mrema *et al.* 2001). The main factors that influence the demand for AF products include the following:

- A high population growth rate and a large population. This results in more demand for forest products for construction, furniture and fuelwood, and the subsequent destruction of forest resources bases (Table 6.3). It also results in a reduction of the natural forest base due to encroachment for agricultural purposes (Smith, 1992, Mrema *et al.* 2001). This may shift the resulting revenues to AF products on the farm in both the short and the long term, if the harvesting is done sustainably (Hosier 1981; Nilsson 1986; Scheer 1995). The increase in population growth can also result in reduction in farm size. For example, average farm size in Mabira forest buffer zone was found to be 4 ha, but 74% of the farmers had land size of 0.1-2.1 ha. Hence more intensive methods of farming and appropriate AF technologies need to be adopted.
- Increases in prices/rates of fuelwood substitutes will force more households, local industries and institutions to increase their consumption of fuelwood from the current sources (forests and farms).
- Government policies, like universal primary education (UPE), result in greater demand for the construction of school, and for the purchase of more furniture.
- Increasing urbanization rate, which calls for greater construction in the urban areas (more bricks to burn and poles as scaffoldings), timber for furniture and fittings, and more fencing poles (Table 6.3).

Agroforestry will therefore, continue to play an important role as an alternative source of forest/tree products. It will also fulfil the main goal of reducing poverty in the rural areas and increasing food security, if all factors that play a role in its success (discussed under constraints and way forward) are met. It is evident that the rural farming communities are becoming increasingly dependant on on-farm and non-farm incomes, generated mostly from crops, livestock and AF related products (Table 6.4) to be food secure (Table 6.5).

TABLE 6.3: *Farmers' Ranking of Major Destroyers of Mabira Forest*

Category of forest destroyers	Percentage of farmers
Charcoal burners	87.7
Pit sawyers	44.2
Corrupt forest department field officers	28.0
Illegal timber dealers	25.0
Encroachers	9.6
Police	3.8

This is therefore exposing more farmers to markets and increasing commercialization (Arnold 1996; Mrema *et al.* 2001). Although income from AF products on-farm seems insignificant, it is a very important source to fill the seasonal deficit in income due to seasonality of farm products (crops and livestock) (Arnold 1996; Banana 1996). AF creates direct and indirect employment, hence creating more income to households in rural areas.

TABLE 6.4: *Farm and off-farm tree and forest activities per month per household*

	Crafts		Beer		Bee hives[1]	Canoes[1]	Casual Labour	Other	
	Baskets	Mats	Local	Waragi				B/B	C/B
Quantities	50	5	93[2]	10 litres	2	1	11	20000	10
Materials used	Papyrus	Papyrus	Bans/ f/wood	Bans, Sugar mul, f/wood	Trees	Trees	Men	Bricks, f/wood	Trees, f/wood
Source	Swamps, Farms	Swamps, Farms	Farms, Forest	Sugar fact./farms Forests	Farms Forest	Farms Forests	Farms	Forests, farms	Forests Farms
Prices/ unit (Shs)	3500	4400	2611	20000	Do not know	Do not know	3800	34	3100

Source: Mrema *et al.* (2001); [1] per year , [2] in 20-litre cans, [a] households do not perform all the activities; Bans= bananas, f/wood= firewood, mol.= mollusses

TABLE 6.5: *Major food items grown and purchased on farms around Mabira forest*

Food item	Quantity Consumed Per day	Frequency Per month	% of h/holds who consume	% amount grown	% amount purchased	% number of farmers who purchase
Maize(kgs)	2.1	26	90	22	77.8	90
Cassava (tubers)(tins)	0.8	8.0	46.7	88.0	12.0	41.7
S/potatoes(tins)	0.9	26.0	83.3	96.2	25.0	75.5
Matooke(hands)	1.4	20.0	81.7	81.8	18.2	71.3
Beans(kgs)	1.4	26.0	93.3	96.2	3.8	3.0
Fish Tilapia	2	7	20.0	0	100	21.6

Sources: Mrema *et al.* (2001)

CONSTRAINTS FACED IN THE PRODUCTION AND MARKETING OF AGROFORESTRY PRODUCTS

Although AF products and services play an important role in income generation in rural areas, both farmers and middlemen who market AF products face a number of constraints which hinder the full impact of Agroforestry intervention. Some of the major constraints are presented below.

- Lack of linkages between end users of products and developers of AF technologies. This results in non-prioritization of the most effective technologies and non-adoption of the same by farmers, leading to limited trade and income, and wastages of resources (Scheer 1995).
- Lack of information on products in high demand, by whom, how much, where, quality standards, and purposes on the part of technology developers and farmers. This is because there is very little research done on the markets and marketing system. For example, a survey of Britania fruit processing industry showed that the industry uses 250 tonnes of mango pulp per year to make mango juice, 'splash', yet all the pulp is imported from Kenya and India (Mrema *et al.* 2001). The reason for this importation is that the local mangoes are not of good quality for processing because (i) they are too high in fiber, and have very little pulp (ii) source is scattered over a wide area and is in small uneconomical quantities resulting in very high costs of collection. In addition, the supply of local mangoes is unreliable (Mrema *et al.* 2001). The same concern has been raised by other researchers as in Taylor *et al.* (1996). There is also lack of information on the needs of farmers and consumers to guide technology development and adoption. It is known that small-scale farmers are much more economically efficient in production (i.e. they produce more per unit of each resource used), and that they employ more labour intensive methods hence creating employment in rural areas (Tomich 1996). However, small scale farmers will intensify tree planting only if there is considerable decline in wooded land, or increased population density and declining farm size, or when the cost of production with the new technology is less than the returns. This information is lacking. Hence duplication takes place, and precious resources are wasted.
- Poor infrastructure (roads, communication) that makes transportation very costly hence it deflates farm gate prices and inflates prices at the market for consumers. This therefore reduces the income generation effect of AF intervention, by creating disincentives for both producers and consumers.
- Lack of awareness by producers on the markets (what the prices for these products are, where they are needed, how much, in what quality etc) and on the production methods (how to plant and manage seedlings and the AF trees and shrubs). This prohibits proper short and long term planning of production, harvesting and marketing of products. Planting, harvesting and marketing are therefore, done haphazardly, disjointedly and seasonally (only when urgent cash is needed).
- Certain government policies also discourage adoption of AF technologies, e.g. the Land policies in Uganda. Most farmers in Buganda may find it difficult to establish woodlots because the land does not belong to them. However, they can plant fruit

trees as these are regarded as agricultural crops. Most farmers are also not aware that the Land Act, of 1998 gives them full ownership of any tree they plant. Some farmers continue not to plant trees for fear of Forest Department (FD) officials who stop them from cutting such trees for sale.

- Lack of training and education makes adoption and management of AF technologies very difficult.
- AF technologies take too long to give a return to farmers (Tomich 1996). This discourages farmers from tree planting, and they opt for faster income generating ventures such as harvesting from forests at no cost.
- When it comes to trade-off between food/cash crops and livestock on one hand, and trees on the other, small size farms, farmers would rather opt for food self sufficiency than planting trees that would not mature for say 15-20 years.
- Some of the technologies require high investments compared to the resources available to the rural farmer.
- Lack of accessibility to planting materials (seed and seedlings).
- Cultural, traditional laws and beliefs in many African countries bar women from owning land, and planting trees – it is believed that such acts can cause death of the husband, infertility, and it undermines the husbands' authority (Davison 1987; Nwonwu 1996). Tree planting is therefore, hindered since the main workers on farms are the women.
- Government apathy and urban market prejudice against the so called "minor products" - the wild fruits, herbs and medicines, wild nuts and honey (Mander *et al.* 1996; Taylor *et al.* 1996) with potential markets, has resulted in non vigorous marketing of these products that form a big proportion of income generated (especially seasonal income) at the farm. This attitude has resulted in over harvesting of trees and shrubs in the forest without replanting with some species being endangered (Taylor *et al.* 1996).

CONCLUSION

AF intervention in Uganda has contributed a lot in terms of products and services to small farmers, some of whom, had been practicing traditional Agroforestry for years. It has provided income to farmers either directly or indirectly and hence, has assisted them to achieve food security and some improvement in their welfare. It has also created employment in rural areas. However, both farmers and marketers of these products face a good number of constraints that make full realization of the objectives of AF a slow and painful experience. More can be achieved if a lot of the constraints are tackled through research by appropriate sectors of the economy, which AF is trying to address.

Way Forward

- Research should be done on markets (their sizes, where they are and preferences) to facilitate identification of appropriate technologies for development and dissemination.

- ❖ Research should also be carried out on factors that determine adoption of identified technologies in order to assist the adoption process by farmers.
- ❖ Awareness should be created within farmers regarding markets, and marketing priorities and requirements for Agroforestry products, through appropriate information dissemination programmes.
- ❖ Improve networking and data sharing between extension officers, NGOs and others, on markets and producers' needs.
- ❖ Government intervention by providing enabling amenities, laws and incentives to plant more trees on the farm to meet the growing needs, so as to increase farmers' income and reduce degradation of natural forests.

If some of the constraints are reduced, Agroforestry is likely to answer the following commonly asked questions:

- Should Agroforestry emphasize tree growing for cash or subsistence use? At the moment there is confusion as what it needs to accomplish.
- How effective in relative terms, are Agroforestry interventions in improving the welfare and food security of farmers?
- Should Agroforestry programmes concentrate on meeting specific household needs (food, cash, fuel) or should they provide support for a wider range of uses (soil fertility, post, poles, timber medicines, etc.)? At the moment the objectives are confusing and as such the effects are hard to see.
- Should Agroforestry intervention be targeted to poor or rich farmers?
- How much emphasis should be placed on new tree planting to meet households' needs, and how much on management of existing technologies?
- What policies need to be put in place and implemented in order to increase the probability of success?

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7

GENDER ISSUES IN AGROFORESTRY IN UGANDA

By

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INTRODUCTION

Agroforestry is a system of sustainable management of resources for agriculture to satisfy changing human needs, while maintaining the quality of the environment and conserving natural resources. Gendered Agroforestry programmes are important because over 80% of employed women are agricultural workers (Ministry of Gender and Community Development 1998).

Resource depletion and destruction in Uganda has shown strong gender influences. It is therefore sensible that promotion of technologies for natural resource restoration or management is gendered. The traditional ways of thinking must change towards a more holistic approach that enhances clearer understanding of gender issues in Agroforestry as significant and complimentary to the social economic advancement in most rural areas.

Agroforestry addresses multiple domestic and farm needs such as fuelwood, fruits, fodder, fertile soils, soil erosion control, water recycling, and shade for certain crops, timber, poles for building and stakes. The triple role of reproduction, production and community service overburdens rural farming women.

Agroforestry promotes farming and management of natural resources in a productive and conserving manner. The extent to which Agroforestry contributes to household welfare from a gender perspective is affected by many socio-economic factors. Uganda is a multicultural society in which men and women have varying relative status, roles and responsibilities, and varying access and control over productive resources (Mangheni and Kwesiga 2001).

Conceptual issues related to gender and Agroforestry

A household is the basic social unit created by marriage, which provides a primary social identity to its members and the potential for continuance through birth of children, property transmissions and inheritance. Within the household there are shared or allocated roles and status, with different household members having varying degrees of authority, control and power. Households are impacted by society or communities and the physical environment. Society can affect households through public roles and political involvement, religious authority, employment patterns, and legislation. The traditional gender hierarchy within households tends to regard men as planners, thinkers and decision makers while women are acceptors of decisions and guardians of children and customs (Montes 1999).

Some extension agents perceive forests and trees as a dominion of man, and the kitchen and the home garden as the place for women (FTTP 1995 cited in Montes 1999). This can be a constraint since extension workers are channels through which institutions transfer technology and conduct training with or without a gender approach. With the coming of new extension thinking and practice that requires participation of beneficiaries in problem identification and planning for solutions, there is a need for gender-balanced approaches to be incorporated in Agroforestry promotion and planning.

Gender based planning is necessary and requires desegregation of households and families within communities on the basis of gender by identifying men and women, and boys and girls (Moser 1991). Women's triple roles must be taken into consideration when identifying their priority practical and strategic interests and needs. Projects must clarify which of the 3 roles and which of the 2 types of needs they address and how.

Box 1
Key gender issues in Agroforestry:

The most important gender issues to consider in Agroforestry extension and technology design are:
- Status, authority, control and power of different household members over land and other resources.
- Decision making, planning and implementation roles.
- Forest and tree uses for different genders.

Introduction of Agroforestry projects and programs therefore requires a thorough analysis of factors within the social system that affect access to resources by women and men. These include the type of social organisation or social system, authority or political leadership and religion, education levels, and values /attitudes of both men and women. In addition, the socio-economic and cultural factors that affect the status of men and women in areas where Agroforestry is to be practiced must be established. Men and women use forest, tree and wood products in different ways. Women typically gather forest products for fuel, fencing, and food for the family, fodder for livestock, medicine, and raw materials for income generating activities. Men on the other hand use many non-wood forest products, but more often, cut wood to sell or use for building materials (Mangheni and Kwesiga 2001).

Gender sensitivity in Agroforestry

When the environment gets degraded women, men, girls and boys are affected differently. For example, women and girls may have to spend more time and energy fetching firewood, water, wild fruits and medicinal plants, and less time on other productive activities. The nutritional status of the home may deteriorate due to the reduction in the number of daily meals and avoidance of foods that require more energy to prepare. Income generating activities involving the use of fuel and water may also be avoided.

Agroforestry aims at overcoming or avoiding environmental degradation which specifically impacts negatively on women, and thus limiting their ability to satisfy their practical (e.g., fuelwood, improved nutrition and food security and increased income from sale of surplus) and strategic needs.

The strategic gender needs met will depend on the approach used by the promoting institution. With a participatory or group extension approach and involvement of communities in planning, farmers can obtain training, get better linkages and gain skills in lobbying and advocacy. Boys and girls may attend school, and men benefit from reduced expenses on food at home, but mainly from sale of products such as poles, timber, seedlings as well as gaining leadership roles in the community.

Ways in which Agroforestry interventions become gender insensitive

Good Agroforestry is potentially labour intensive, requiring management of crops, animals and trees on the same piece of land. Shoot and/or root pruning are often necessary to minimize competition for light, water and soil nutrients. The timing of Agroforestry products output, like fuel, fodder and green manure, must also be carefully managed (Vi 2001). Consequently Agroforestry adds to the labour, time and financial burdens of households, with often women taking the larger share especially if men are engaged in off-farm activities.

Organisations responsible for Gender issues in Agroforestry in Uganda

Social relations of gender are intertwined and determine the environmental resource use. Polices have however, failed to eliminate difficulties of involving women and men in projects designed for their benefit (Green *et al.* 1998). Below are some of the institutional frameworks in Uganda guiding and promoting natural resource management, and Agroforestry in particular.

The Ministry of Gender Labour and Social Development

The Ministry of Gender Labour and Social Development has been mandated by the government of Uganda to spearhead the institutionalisation of the policy on gender in the country. The National Gender Policy goal was enacted to guide national planners, policy implementers and development practitioners in improving the social, legal/civic, political, economic and cultural conditions of the people of Uganda with particular emphasis on women.

The specific objectives of the policy are to:

- Provide policy makers and other key actors in development with field reference guidelines for identifying and addressing gender concerns when taking development policy decisions.
- Identify and establish an institutional framework with the mandate to initiate, coordinate, implement, monitor and evaluate national gender responsive development plans.
- Redress imbalances, which arise from existing gender inequalities.
- Ensure the participation of both men and women in all stages of the development process
- Promote equal access to, and control over, economically significant resources and benefits

- Promote recognition and value of women's role and contributions as agents of change and beneficiaries of development process (RoU 1997; Mangheni and Kwesiga 2001)

Below are some cases of Agroforestry interventions and the related gender issues in southwestern, northern, central and eastern Uganda.

Kabale district

Kabale is characterized by steep terrain, which is difficult to manage. The district has a high population density estimated at 370 persons per km^2. Farmers in the district practice various soil conservation measures, which involve more women than men (Miiro 1997). However, farmers are still faced with the problem of land degradation due to soil erosion, land fragmentation and over cultivation.

A number of organisations have been promoting Agroforestry in the district. These include among others Africare, AFRENA project, CARE; Development Through Conservation (DTC) project, and Africa 2000 Network. Each of the projects has been employing specific approaches to promote Agroforestry, and focus on gender issues has varied from one project to another.

Africare through its Uganda Food Security Initiative (UFSI) is collaborating with AFRENA – Uganda and local communities, and has initiated a number of activities including the promotion of Agroforestry technologies for soil fertility, soil erosion control and for medicinal, fodder and food production purposes. A participatory planning process involving communities provides for the development of action plans and strategies to implement them. The goal of USFI is to improve food security situation of Ugandans particularly those in Kabale district. In order to achieve this, USFI has laid four strategies: 1) Reclaim and enrich degraded land 2) increase food production and reduce food losses 3) improve year-round farm to market roads 4) improve food access and utilization by all members of the household. UFSI Africare uses a farmer-centered approach to land management involving participatory diagnosis and analysing present land management practices, planning, monitoring and evaluation of the practices, and implementation using locally available resources. These are reinforced with a farmer-to-farmer learning activity. Village production committees are an integral part of the promotions with the role of mobilising the communities and the needed resources, as well as training others. The achievements of UFSI in Kabale district are outlined below:

- 119 community and group nurseries have been established since 1997.
- Many people have been trained with the group nurseries as entry points.
- Leadership capacity of the groups has been built.
- Soil and water have been conserved on fields where Agroforestry trees have been planted.
- Fodder for animals has been obtained leading to increased milk production.
- Farmers have learnt how to manage their land resource for increased productivity.
- Local community structures for managing natural resources have been strengthened.
- There is easy access to good quality tree seed.
- Farmers have received training on tree seed production.
- Stakes for climbing beans can be obtained and fuelwood is now in fair supply.

- A total of 3,181,500 tree seedlings have been planted since 1998 (Kakuru *et al.* 2001).

The achievements of UFSI indicate the extent to which gender issues are addressed during the project implementation processes. Thus, it is likely that practical gender needs as well as strategic gender needs such as community planning and decision making, which have an element of empowerment have been met for women, men, boys and girls.

About 34% of households in Kabale have 7 children per household and only 0.21ha of land to cultivate. The district depends on forest resources and other organic matter materials for its energy sources. Currently the way the biomass from these sources is being produced and used is often unsustainable and causes adverse effects on the environment. For example, only 60% of firewood demand in the district is met presently. Women often prepare meals using crop residues as fuel. The lack of fuelwood and its adverse effects on the environment adversely affects women by increasing their labour burdens. Fuelwood collection in Kabale is a work for women and children. The further away the source of fuel the greater the workload of women and children. This reduces on the time available for other household and income generating activities.

Solutions to this problem have involved the promotion of Agroforestry, both as a soil and water conservation measure, and as a multiple use intervention for farm household welfare. These interventions have been particularly helpful to women who are involved in activities of food preparation and are responsible for looking for scarce fuelwood from far distances. Children are also involved in firewood collection and herding of livestock, which are a menace to the planted Agroforestry trees. However, despite the labour implication of Agroforestry technologies, farmers in Kabale have been able to experience improved human nutrition and availability of fodder for livestock, particularly the zero-grazing of cattle and goats.

The AFRENA project in Kabale has been involved in Agroforestry activities that address household gender concerns and constraints in the district. AFRENA project aims at introducing perennial cash crops, utilizing upper parts of terraces, improving nutritional status of farmers and protecting the environment.

Both AFRENA and Africare have used a participatory community action approach in introducing Agroforestry interventions. Africa 2000 Network has introduced tree nurseries and encouraged tree planting, while CARE DTC project has encouraged the use of improved fallows using trees and shrubs. In the DTC project, both men and women have been involved in experimenting various Agroforestry technologies. Capacity has therefore been built for both men and women farmers to try out things on their own. This is aimed at improving farmers' creativity in managing their land resource.

Mbarara District

Several projects have been involved with Agroforestry interventions in Mbarara district. For example, CARE International, the Uganda Soil Conservation Pilot Project (USCAPP), and the Uganda Land Management Project (ULAMP).

In 1985 CARE introduced a Farm Forestry Project for the aforestation of degraded hills through establishing wood lots and planting of fruit trees (Nyakuni 2001). *Eucalyptus* seedlings were given free while those of fruit trees were sold. In 1992 the new Regional Land Management Unit (RELMA), following a participatory rural appraisal to identify problems and their solutions, initiated the Uganda Soil Conservation Pilot Project (USCAPP). The project which operated a participatory, community ownership approach led to formation of 17 women groups and 21 mixed groups that were regularly engaged in planning, decision making and implementation of different activities..

In 1991, the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) started the Uganda Land Management Project (ULAMP) with the goal of achieving food security and incomes of small-scale farmers through improved land management. The project also used a participatory extension approach utilizing local knowledge and skills as well as involving beneficiaries in decision-making. Common interest groups (CIGs) were formed and they were an important feature of the project whose activities were based on farmers' interests and action plans.

A total of 368 CIGs were formed with a total membership of 7432 people of which, 4156 were women. The project recorded more women than men because the former had prior training in fruit processing, which is an important income generating activity. Women were empowered and efforts of gender awareness increased women participation in tree planting. The project made important achievements including improvement of women's' income, which resulted in better household welfare, and a culture of tree planting especially fire wood species. This success was registered due to consideration of gender needs such as developing fuelwood saving devices, and encouraging many women to be engaged in planting fast growing tree species, such as *Sesbania* and *Calliandra*.

Northern and Eastern Uganda

Experiences of two programs found in the two regions are highlighted below. The two programs that have been promoting Agroforestry in northern and eastern Uganda are the Shea project for Local Conservation and Development Project which operates in Katakwi, Kitgum, Kotido and Lira districts and the Soroti Catholic Diocese Integrated Development Organisation (SOCADIDO) Agroforestry project in Soroti, Kumi, Katakwi and Kaberamaido districts.

The Shea project for Local Conservation and Development is an integrated, rural based project that promotes the conservation of parklands by providing access to improved technologies, micro-credit and high value markets for Uganda shea butter. In addition, environmental education, tree nurseries and applied research activities are conducted. The tree provides shea butter from the sun-dried kernels, food oil for home consumption (Lovett 2001) and charcoal. Household practical gender needs are therefore addressed by the availability of food oil which women need to prepare meals, and cash benefits for both men and women from sales of the product.

Gender-desegregated data and information showing the extent of involvement in tree management has ensured the targeting of the most appropriate persons. The project has led to increased household income, raised the value of shea trees and enhanced their conservation. There is, however, no information to show the gender benefits and how. The project involves a number of stakeholders ranging from policy makers to farmers, but the representation of different genders and their different interests are not documented. Lack of such clear gender analysis and their involvements may explain why the project has some constraints such as weak organisation structure, inadequate links to key national institutions, high costs and lack of a sustainable strategy (Lovett 2001).

The SOCADIDO project has introduced Agroforestry to address problems of loss of vegetation due to charcoal burning, brick making, firewood needs and building purposes. These are largely male centered activities in the project area, except for collection of firewood, fruits and medicine, which are mainly women's activities. The project, however, targets both men and women as it focuses on nutritional improvement and food security, environmental conservation and generation of income through diversified sources. Fifteen tree nurseries have been established while 50 other tree nurseries which are privately owned by farmers have also been developed in the four districts. Seedling production has been a major income source to those involved. The SOCADIDO project for Agroforestry does not however indicate the extent to which the benefits have accrued to men, women, boys and girls in the four districts.

South Central Region

One of the major tree planting and promoting organisations in the region is the Vi Agroforestry Project operating in the districts of Masaka and Rakai in south central Uganda. The project is a Swedish Non Governmental organisation (NGO) whose goal is to contribute to improved livelihoods of small scale and resource poor farmers in Rakai and Masaka districts. The immediate objectives of the project include:

- Increased fuelwood availability at household level in 1 – 5 years (2000 – 2004).
- Increased food and nutritional security at the household level in 1 – 5 years (2000 – 2004).
- Increased sources of income at the household level in 1 – 5 years (2000 – 2004).

The VI Agroforestry project has been promoting Agroforestry largely for resource poor small-scale farmers and using participatory planning approaches. The project has benefited 40,000 households, working through community action plans and a group extension approach. The project has made a significant contribution to the livelihoods of women who largely sustain home food requirements.

The men in the area have taken advantage of the project to grow timber tree species for sale. The project emphasizes income-generating opportunities for women. Women are, for example, involved in commercial seed production and in establishing fruit tree nurseries. The engagement of men in off-farm activities has left most field activities including the labour demanding Agroforestry technologies to girls and women. This is further constrained by the medium to long term benefits of Agroforestry which many farmers cannot afford investing in (Vi 2001).

Nakasongola District

The World Vision, a Christian Child Care Organisation, has undertaken environmental protection project activities in over 20 districts in Uganda. In Nakasongola district, sensitizations of the local community about environmental degradation and possible community based solutions have been done. The project has targeted women in addressing household food, fuel and income needs. However, full success of the project in tree planting in the district is still limited by the problems of drought and termites. These constrain the balance of gender needs that are being addressed in the area. Drought and termite resistant tree species are therefore needed.

Constraints to mainstreaming gender issues in Agroforestry in Uganda

The main constrain in gender mainstreaming in Uganda is lack of knowledge and appreciation of gender policy by institutions involved in promoting Agroforestry as an intervention. At the institutional level, knowledge of gender discourse, and the will and resources to effect it is limited. In a number of institutions, there is lack of clear strategies to ensure equity and equality of both men and women in terms of job slots and opportunities for further professional development. There is also imbalance between men and women trained in Agroforestry, with more men being trained than women.

Generally, there are very few women extensionists, and also very few women who are aware of scientifically tested Agroforestry technologies and practices. In the extension of Agroforestry technology there is need to carry out a gender analysis so as to come up with a clear knowledge on the needs, interests and capabilities of both men and women. This requires gender analysis skills by extension staff and also institutional enforcement of gender balanced programmes. In addition, there is a need for skills for harnessing local indigenous knowledge related to Agroforestry. Women who are closer to nature are bound to have plenty of knowledge and information related to local and indigenous Agroforestry practices.

At the household level, there are socio-economic and cultural constraints for ensuring gender equity and equality in the use and benefit of Agroforestry programs. There are also differences related to resource access and control. Often, land on which trees are planted belongs to men, and they are the ones to make decisions on how the land is to be used. In such circumstances, women lack confidence in investing or engaging in Agroforestry activities for which they would not have adequate freedom to introduce at home.

The partrilineal bias to household decision making, resource ownership, control and access in Uganda's multicultural society is another constraining factor to implementation and adoption of Agroforestry programs. This leaves the women in a disadvantaged position because they do not own land and resources necessary for implementing Agroforestry practices and technologies. Related constraints include finances, labour inadequacy, and time availability.

Another cross cutting constraint is HIV and AIDS, which affects farm labour availability due to loss of workers, and also the need to spend time caring for those who are ill. This job is usually undertaken by women and girls in affected households.

Below are suggestions on what can be done to strengthen institutional and grass root capacity to promote gender sensitive Agroforestry programs.

Training

Institutions promoting Agroforestry need to be training in the following areas:

- Social and gender analysis,
- Developing gender sensitive Agroforestry interventions,
- Reporting gender-disaggregated information.

- Use of local knowledge related to Agroforestry with a gender perspective, as well as incorporating this information in interviewing programs.
- Addressing Agroforestry development and extension gender needs and solutions through strategic participatory approaches.
- Development of agribusiness skills for farmers.
- Promotion of gender balanced access to, and sharing and control of, resources at farm and community levels. .
- Developing community action plans that are gender sensitive.

Training should target managers, administrators, extension staff, and both men and women in local communities.

Sustainability

In order to sustain gender balanced Agroforestry interventions, there is a need for regular gender sensitization, particularly among the beneficiary communities about the benefits of gender sensitive interventions. One way of increasing the relevance and equity of gender in the formulation and implementation of projects is to get political decision makers recognize this point (Montes 1999). The division of labour among men and women can be a starting point for developing a strategy. Training programmes about gender issues for project personnel and collaborators need to be prepared and implemented with sufficient financial resources. Monitoring procedures are also necessary to assess the adoption of gender awareness and perspectives in Agroforestry projects (Mejia and Zuniga 1997).

There is a need to have a proper understanding of gender issues and requirements at all levels of technology development, and training and through out the administrative and management hierarchy of Agroforestry programs (Montes 1999). In addition, there is a need to recognize the values of women and men, and the opportunities of appropriately empowering each gender at community or social group level.

The use of participatory approaches, promotion of community ownership, use of indigenous knowledge and the encouragement of market oriented Agroforestry will contribute a lot to the sustainability of Agroforestry programs. The demonstrated use of participatory approaches, community action plans, and group and farmer led approaches to extension by the promoting institutions in the regions are good examples.

Collaborative linkages are needed between the promoting institutions to exchange best practices of gender in Agroforestry. Linkages should also be made with academic and research institutions such as the department of women and gender at Makerere University, to give the needed professional input and advice on gender in Agroforestry.

There is a need to develop mutual understanding between men and women in cases such as resource ownership and allocation, and utilisation of Agroforestry products where conflicts are likely to arise.

Research

There are several possible research areas in Agroforestry and gender, a few of which, are suggested below as an initial step:

- Policy effects and implications of promoting gender balanced Agroforestry programs.
- Changes in institutional culture in gendered Agroforestry programs.
- The changing roles of extension under the new National Agricultural Advisory Services for gender balanced Agroforestry programs.
- Regional and institutional strategies, gaps and opportunities related to gendered Agroforestry programs.
- Household level resource control and access issues for gender balanced Agroforestry practice.
- Gender based Agroforestry business and marketing.
- The extent to which gendér roles, social, cultural, and wealth factors affect the Agroforestry systems in Uganda.
- HIV/AIDS effects of gendered Agroforestry programs.

Regional gaps

Information on gender and Agroforestry is needed from northwestern and eastern districts of Jinja, Iganga, Bujiri, Busia Pallisa and Tororo in Uganda. This would integrate and give a more comprehensive picture of the status of gender and Agroforestry in Uganda.

CONCLUSIONS

Most organisations have endeavoured to mainstream gender in their activities in Uganda. Many private and government organisations are promoting gender sensitive Agroforestry systems through participatory management of resources right from household to community and district levels. Community participation in, and ownership of, Agroforestry interventions have been enhanced. This approach has also encouraged individual entrepreneurship of both men and women.

The integration of gender issues into Agroforestry has enabled the generation and dissemination of more effective technical information, enhanced the adoption of Agroforestry technologies, and the development of gender sensitive research programmes. Women groups have been formed in the process. Gendered Agroforestry strategies have also encouraged innovativeness and use of indigenous technical knowledge to which, the female farmers contribute a lot since they spend more time managing land resources.

There has been promotion of partnerships in the process, for example, Makerere University partnering with districts to address key Agroforestry issues in their areas through training. At the grass root level, concessions have been reached between men and women regarding Agroforestry interventions, requirements and benefits. Gendered Agroforestry has provided an opportunity for scaling up Agroforestry to reach the deeper areas of the countryside.

There is a national gender policy that requires all institutions to mainstream gender in their programs and activities in Uganda. This also applies to institutions that are promoting Agroforestry in the country, especially the Department of Production at district levels. From the synthesis of the regions in Uganda, Agroforestry is being promoted mainly by NGOs and projects. However, extents of gender awareness and types practices vary from one organisation to another, and from region to region. The ULAMP project in Mbarara, and Vi Agroforestry project in Masaka and Rakai, have however, demonstrated gender sensitive approaches to Agroforestry programs. For most regions, there is little information about gender-desegregated achievements related to, for example, number of nurseries established, households incomes etc. Overall, the extent of engendering Agroforestry promotion in the various regions of Uganda has largely depended on the promoting organisation.

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8

AGROFORESTRY EXTENSION

By
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INTRODUCTION

Extension today is no longer a domain of extension agencies only. It is also carried out by farmers, scientists, Non-Government Organisations (NGOs), commercial companies as well as mass-media organisations. The main players in Agroforestry extension in Uganda include Government Departments, NGOs such as AFRENA, SOCADIDO, AFRICARE, and several Community-Based Organisations (CBOs). Agroforestry extension is primarily concerned with human resource development and the transfer of Agroforestry technologies to rural households in order to help them fight poverty, hunger and natural resources degradation. It involves different issues like; (i) offering advice to Agroforestry farmers as demanded (ii) helping the farmers analyze their problems and identify opportunities (iii) supporting group formation by communities, and (iv) Facilitating collective as well as individual action.

Extension objectives in Agroforestry, therefore, range from effective transfer of technology such as tree seeds and nurseries, to the building up of strong rural organisations. Such rural-farmer organisations can exert influence on Agroforestry research and policy agendas and also assume the responsibility for collective decisions over natural resources in their areas. Several methods are used in Agroforestry extension. These include (i) Brochures, handouts, newsletters, video shows, and demonstrations (ii) Sensitization meetings with various focus groups such as Local Councils (LCs), farmers, women, youths, persons with disabilities (PWDs), etc. (iii) Field trips or study tours for the groups (iv) Community-based problem solving and identification of suitable Agroforestry practices, and (v) Development of community action plans with particular reference to Agroforestry, etc. Similarly, available Agroforestry technologies are often quite wide in scope, including contour hedge rows, boundary planting, and establishment of wood lots, planting of fodder trees, growing of fruit trees and growing of leguminous trees.

Extension should encourage local development or the adaptation of technologies that address the needs of specific categories of clients. It should also be able to support local farmers' organisations and promote farmer-to-farmer extension for sustainability of the interventions. In addition, the diversity of extension providers ranging from agencies in the public, private, NGOs and academic sectors gives the clients a wider choice of the sources of information to support the long-term sustainability of their Agroforestry farming practices. The importance of sustainability should be clearly addressed in relation to technical content. For example, it is more sustainable to help farmers estimate distances than asking them to make accurate measurements each time they are to carry out a practice. Moreover materials for extension should be designed to offer options and problem solving strategies.

The Uganda National Agricultural Advisory Services (NAADS) approach to extension emphasizes building strong farmer-organisations as a way of promoting sustainability. Therefore, extension in Agroforestry should:

- Embody a whole farm/farming system orientation when working with individual clients.
- Have an interdisciplinary orientation when supporting collective Agroforestry management.
- Use collaborative problem-solving as the dominant mode of influence on client behaviour.
- Use extension resources (NAADS) to support the development of independent client organisations.
- Work to influence and facilitate planning, decisions and action at group and community levels.

Importance of Agroforestry extension to livelihoods in Uganda

Agroforestry can potentially increase the productivity of over 90% of the arable land area in Uganda (ICRAF 1989). Limitations to efficient use of arable land include soil erosion, low soil fertility, lack of funds to purchase in-puts, land tenure, and insufficient knowledge among farmers and extensionists of easily affordable interventions.

Agroforestry is an innovation promoted for efficient and increased farm productivity, overcoming adverse soil and climate changes, and exploiting market opportunities. When practiced carefully and with proper planning, Agroforestry can yield a number of advantages not only for efficient economic gain but for proper acceptance within the social framework. Agroforestry has the potential to improve farm productivity through:

- Environmentally sound soil conservation methods.
- Enhancement of soil fertility.
- Integrated pest management.
- Production of food, fodder, fiber and other high value commercial products.

However, without sufficient advice, Agroforestry can result in great losses to farmers, especially since land for rotations may be tied up for prolonged periods under tree cover.

CASE STUDIES

Dissemination of Agroforestry through local government decentralized structures in Butare sub-county local council, Kabale district

Background

Butare sub-county is located in the highlands of Kabale district in southwestern Uganda. It has an estimated population of 60,200 (2000) and covers an area of 124 Km^2. The land is highly fragmented and ownership is mainly under customary tenure system. The soil fertility is highly depleted due to continuous cultivation and soil erosion. There is also acute shortage of fuelwood as there are no forests or other alternative sources of energy.

AFRENA/ Butare Sub-county Collaboration

Many organisations in Kabale district are involved in some form of Agroforestry research and development but the main actors in Butare sub-county are AFRENA and AFRICARE. After the El Nino rains in 1998, community members from one village (Kyantobi) in Butare sub-county approached AFRENA research staff at Kabale for advice and support to control the constant floods and soil erosion.

AFRENA responded by organizing a meeting in which the community leaders and local councils were invited. After this meeting, AFRENA staff and local council officials toured the entire valley to diagnose the soil and water conservation problems in the watershed. After the tour community members, local council leaders and AFRENA staff had another meeting, which recommended strategic planting of trees as a core solution, and identified roles for each of the collaborating partners (Table 8.1) Local council officials pledged to mobilize the community, while AFRENA pledged technical support and tree seeds. This marked the beginning of the AFRENA- Butare sub-county collaboration in Agroforestry.

Achievements of Collaboration

- A memorandum of understanding (MOU) was signed between Butare sub- county local councils and AFRENA in 1999 spelling out the broad basis of collaboration.
- AFRENA organized a number of activities for example:
    - Sensitization meetings for farmers, local leaders, women, youth and persons with disability groups.
    - Trainings for farmers, community leaders, CBOs, youth groups and teachers.
    - Field visits and study tours for local leaders and farmers
    - Village territorial mapping by farmers to identify problems and Agroforestry niches.
    - Establishment of community and individual nurseries and Agroforestry action plan
    - Development of an Agroforestry model site at Kyantobi.
- A number of Agroforestry technologies were tried including contour hedgerows, boundary planting, woodlots, fodder pruning and fruit growing.
- Many Agroforestry tree/shrub species were introduced and adapted by farmers. These included *Calliandra, Gravillea, Alnus, Leuceana, Prunus africana, Acacia, Tephrosia* and different fruit trees.
- As a result of the training, exposure and participation, local leaders have started integrating Agroforestry activities in their development plans.

TABLE 8.1: *Roles of partners in scaling up Agroforestry*

Farmer Mobilization Implementation	Local councils Mobilization Resolving conflict	AFRENA (NGO) Support Germplasm
Identify needs, problems	Policy/ Bye-laws	Training
Plan	Plan	Support Planning tools
Monitoring	Support	Support Monitoring tools
Experiment/ Innovation	MOU Support dissemination	Research Information
Funds	Funds	Support Funds

Agroforestry development activities by the Soroti Catholic Diocese Integrated Development Organisation (SOCADIDO) in eastern Uganda

Background

Soroti Catholic Diocese Integrated Development Organisation (SOCADIDO) is the development arm of Soroti Catholic diocese. The diocese comprises of Soroti, Kumi, Katakwi and Kaberamaido districts. SOCADIDO Agroforestry project was initiated in 1995. This was an effort to address problems created in the area during and after insurgency, which started in 1986. Coupled with this was the problem of cattle rustling which reduced the number of cattle from 420,000 in 1986 to about 20,000 in 1993.

Poverty levels increased and agricultural production declined as a result of loss of cattle which is the main source of income and means of opening land. Most people therefore resorted to quick income generating activities like charcoal burning, brick making, fuelwood collection for sale and eventually poles for resettlement. In addition, warring factions constantly burnt bushes for security reasons. All this led to deforestation, leaving the environment bare. To address these problems, Agroforestry was proposed as one of the possible remedies. The objectives of SOCADIDO Agroforestry project are to:

- Improve nutritional well being of the people through self-sustaining activities in food and other products.
- Ameliorate environmental degradation through tree planting.
- Improve the income levels of rural households through sustainable and diversified farming production systems.

Project Activities

Tree Seedling Production

The project has 15 institutional nurseries distributed as follows:

- Soroti district - Amirit, Katine and Kidetok
- Kumi district - Bukedea, Kumi, Ngora and Mukura.
- Katakwi district - Toroma, Magoro, Wera, Amuria, Usuk and Obalanga.

- Kaberamaido district - Kaberamaido and Otuboi in Kaberamaido district.

A variety of tree seedlings are produced in the nurseries and made available to farmers at a minimal fee so that they feel the ownership of the seedlings. The project has encouraged and facilitated private nurseries to ensure sustainability. These private nurseries produced a total of 112,000 seedlings in 2000.

Demonstration Centers

Most nurseries of the project have demonstration centers where various practices are shown. Exemplary farmers are also used as models in their areas.

Extension Services

Field staffs that have had several in-house trainings are well equipped to provide technical advice to members of the farming community on various Agroforestry technologies.

Revolving Fund

The project operates a small revolving fund scheme where agricultural inputs including improved seeds, farm tools and equipment and some chemicals are provided on loan.

Training

Training of farmers and staff is one of the key activities the project undertakes to impart knowledge and skills to them so that they may continue on their own as a sustainability measure. To a limited extent, exchange visits are also organized.

Research

The project collaborates with NARO in carrying out on farm research. Together with Serere Agricultural and Animal Research Institute (SAARI), the project conducted several farm trials on groundnut varieties resistant to Rosette, and with Kawanda Agricultural Research Institute (KARI), the project conducted Biological Nitrogen Fixation (BNF) trials with farmers.

With VECO Uganda, research-extension-farmer linkage is being improved by actively involving the farmers in research processes, and encouraging them to give feedback to researchers and extension workers.

Achievements

The following have been achieved by SCADIDO:

- Farmers have adopted a number of Agroforestry practices like establishment of woodlots, planting of fruit orchards and live fences.
- The livelihoods of early beneficiaries of this project have improved considerably because of increased incomes from the established woodlots and orchards.

- Establishment of 50 private nurseries.
- Capacity building of farmers in Agroforestry knowledge and skills through training programs of the project.
- Introduction of energy saving technologies like Lorena cook stoves.
- Multiplication and dissemination of improved sweet potato varieties
- People have developed a positive attitude towards integrating trees in their farms

Constraints

The major constraints faced so far have been unpredictable weather patterns, wild fires which destroy trees, general poverty leading to low purchasing power of households, decreasing adoption rates, pest attacks especially by termites, insecurity especially in Katakwi, land tenure systems which do not encourage women to plant trees, inadequate resources and extension services.

Experiences of Africare farmers in Kabale District

Background

Africare started its activities in Hamurwa sub-county and Ikumba village respectively, in May 2000. Its major role in the first few months was to educate the community about the importance of Agroforestry. Africare gave out seeds to organized groups in September 2000. Fruit trees, tree species for animal feed (*Calliandra* and *Leucaena*) and trees which grow well with crops (e.g. *Alnus* and *Grivellea*) were given mainly to interested farmers. This was mainly for demonstration and seed multiplication. The main problems in the sub-county were:

- Poverty at household level.
- Traditional beliefs against trees growing with crops.
- Pests and diseases.
- Lack of technical knowledge among farmers.
- Men not participating in agriculture.
- Soil erosion.
- Theft of fruits and other crops.
- Climatic/ natural hazards.

Farmers' individual gains

Major gains to farmers arising from this project are:
- Increased food production for consumption and sale.
- Increased milk production.
- Soil conservation (hedgerows).
- Improved soil fertility by tree and animal manure.
- Availability of stakes for climbing beans.
- Medicine, shade, windbreaks, fuelwood, poles/ building materials.

- Acquired knowledge from visiting professional staff and training workshops.
- Energy saving cooking stoves.

Vi Agroforestry Project in Kasekere Kiwawo, Masaka District

Background

The project activities in the area started in April 1999. After ten months, the project organized a ten-day workshop during which a PRA exercise was conducted to analyse the area and problems of the community. NGOs and government departments were also invited to participate. Participant farmers elected a development committee of 12 members who are responsible for the project activities that include:

- Community mobilization - development committee together with local leaders has mobilized the community to form groups.
- Training - a number of on farm trainings have been organized through seminars, tours and demonstrations by the project.
- Monitoring and evaluation of the performances in the different groups

Experiences of Vi Agroforestry farmers

The farmers report improvements in their Agroforestry management skills, and increased production and incomes from their farms since they began working with the Vi Agroforestry project. They also attribute the following to the support they get from the Vi Agroforestry project:

- Availability of enough food for their homes and some for sale.
- Availability of enough fuelwood on their farms
- Improved coffee plantations and increased yields
- Planting of fruits on their farms and the incomes accruing from selling them.
- Improved nutrition because of enough fruits, vegetables and a variety of foodstuffs
- Keeping zero grazing cows and goats.
- Improvement in Agroforestry and general farm management skills.
- General feeling of ownership of, and genuine involvement in, Vi Agroforestry project activities.

Experience of Agroforestry Practices in Mbarara District

Background

Agroforestry practices in Mbarara were initiated by CARE (Uganda) in two sub counties in 1995. The aim was to plant trees in the degraded hills of Bukanga and Isingiro counties for supply of fuelwood and control of soil erosion. The project established a number of *Eucalyptus* nurseries managed by hired labor under the supervision of forestry staff. The seedlings raised were distributed free to interested farmers for establishment of woodlots.

In 1987 a central fruit nursery was established at a forestry station near Mbarara town. This was meant to provide seedlings of improved varieties such as passion fruits, avocado, etc. Other tree seedlings such as kei-apple, *Cypress*, mahogany and pines were raised and sold to farmers.

The first attempt to promote Agroforestry extension in the district was by the Farm Forestry Project (1987-89) which was implemented mainly by forestry department staff, through raising and distribution of seedlings of Agroforestry tree species to the farmers. When the project ended in 1989, Agroforestry extension declined in the district due to lack of resources. In 1992 the Uganda Soil Conservation Pilot Project (USCAPP) was initiated by the Regional Land Management Unit (RSCU) now Regional land Management Unit (RELMA) in four parishes in two sub-counties. The purpose of the project was participatory experimentation and development of better land management technologies and approaches for promotion of increased land productivity.

Main activities of USCAPP in promoting Agroforestry

Main activities of USCAPP were:

- Sensitization of the community about the importance of trees in soil erosion control, provision of quality fodder, curbing malnutrition and improving soil fertility.
- Creating awareness about useful Agroforestry tree species through study-tours within Uganda and Kenya.
- Training staff and farmers on collection and preparation of tree seeds, raising tree seedlings, establishment and management of trees.
- Provision of limited inputs (seeds, nursery and materials).
- Carrying out farm planning exercises with contact and model farmers for proper integration of trees, livestock and crops.
- Promotion of fuel saving stoves and fireless cookers for efficient utilization of fuelwood.
- Promotion of home economics especially fruit processing and utilization.
- Promotion of income generating activities for women groups - these included handcrafts and raising of tree seedlings for sale.

The main constraints were shortage of tree seeds, small and scattered plots of land. The Agroforestry tree species that were preferred by farmers were *Grevillea* species for border demarcation and shade, fruit trees which were planted in the compounds and around homesteads, *Calliandra* spp which were planted on conservation structures as fodder banks.

USCAPP Achievements

The major achievements of USCAPP have been:

- ✓ Increased food production especially bananas.
- ✓ Improved contact with farmers through group formation and regular trainings.
- ✓ Increased tree planting through establishment of woodlots and fodder banks.
- ✓ Better management skills and increased knowledge through regular staff and farmer training and tours.

To improve the adoption of Agroforestry in the district, farmers need to be organized into groups for effective coverage and active participation. Uganda Land Management Project (ULAMP), which began in 1999, organizes farmers into Common Interest Groups (CIGs). The project is implemented in 12 sub-counties and 42 parishes in the district. The overall goal of ULAMP is to achieve food security and incomes to small-scale farmers through improved land management and marketing skills. A number of soil and water management technologies were adopted by farmers, which resulted into increased banana production and participation of the community in tree planting exercises.

ROLE OF EDUCATION INSTITUTIONS IN AGROFORESTRY DEVELOPMENT

Enabling policies and frameworks are fundamental prerequisites for scaling up the impact of Agrofroresty in developing countries. In Uganda, the following policies which were developed recently provide a great opportunity for scaling up the role of education and training in Agroforestry development: the Plan for Modernization of Agriculture (PMA), Poverty Alleviation (PAEP), Universal Primary Education (UPE), District Agricultural and Training Centers (DATICs), Decentralization, and the formation of the National Agricultural Advisory Services (NAADS).

Plan for Modernization of Agriculture (PMA)

Aspects of Agroforestry have only been introduced into the curricular of a few tertiary institutions such as Makerere University (1989), Nyabyeya Forestry College (1998), Kyambogo University, and Bukalasa and Arapai agricultural colleges. Many of the workers in forestry, agriculture and other land use disciplines who graduated before the introduction of Agroforestry education have limited ability to promote it effectively, under the PMA. The more recent graduates are, however, better equipped with knowledge in Agroforestry than earlier ones. It has also been shown that for Agroforestry to make a positive impact on household livelihood, its promoters must have analytical skills to handle the more complex issues farmers require advice on.

There is a need to increase time allocated for Agroforestry education at tertiary levels and to also introduce the subject at the lower levels of education. The impact of Agroforestry in enhancing agricultural productivity has been demonstrated in many places including Kabale hills through soil conservation and in Northern Uganda through the shea butter nut project. It is therefore recommended that the way forward should includes: regular interactive Agroforestry curricular reviews; introduction of Agroforestry education in primary and secondary schools; refresher courses for in-service workers and collaborative research to develop further technologies that enhance farm production.

Universal Primary Education (UPE)

UPE is another strategy for alleviating poverty in Uganda through increased access to education by majority of rural people. Since the bulk of the farming population in Uganda consists of primary school dropouts, Agroforestry should be taught right from primary, through secondary schools to tertiary level.

District Agricultural Training and Information Centers (DATICS)

Related to Universal Primary Education is the development of DATICS. DATICS will provide short courses, workshops and demonstrations for farmers with basic primary education. DATICS will enable farmers and trainers at all levels to develop and share information and materials in a participatory manner. It is recommended that Agroforestry should be sufficiently addressed at all levels of education, and that information and training materials be shared and exchanged in order to streamline training.

Decentralization

One highlight of decentralization in Uganda is the need to protect key ecosystems such as national parks and tropical rain forests at district level, by promoting growing of trees on farms in the buffer zones. Therefore, staffs from diverse backgrounds have been recruited to increase campaigns for domestication of trees on farms in order to relieve the pressure on protected areas for tree products. These must be trained in Agroforestry to equip them with the right Agroforestry skills to enable them give correct advice to farmers regarding appropriate Agroforestry practices.

National Agricultural Advisory Services (NAADS) Education

NAADS is currently the change strategy for diversifying and increasing farm benefits in rural areas. The programme therefore requires well skilled people to help farmers increase and diversify farm productivity. This provides a great opportunity and challenge for Agroforestry training institutions, to provide well qualified staff to facilitate the adoption of Agroforestry by farmers as a farming system, through the NAADS programmes.

CONSTRAINTS TO AGROFORESTRY EXTENSION

As pointed out earlier, there are many constraints still being faced with Agroforestry extension. These include:

- Unpredictable weather patterns,
- Wild fires in the dry season,
- Shortage of seeds and other planting materials, especially those required by farmers such as neem (*Melia azedarach*), *Grevillea* and improved fruit varieties,
- Shortage of extension staff,
- Lack of technical know-how on Agroforestry practices,
- Inadequate support for Agroforestry extension by local governments,

- Little effort to promote local trees which farmers are more conversant with, especially for medicinal purposes,
- Low morale of local governments staff due to inadequate facilitation,
- Limited linkages with research and other technology development agencies,
- Lack of permanent water sources in the drier districts,
- Lack of marketing opportunities which hinders production of fruit trees,
- General poverty which leads to low purchasing power of households,
- Slow rates of adoption of Agroforestry technologies,
- Pest damage especially from termites,
- Insecurity in some areas like Katakwi districts,
- Poor land tenure systems which do not encourage women to plant trees,
- Small scattered plots of land which affect farm planning,
- Inadequate extension services and resources.

WAY FORWARD FOR AGROFORESTRY DEVELOPMENT

- Communities must be involved by first organizing farmers into groups, building their capacities and instilling ownership so that they can spearhead development activities including Agroforestry,
- Income levels of women need to be improved to enable them effectively contribute towards household decisions including planting of trees,
- Participatory needs and opportunities assessment should be encouraged because it is crucial for effective involvement of communities in identifying problems, searching solutions and planning the course of action,
- Establishment of coordination committees should be encouraged because it promotes participatory monitoring and constant linkage between community members, local leadership and extension agents,
- Agroforestry practices need to be integrated to address specific production needs of households e.g. planting trees with bee-keeping, composting for bananas, neem beans for pest control, etc.
- Study tours and cross visits should be encouraged because they provide good learning opportunities for farmers through shared experiences and exploration,
- Establishment of community nurseries should be encouraged because it improves availability of seedlings locally,
- Collaborative partnerships between organisations should be encouraged to improve sharing of knowledge and awareness on existing opportunities,
- Complementary Agroforestry enterprises need to be promoted,
- Appropriate shrubs need to be identified and promoted to improve fallows for soil fertility enhancement,
- Involvement and participation of local leaders right from the beginning should be emphasized to enlist their support for Agroforestry activities,
- Extension staff need to be motivated and facilitated for effective promotion of Agroforestry practices,

- Promotion of rain water harvesting, storage and irrigation techniques should be encouraged to as a solution to water shortages for domestic and tree nurseries establishment.
- Local governments, NGOs, research and extension need to work in a collaborative manner in order to enhance efficiency, cost effectiveness and long term sustainability of Agroforestry practices,
- Agroforestry should be taught at all levels of the Ugandan education system, and refresher courses organized for in-service workers in agriculture, forestry and environment sectors.

FURTHER READING LIST

BAKAMA, J. 2001. Kabale district farmers' Agroforestry perspective. A paper presented at the 2nd National Agroforestry Workshop, Mukono, 10th-14th September 2001

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This section was synthesised by Okiror (Lecturer, Faculty of Agriculture, Makerere University) with editorial contribution from Philip Nyeko (Lecturer, Faculty of Forestry and Nature Conservation). The basic material was from various presenters in the Workshop on Building Strategic Partnerships for scaling up the impact of Agroforestry, Mukono, September 2001 as detailed in the case studies and list of references)

9

HUMAN RESOURCE CAPACITY IN AGROFORESTRY DEVELOPMENT

By

Sara Namirembe, Phillip Nyeko (Faculty of Forestry and Nature Conservation, Makerere University) and Wilson Kasolo (Nyabyeya Forestry College).

INTRODUCTION

The Ugandan population mainly depends on wood energy. The World Bank (1986) reported that firewood and charcoal constituted approximately 96% of Uganda's energy consumption, equivalent to 18.3 million m^3 of wood per annum. The significance of trees on farm has grown due to diminishing forest areas and limited access to designated national parks. Agroforestry is promoted for efficient and increased farm productivity, overcoming adverse soil and climatic changes, and exploiting market opportunities. Agroforestry is at the centre for the plan for modernisation of agriculture and it has been demonstrated, in certain areas of the country, to potentially fulfil this role if well implemented.

Uganda is undergoing structural changes aimed at creating mechanisms that alleviate poverty by promoting gender equity and increasing access to education, information, markets and farm inputs. New policies aimed at empowering the population to actively participate in decision making and investing in enterprises that improve their livelihoods has been developed. These include the Plan for Modernisation of Agriculture (PMA), Universal Primary Education (UPE), decentralisation, and the development of National Agricultural Advisors (NAADS) and District Agricultural Training and Information Centres (DATICS).

Agroforestry is a multidisciplinary approach to improve farm productivity through environmentally sound soil conservation and fertility enhancement, integrated pest management and production of food, fodder, fibre and other high value commercial products. It is one of the strategies for PMA, which aims at business-oriented, efficient and sustainable farm production for improved livelihoods. Agroforestry uses a systems approach and must work in collaboration with other service providers to effectively respond to farmers' needs.

The forestry estate is not decentralised in Uganda although the power to manage and control other resources has been relegated from the centre to district governments. Central forest control limits community access to wood products; therefore, trees on farm continue to play a major role in livelihoods. The basic objective of Agroforestry is to provide tree products and services on farm. Agroforestry is also used to protect key ecosystems such as national parks and tropical high forests through promotion of tree domestication on farms in the buffer zones. Staff from diverse educational backgrounds (Forestry, Environmental science and Agriculture) is charged with this.

HUMAN CAPACITY IN AGROFORESTRY

The status of Agroforestry education in Uganda has been evaluated on different occasions (e.g., Kazoo and Rueben 1994; Kazoo and Tem 1995) and strategies for human capacity building identified and undertaken. There has been a positive trend in the number of people with basic knowledge in Agroforestry, especially instructors at tertiary level and some NGO workers. However, this has not translated into increased or improved Agroforestry practices because of the complexity of farmers' demands in relation to the basic nature of training offered so far.

Agroforestry is currently part of curricula in tertiary institutions: Makerere University (since 1989), Nyabyeya Forestry College (since 1998), and the Institute for Teacher Education, Kyambogo (ITEK), Bukalasa and Arapai Agricultural Colleges (only recently). Graduates become teachers, researchers or officers in forestry, environment, agriculture or animal husbandry with the collective responsibility to promote efficient farming and natural resource management. Since Agroforestry training is only recent, a number of service providers on the ground graduated before its introduction in curricula and therefore have limited ability to promote it effectively.

An Agroforestry training needs assessment jointly conducted by staff of the Faculty of Forestry and Nature Conservation (FFNC) with the African Network Agroforestry Education (ANAFE) (1999-2000) showed that most extension staff working in Agroforestry-related areas did not have sufficient understanding of Agroforestry to adequately advise farmers on a case by case basis. A survey by FFNC with Rockefeller Foundation support (2001) to identify training opportunities resulting from decentralisation revealed a number of districts where improved Agroforestry interventions could potentially improve community welfare, but were currently without trained personnel to promote the practice.

Documented reference material on Agroforestry is concentrated at training institutions, especially Makerere University and Nyabyeya Forestry College in libraries with strict regulations where only students, trainers and a few researchers have access. Even then, the number of copies is insufficient. Only Makerere University has access to internet where more information can be sourced, but it has insufficient work stations and printing support to even satisfy its own student and staff demands. Research institutions such as the Forestry Resources Research Institute have smaller libraries to which researchers and university students have access. Some information is scattered in various projects. Extension agents, primary and secondary school educators, curricula designers, policy makers and farmers have limited or no access to this information resulting in poor access to the latest advances in Agroforestry knowledge. In general, stakeholders and promoters of Agroforestry have little awareness of possible sources of Agroforestry information in the country and how to access it.

The Rockefeller supported survey (2001) also showed that farmers practice some form of traditional Agroforestry from which they did not seem to be benefiting economically. The extension support they received was mainly on agricultural crops for which the returns could be better perceived. Advice on tree management was rarely sought for. A clear business touch to managing trees on farm would strongly enhance the adoption and quality of Agroforestry and its capacity to improve livelihoods.

Staff at tertiary training and research institutions has received training through the ANAFE and DSO support. Extension workers have received exposure to Agroforestry through short workshops arranged by non-governmental organisations. These are few and far between, and often insufficient to equip them with applicable knowledge. Trainers at primary and secondary school levels receive no training in Agroforestry and are unlikely to include it in their teaching yet they have been the strongest promoters of tree planting in the country through mass media and school projects.

STRATEGIES FOR HUMAN CAPACITY BUILDING

Training, curricula development and review

The immediate means of overcoming knowledge gaps among serving staff is through design of short courses addressing particular aspects of Agroforestry e.g., a given agro-ecological condition or technology, method of marketing etc. Through the Rockefeller support, FFNC has developed curricula and proposes to run a two-week course in Agroforestry for service providers at the district level. This course highlights unique agroecological and social characteristics of various districts.

Whereas it is appropriate to train service providers in the basic concepts and principles of Agroforestry using a top-down approach, the focus of further training should be aimed at problem-solving. These courses should be based on frequently sought advice to reflect the prevailing interest of the client community. Thus, training needs assessment and short course generation should be continuous and dynamic, reflecting unique differences in geographical locations of communities and changing needs over time. This has a cost implication, which can be minimised through collaboration among stakeholders (farmers, development workers, researchers and trainers at all levels), training of trainers and frequent in-building of short-course material into regular training curricula at all levels for continuity.

The long-term approach to overcome knowledge gaps at farm level is through long term staff training and frequent review of curricula to ensure well rounded practical graduates capable of delivering the necessary services to communities. A workshop with some of the technical stakeholders was conducted in December 2001 (with DANIDA support) to develop a new curriculum for a diploma in Farm Management. A participatory approach to curricula review is recommended in spite of the high cost and slow process because it inspires all stakeholders to achieve the training objectives (Hermsen 2001). The current school of thought goes even further to recommend collaborative participatory learning to ensure that the marginalised stakeholders are empowered to drive and contribute to decision-making processes that impact on them (Taylor 2002).

Participatory or collaborative learning includes community-based learning, participatory curriculum development, popular education, experiential learning, distance learning, and initiatives which improve access to education (Taylor 2002). Collaborative education can also occur through interaction (e.g., guest speakers at seminars, staff exchange) between educational institutions at different levels, development and research organisations. In relation to popular education, subjects such as gender (Van Crowder *et al.* 2000), agribusiness and post harvest processing are highly recommended as strategies to combat poverty. A significant response of girls and women to gender positive agricultural education in Uganda was noted during the DANIDA 2001 workshop.

While collaborative learning would enhance the rate and quality of impact of education on rural development, it is costly and challenges the existing structures of evaluation. It requires transformation from a teaching institution to a 'critical learning system' influencing and being influenced by others (Bawden 2001). Instructors at all education levels must evaluate the potential of a participatory approach and learn the skills to effect it (Taylor 2002). This would require scholars to evolve their loyalty to things bigger than their professions (Wairama 2001) and the employment opportunities to evolve accordingly (Van Crowder *et al.* 2000). The obvious niche for collaborative learning is the transfer of vocational skills and applied knowledge. It can however, be used creatively to enhance effectiveness of learning basic knowledge principles.

Often, Agroforestry-related issues farmers seek advice on are complex, requiring service providers to have analytical skills to identify ways in which Agroforestry can make a positive impact on household livelihood. Farmers practice Agroforestry amidst a number of challenges such as heavy taxation, limited access to inputs and markets, and season failure. A survey report by the national agricultural research organisation (NARO) details technologies required by different target groups in various ecozones in Uganda (Ojacor and Padde 1998). However, curricula do not yet reflect the highlighted real situation on the ground. A systems approach to practical situations through Agroforestry requires more training time than can be allocated in tertiary institutions.

Introduction of Agroforestry at earlier levels of primary (with high enrolment now due to the policy of universal primary education) and secondary education enables ample time for basic principles to take root in the learners' minds to appropriately address complex real life situations at the tertiary levels. This approach would also ensure that the basic concepts of Agroforestry are passed on to a large percentage of future farmers, likely to leave school before the tertiary level. Curricula at primary and secondary school levels are reviewed and regulated by the national curriculum development centre (NCDC). A syllabus for agriculture education in primary school has already been developed and is scheduled to start in 2002. While this syllabus already has a component of growing trees on farm, it has a flexible element of project oriented learning, a good entry point for Agroforestry education (F. Amulen, pers. comm.). The NCDC will soon review secondary school agriculture syllabus, which is an opportunity to incorporate Agroforestry.

A systems learning approach right from an early stage in education requires interdisciplinarity and enables learners to address real problems and understand the extent to which different areas of knowledge contribute to their solution (Oweyegah-Afunaaduula *et al.* 2001). While the extent to which an individual can be interdisciplinary is limited (Bwanga-Bugonzi 2001), teams of interdisciplinary experts with emphasis on various fields have a greater potential to impact the development process than teams (or individuals) of single-discipline experts.

Information development and dissemination

In addition to curricula, human capacity can be built through development of practical, ecologically focused reference and teaching material (e.g., Rocheleau *et al.* 1992). The impact of Agroforestry in enhancing agricultural production has been demonstrated in Kabale hills through soil conservation and fertility enhancement, in Masaka through supply of tree seeds to farmers and in Northern Uganda through the Shea butter nut project. In the two former cases, the success was due to a strong extension support while the latter resulted from identification and organisation of a market outlet for the products. There have been other successes, which must all be shared with continuous flow of literature between active organisations, and university, college and school libraries. The new Uganda Agroforestry Development Network (UGADEN) will play a major role in addressing information flow by creating and circulating a data base on Agroforestry information in collaboration with DATICs.

The objective of District Agricultural Training and Information Centres (DATICs) is to provide the necessary information support to farmers with basic primary education, who do not continue with formal education. DATICs are focal meeting points for exchanging views and conducting short courses, workshops and demonstrations. They would be ideal for participatory development of training materials.

The limitation to information access among stakeholders in Agroforestry also results from low investment in information packaging and dissemination. A lot of survey findings, workshop outputs, project reports and student theses contain pertinent information, which just ends on a few shelves. Training would be greatly enriched and unnecessary repetition of activities avoided if such information were made available and circulated.

Participation in the national agricultural advisory services (NAADS)

The national agricultural advisory services (NAADS) is a new extension strategy to foster provision of only the services farmers seek and are willing to pay for. Teams of multidisciplinary experts will be effective in achieving this. It necessarily ensures that farmers are listened to in order to develop or adapt new interventions, to forms which can be applied profitably and sustainably. Whereas NAADS promotes demand-driven interventions, the underlying assumption is that farmers have all the necessary exposure and information to ask for the appropriate advice for their development, and that the advisory service providers have the necessary knowledge and information to deliver. For this approach to work, a two-thronged method to capacity building is needed:

- Creating awareness and availing farmers with the basic knowledge and necessary information to seek to invest in beneficial enterprises and ensure quality advice for their money.
- Training service providers in the interdisciplinarity and systems approach of Agroforestry, and the art of interacting with farmers and partners.

A sufficient number of qualified advisors to make countrywide impact are necessary. This requires review of curricula or a mixture of disciplines in one person, or formation of advisory teams with basic understanding of AF. NAADS as currently proposed are not fully manned and would be very expensive to run if they were. Education institutions can potentially make a strong and cost-effective contribution to NAADS because they have man power skilled in information generation, documentation and transfer. Students can contribute to information flow and outreach during the interactive training programmes.

CONCLUSIONS

Uganda has the necessary institutional structure and policy support to continuously deliver formal and informal training in Agroforestry at all levels. It requires creativity and commitment to continue dialogue and ensure efficient knowledge exchange. There is evidence of strong national commitment to modernisation of agriculture (in which Agroforestry plays a key part) and enhancing rural livelihoods through support of curricula review and innovative development of new contact points between trainers and farmers. Furthermore, rigorous research in collaboration with development organisations must be promoted to develop practical, viable and profitable farm technologies. There is a critical mass of trainers to train others to sufficiently take advantage of situations where Agroforestry can make a difference in people's livelihoods.

Way forward:

- Regular interactive curricula review to train future service providers in a business approach to farming and in dialogue with farmers and partner institutions.
- Short courses to train existing service providers in appropriate Agroforestry practices for various ecological zones and in dialogue with farmers.
- Collaborative development and dissemination of reference and training material or information leaflets.
- Strategies for capacity building of farmers (e.g., training of trainers, training materials development) through DATICs to actively participate in the NAADS
- Collaborative research and training through seminars and staff exchange

Introduction of Agroforestry education in primary and secondary schools

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This section has been synthesised from various workshop papers (listed below) by Sara Namirembe with some editorial contribution by Phillip Nyeko (Lecturers, Faculty of Forestry and Nature Conservation, Makerere University) and Wilson Kasolo (Principal, Nyabyeya Forestry College).

10

SCALING UP THE IMPACT OF AGROFORESTRY IN UGANDA

By

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INTRODUCTION

Agroforestry is a traditional practice in many Ugandan smallholder farming systems ranging from coffee and banana gardens inter-cropped with upper storey trees in the Lake Victoria Crescent, to parkland systems of the drier areas of northern region. Since the 1980's, there have been research efforts to enhance the productivity of these Agroforestry systems and to develop new systems for areas where Agroforestry is not a common practice. The increasing significance of Agroforestry is also reflected in its institutionalization through the establishment of Agroforestry curricula in tertiary education institutions, and an Agroforestry research programme in the National Agricultural Research Organisation (NARO). Most importantly, Agroforestry promotion has become a key component in many development programmes, non-governmental and community-based organisations and is now considered as a key component of the Plan for the Modernization of Agriculture (PMA), which is a central pillar of Uganda's strategy for development and poverty eradication.

Agroforestry plays an integral role in approaches for improving land productivity and rural livelihoods while protecting the environment. The integration of specific tree species in various configurations, contributes to improved crop yields through soil and water conservation, and the improvement of physical and chemical characteristics of soils. Quality fodder from shrubs and trees for small holder dairy farming can enhance farm income significantly. Fruits and nuts from a number of trees are potential high value products for farmers when appropriately processed and marketed. Throughout the tropics, an increasing proportion of wood products originate from farms rather than forests and plantations. Due to the high production costs in forests, this trend is likely to increase in future. In addition, the most promising approach to conservation of tree species and their genetic pools in natural ecosystems lies in their domestication for integration into farms. Other important functions of trees in the environment such as carbon sequestration, microclimate moderation and habitat enhancement are widely recognized.

While there is little debate in Uganda regarding the potential central role of Agroforestry in the modernization and sustainability of agriculture, it appears that only a small proportion of the potential impact of Agroforestry initiatives in addressing rural needs has been realized. Practical information on how to best integrate trees in the variety of farming systems occurring in Uganda is limited. This is mainly due to the fragmented and uncoordinated efforts of the institutions involved. For example:

- A wide range of Agroforestry innovations have been developed at Kabale for highland areas of Uganda, but have not been disseminated to other highlands despite the good coverage of many highland areas by development organisations.
- Much of the work in dry land areas of Uganda, e.g. on the shea butter tree and its markets is little known and the potential of scaling-up parkland Agroforestry is not adequately exploited.
- Inadequate access to quality tree seed and planting materials is a key constraint to most Agroforestry initiatives in the country. A coordinated approach to produce and supply planting material is currently lacking.

Research and development services for rapid adoption of Agroforestry in all agro-ecological zones of Uganda cannot be provided by a single organisation in the country. Recently, local partnerships and coordination initiatives between local governments and organisations involved in Agroforestry research and rural development have had positive impact, and demonstrate strong ground for efficient extrapolation of good Agroforestry practices to relevant areas in the country. Also, recent developments, i.e. the creation of the Agricultural Research and Development Centers (ARDCs) in Uganda's major agroecological zones, and the establishment of a National Agricultural advisory Services (NAADS) as a demand-driven extension service provider, further increases the potential for scaling up of Agroforestry impact on rural livelihoods through a coordinated nationwide Agroforestry programme.

AGROFORESTRY RESEARCH AND TECHNOLOGY ADOPTION

After conducting research and developing technology, the biggest challenge ahead is delivering on the potential promises of Agroforestry innovations. Strategic and adaptive research on farms has confirmed the significant contributions Agroforestry can make to the livelihood of rural households and the rehabilitation of ecosystem functions (e.g. see AFRENA-Uganda 2000; AFRENA-Uganda 2001; Raussen *et al.* 1999; Siriri and Raussen 1999). Promotion of Agroforestry through government extension services and non governmental organisations has been largely successful in various parts of the country, although still only a fraction of the potential impact of Agroforestry has been realized as indicated in Table 10.1 (the total number of farm households in Uganda is estimated to be more than 2.5 millions with approximately 15 million people). The impact may increase if the fragmented efforts could be interlinked. Making Agroforestry innovations available to at least a quarter of Uganda's rural households over the next decade would be a tremendous but achievable task.

A new and promising pathway for adoption of Agroforestry in Uganda is through farmer-based organisations supported by the recently decentralized and empowered local governments which were first democratically elected in 1998 (Raussen 2000; Raussen *et al.* 2001). A similar land care approach has been very efficient in Australia, Southeast Asia and is emerging in various parts of Africa (Garrity 2000).

Targeting the most important areas and vulnerable farming systems is often not easy for local planners. Modern tools like GIS could provide better decision support when scaling up Agroforestry. Using geographical features, such as local watersheds rather than administrative boundaries should be considered as a good opportunity to enhance Agroforestry adoption rates (Raussen *et al.* 2001).

TABLE 10.1: *Estimated adoption of past and current initiatives to promote Agroforestry in Uganda*

Agroecological zone	**Organisations involved in Agroforestry promotion**	**Agroforestry innovations promoted**
Eastern	AFRICA 2000, INSPIRE, SOCADIDO..	Intercropping, alley cropping, SWC bands, fodder banks, improved fallow, home gardens, woodlots, fruit trees, boundary planting, live fencing, shade trees.
Eastern Highlands	IUCN, IRDI, ULAMP, MMM, HPI.	Woodlots, fruit trees, fodder banks.
Karamoja Drylands	CHURCHES, GEF-BIODIVERSITY PROJECT	Shade trees, boundary planting, woodlots.
Lake Albert Crescent	BUCODO, BFP, NFC, BAT, UNFA, ARDC, ACTIONAID, AFRICA 2000, EPED, URDT.	Hedgerows, boundary planting, intercropping, improved fallows, fruit trees, woodlots.
Lake Victoria Crescent	EA, PLAN-Uganda, VI, FD, JEEP, MWNFP, AFRICA 2000, WORLD VISION.	Fruit trees, boundary bands, medicinal trees, improved fallow, intercropping, biopesticides, woodlots.
Mid Northern	FD, SHEA PROJECT, ASDI, HPI, CHURCHES, ARDC, BAT, EC.	Woodlots, fruit trees, fodder banks, shed trees.
Northern	FD, HPI, CHURCHES, ARDC, BAT, EC.	Woodlots, fruit trees, fodder banks.
South East	AFRICA 2000, SOCADIDO.	Fodder banks, improved fallow, home gardens, woodlots, fruit trees, boundary planting, live fencing, shade trees.
Southern Drylands	LVEMP, VI, UNFA, ACORD, IRDI, LWF, FD, ULAMP, GTZ, AFRENA	Woodlots, intercropping, home gardening, boundary planting, fallows.
Southern Highlands	AFRENA, AFRICA 2000, AFRICARE, UNFA, BAT.	Hedgerows, boundary planting, improved fallows, fruit trees, woodlots.
West Nile	BAT, CARE, FD, NEMA, WORLD VISION, UNHCR, CHURCHES, CEFORD.	Woodlots, intercropping, fodder banks, fruit trees.
Western Highlands	AFRENA, AFRICA 2000, AFRICARE, UNFA, BAT.	Hedgerows, boundary planting, improved fallows, fruit trees, woodlots.

Learning from successes and failures of various dissemination approaches will be essential when designing an efficient and cost-effective partnership program for scaling up Agroforestry in Uganda. As a result, there is a need to design a monitoring system that can provide insights into the adoption of Agroforestry practices and dissemination.

Matching Agroforestry to Uganda's agro-ecological zones and farming systems

Climate, soil and terrain interact with farmers' traditions, preferences and local socio-economic situations, resulting in varied agricultural systems and land use practices. For Agroforestry innovations to be adapted to the local situations the above factors are important. More than two decades of farming systems research and extension have confirmed the importance of locally adapted innovations for successful scaling up of Agroforestry.

It is useful to define areas that share common natural features and agricultural characteristics, the "agroecological zones" and to highlight their similarities and differences (Worthmann and Eledu 1999). Delineations of Uganda into agro-ecological zones have been proposed. Recently a detailed study has been produced by Worthmann and Eledu (1999) which used 25 variables to delineate 33 agro-ecological zones. The information is detailed although it may need to be combined with local knowledge and local studies for planning at the district or sub-county levels.

At the national level an aggregated delineation with 12 agro-ecological zones (Figure 10.1) has been proposed by NARO and forms the basis of the planning at the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF). The zones consist of:

1. Eastern
2. Eastern Highlands
3. Karamoja Drylands
4. Lake Albert Crescent
5. Lake Victoria Crescent
6. Mid Northern
7. Northern
8. South East
9. Southern Drylands
10. Southern Highlands
11. West Nile
12. Western Highlands

The ecozones are abnormally contiguous in this sub division, evidence that distantly separated ecological peculiarities are compromised in favour of facilitating administration. NARO has begun to establish an Agricultural Research and Development Centre (ARDC) in each of these zones. The 12 ARDC will serve as centres for adaptive research and dissemination. District Agricultural Training and Information Centres (DATICs) will support the dissemination of new technologies generated by research activities.

At present a co-ordinated partnership program for scaling up Agroforestry impacts basing on the same broad zonal delineation is also envisaged in order to ensure congruence in:

- Planning of research and development activities.
- Adapted technology development.
- Better dissemination of innovations through improved technology targeting.

Furthermore, the size of the zones appears to be appropriate to combine short distances for information exchange and joint planning with a critical mass of organisations in the zones. Such a decentralized approach is consistent with the research strategies of PMA, which aim at addressing the "unique constraints faced by subsistence farmers in different ecological zones of Uganda" (GOU 2000).

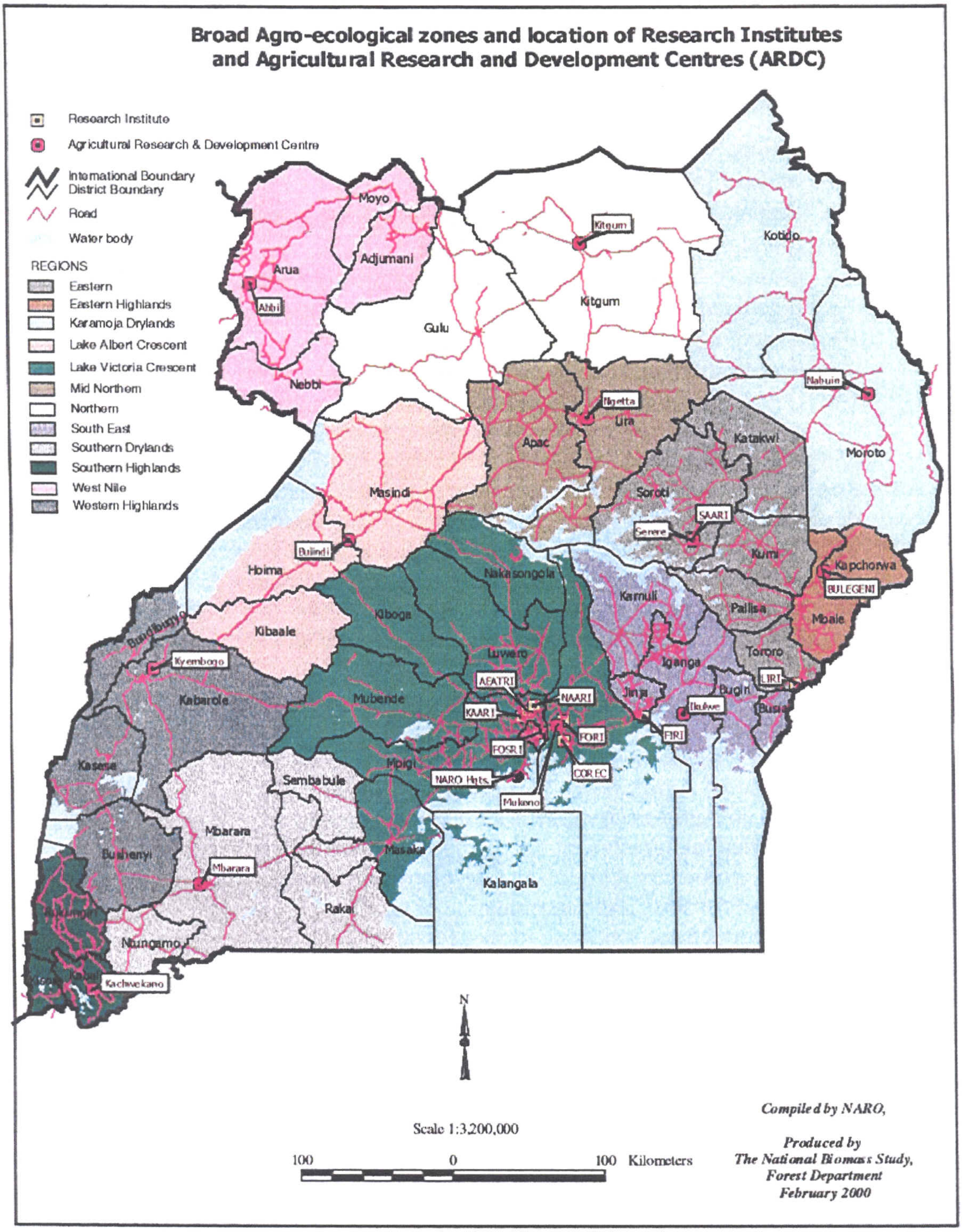

FIGURE 10.1: *Aggregated agroecological zones of Uganda*

FUNDAMENTALS AND CONDITIONS FOR SCALING UP AGROFORESTRY IMPACT

Cooper and Denning (2000) compiled a list of key frame conditions to be considered when planning for scaling up Agroforestry, which include:

- national and regional peace and security;
- transparent governance;
- demand for Agroforestry products and market access;
- sound national and global economies;
- presence of legislation for intellectual property rights;
- functional rural infrastructure;
- an active process of democratisation;
- decentralisation of decision making authority and;
- Development partner priorities and resource availability.

Having realised the need for and identified some core elements of a national strategy for scaling up Agroforestry in Uganda, other components to operationalize this strategy are being developed. A Uganda Agroforestry Development Network (UGADEN) has already been established and is deemed to be an appropriate form of cooperation by the various organisations. Such a network was proposed at the first National Agroforestry Workshop in 1996, but did not become operational due to resource constraints. A similar network for the East African Region (AFRENA – ECA) operated successfully and created many synergies between member countries. Based on the vision of PMA, UGADEN is expected to significantly contribute to farmer responsive research and development system that generates and disseminates problem – solving, profitable and environmentally sound Agroforestry innovations on a sustainable basis.

Two National Agroforestry Workshops of 1996 and 2001 laid a foundation for the process towards an Agroforestry network for scaling up impacts. The achievements of the workshops included taking stock of the current initiatives in Agroforestry; review of recent experiences in Agroforestry research and development; identification of key constraints and potentials for Agroforestry, and determination of which Agroforestry innovations are already available and those requiring further research in the twelve agro-ecological zones. Organisations that could coordinate research and dissemination activities were also identified. Some of the workshop findings are presented in Table 10.1.

LESSONS LEARNED AND RECOMMENDATIONS FOR THE WAY FORWARD

- Despite considerable progress in Agroforestry research and dissemination in Uganda over the last decade, the impact of Agroforestry on smallholders' livelihood is generally still modest.
- Decentralisation and the commitment of Uganda government to modernise the country and thereby eradicate poverty are important pillars for scaling up the impact of Agroforestry on rural livelihoods.

TABLE 1: *Agroforestry scaling up problems and opportunities in Uganda's agro-ecological zones*

Agro-ecological zone	**Problems in scaling-up Agroforestry**	**Agroforestry innovations with high potential**	**Organisations that could coordinate AF research**	**Organisations that could coordinate AF dissemination**
Eastern	♦ lack of germplasm ♦ lack of information ♦ coordination ♦ lack of extension	♦ hedgerows ♦ improved fallows ♦ biomass transfer ♦ high value trees ♦ boundary planting	♦ AFRICA 2000, ARDC	♦ AFRICA 2000, SOCADIDO
Eastern Highlands	♦ lack of germplasm ♦ lack of information ♦ land use conflicts ♦ lack of policy	♦ contour bands ♦ woodlots ♦ river bank planting ♦ shade trees with coffee and bananas	♦ IRDI, ULAMP, ARDC	♦ IRDI, ULAMP, IUCN, ARDC
Karamoja Drylands	No Information yet	No Information yet	♦ GEF	♦ GEF
Lake Albert Crescent	♦ lack of extension ♦ lack of awareness ♦ land tenure ♦ gender imbalance	♦ soil management ♦ woodlots ♦ fruit trees ♦ dry land crops	♦ ARDC, NFC	♦ ARDC, UNFA, BUCODO, URDT, BAT
Lake Victoria Crescent	♦ lack of germplasm ♦ land and tree tenure ♦ lack of information ♦ lack of policy	♦ fodder banks ♦ improved fallows ♦ boundary planting ♦ woodlots	♦ ARDC	♦ EA, JEEP, AFRICA 2000, WORLD VISION
Mid Northern	♦ insecurity ♦ cultural inertia ♦ land tenure ♦ drought conditions ♦ lack of germplasm ♦ coordination	♦ parkland system ♦ woodlots ♦ high value fruit trees ♦ fodder banks ♦ improved fallows	♦ ARDC	♦ ACCORD, HPI, IRC BAT, ASDI
Northern	♦ insecurity ♦ cultural inertia ♦ land tenure ♦ drought conditions ♦ lack of germplasm coordination	♦ parkland system ♦ woodlots ♦ high value fruit trees ♦ fodder banks improved fallows	♦ ARDC	♦ ACCORD, HPI, BAT, ASDI

Agro-ecological zone	Problems in scaling-up Agroforestry	Agroforestry innovations with high potential	Organisations that could coordinate AF research	Organisations that could coordinate AF dissemination
South East	♦ lack of germplasm ♦ land and tree tenure ♦ lack of information ♦ lack of policy	♦ fodder banks ♦ improved fallows ♦ boundary planting ♦ woodlots	♦ ARDC	♦ JEEP, AFRICA 2000
Southern Drylands	♦ lack of policy ♦ germplasm ♦ relevant information ♦ land ownership ♦ land availability ♦ gender imbalance	♦ Soil fertility improvement ♦ Drought management ♦ Ranching	♦ ULAMP, ARDC	♦ VI, ARDC, DATICS, ACORD, LWF, IRDI, GTZ, UNFA
Southern Highlands	♦ planting materials ♦ low levels of sensitisation ♦ gender issues ♦ land tenure systems ♦ free range grazing	♦ hedgerows ♦ improved fallows ♦ biomass transfer ♦ high value tree crops ♦ boundary planting	♦ AFRENA, ARDC	♦ AFRICARE, AFRICA 2000, CARE-DTC, BAT
West Nile	♦ Lack of germplasm ♦ Capacity building ♦ Access to technologies ♦ Lack of policy ♦ coordination	♦ soil fertility management ♦ improved fallows	♦ ARDC	♦ BAT, WORLD VISION, ULAMP, CEFORD, CHURCHES
Western Highlands	♦ lack of germplasm ♦ lack of information ♦ land use conflicts ♦ lack of policy	♦ contour bands ♦ woodlots ♦ river bank planting ♦ shade trees with coffee and bananas	♦ ARDC	♦ AFRICARE, AFRICA 2000, CARE-DTC, BAT

- Accelerating the adoption of ecologically and economically sound Agroforestry innovations, requires intensification of Agroforestry dissemination in areas where such work has been ongoing for some time, as well as developing a national Agroforestry strategy that would cover areas where such work is still in its early stages.
- The operationalisation of the already established Uganda Agroforestry Development Network (UGADEN) for co-ordinating research and dissemination activities will be essential to successful Agroforestry impact scaling up.

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