Kenya's Water Towers Protection and Climate Change Mitigation and Adaptation (WaTER) Programme

EXTENSION GUIDE FOR AGROFORESTRY PRACTITIONERS IN KENYA: KFS, COUNTIES, NGOs, CBOs AND FARMERS

Mengich, E.K., Oballa, P.O. and Etindi, G.M.

Component 4: Science to Inform Design of Community-Level Actions and Policy Decisions

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Kenya Forestry Research Institute (KEFRI)

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Cover caption:

Main pictures: View of an agroforestry landscape in Nandi, consultation with officials of Kasamwa Self Help group in Trans Nzoia, Demonstration of fruit tree planting in Elgeyo Marakwet, and Training on use of alternative energy saving technologies in West Pokot.

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FOREWORD

Kenya's water towers are facing unprecedented threats attributable to forest degradation, fragmentation and climate change. The main drivers of degradation include: encroachment, deforestation, charcoal production, unsustainable land use and overgrazing. These factors have severely reduced the capacity of these forests to provide ecological and socio-economic benefits in required quantity and quality in a sustainable manner. There is urgent need to arrest this degradation and enhance resilience and productivity of these ecosystems through suitable rehabilitation and conservation interventions. This will contribute to the desired 10% forest cover as outlined in the MTP II of the vision 2030.

Through support of the European Union (EU), under the Water Towers Programme, KEFRI has implemented activities aimed at conserving these ecosystems with a focus on Mt. Elgon and Cherangany Hills water towers. The activities are implemented through two of the institute's eco-regional research programmes: Lake Victoria Basin Eco-region Research Programme (LVERP - Mt. Elgon) and Rift Valley Eco-region Research Programme (RVERP – Cherangany Hills). Activities already implemented include; demonstration of technologies for rehabilitation of degraded areas in natural forest, establishment of bamboo sources of germplasm and demonstration plots, establishment of on-farm tree demonstration plots, and promotion of alternative energy sources. The demonstration plots serve as farmers' sites for training and learning.

The on-farm component of the project allows for integration of trees on farms and in the landscape to diversify and sustain production for increased social, economic and environmental benefits. It also supports the Economic Recovery Strategy for Wealth and Employment Creation Paper (2003) which prioritized tree growing on-farm as one of the approaches to realize the potential of forestry in creation of wealth and employment. The paper indicates that through the approach and involvement of the private sector, Kenya could increase her forest cover substantially to meet her wood requirements. Furthermore, the Forest Policy (Sessional paper No. 9, 2005) emphasized the development of farm forestry as a way of diversifying subsistence products and incomes while contributing to soil and water conservation. The policy underlines the need to support farmers with sound management principles, incentives, information, better germplasm and marketing strategies. During the first year of project implementation, several agroforestry technologies including woodlots, boundary planting and fruit tree planting were established for demonstration to land users across the catchments. The main tree species planted were Blue gum (*Eucalyptus grandis*, Cypress (*Cuppressus lusitanica*), Grevillea (*Grevillea robusta*) and fruit trees that comprised Avocado (*Persea americana*), Mangoes (*Mangifera indica*) and Pawpaw (*Carica papaya*). It is anticipated that these technologies will be adopted and promoted both within and beyond the project area. It was, however, noted that several challenges/drawbacks needed to be overcome in order to enhance restocking of trees on farmlands. These included, among others, the lack of technical knowhow by the intended beneficiaries as demonstrated by on-site observations and the many requests for training and exposure tours by local communities.

This extension guide is written for a wide range of agroforestry practitioners, extensionists and trainers including the Kenya Forest Service (KFS), Non-Governmental Organizations (NGOs), Community-Based Organizations (CBOs), local institutions and farmers. The information provided has been sourced from literature reviews, observations from KEFRI's research trials, direct consultation with farmers and other people who practice agroforestry, and personal experience. We hope it will greatly assist the intended users in their endeavour to further the development of agroforestry as a sustainable land use.

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1.0 INTRODUCTION

Extension is a non-formal educational system aimed at improving the livelihood of people. It may be used to mean "any programme or activity that assists local people to be willingly involved in activities from which they will derive some recognizable benefit within a reasonable period of time. It is a two-way educational process where local people and extension workers learn from each other. Successful extension depends upon a relationship in which the local people and the extension worker co-operate as equals.

1.1 Why agroforestry extension?

Agroforestry can be defined as a dynamic, ecologically based, natural resources management system that through integration of trees on farms and in the landscape diversifies and sustains production for increased social, economic and environmental benefits for land users at all levels. The major land resources opened for agroforestry development are mainly agricultural lands (including pasture and rangelands), wastelands and river valleys. The private land tenure system favour agroforestry since it is individual owners who do the planning within their land parcels.

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1.2 Methods of extension

There are several methods of extension. These are as follows:

- The individual/household approach
- The group approach: meetings, field days, demonstrations, support to groups
- The school approach
- Mass extension methods

1.2.1 The individual/household method

This method is most effective for activities to be undertaken by or within the full control of the individual farmer or household. Matters related to the individual farm should, as much as possible, be discussed with the whole family. If the whole family is involved, more problems are highlighted and more experience is brought to the discussion that will make the implementation of the ideas much easier.

Plate 1 Individual/household approach method

Advantages of the individual method are:

- Unclear messages that have not been fully understood can easily be clarified
- The extension officer is able to secure cooperation and inspire the confidence of the family through personal contact
- It facilitates immediate feedback on the effectiveness of the measures discussed
- It may be the best way to ensure that everyone in the family participates in decision making.

Disadvantages of the individual method are:

- It is expensive in terms of time and transport
- Only a few farmers may be visited, and sometimes they may be mainly the extension worker's friends
- The area covered is small since all the effort is concentrated on a few farmers.

1.2.2 The group approach

The group approach involves working with groups or the community at large. It is suitable when discussing matters related to the whole community, and when there are activities to be undertaken by a group, e.g. group nurseries. It is also suitable when there is a need to address individual matters but more cheaply than can be done with the individual approach. The direct target group may be, for example, a women's group, a church organization, a co-operative society or the community in general.

Plate 2 Group approach method

Extension work can also be carried out at meetings, either organized specifically to discuss agroforestry issues or by making use of meetings that were already organized for some other purpose but where some discussion on agroforestry can be accommodated. Meetings are effective venues for receiving information from the community, for discussing issues communal or individual interest and for spreading new ideas.

Plate 3 Issues related to agroforestry are effectively discussed in community group meetings

Field days and demonstrations are best organized on individual farms. There are two kinds of demonstration: result demonstrations and method demonstrations. Result demonstrations show farmers the results of a practice that has been in use for some time and are intended to arouse the farmer's interest in the practice. They can also be used to compare older practices or techniques

with new ones. Method demonstrations show farmers how a particular activity or task is carried out, e.g. how to plant a tree. This type of demonstration is among the oldest methods of teaching. It is an effective method since the farmers can practice, see, hear and discuss during the demonstration.

Advantages of the group approach are as follows:

- It is generally cheaper than the individual approach
- More people are reached within a given period of time
- There is an exchange of ideas and experiences among the group
- It is easy to monitor.

Disadvantages of the group approach are:

- It may take a long time to arrive at a decision
- Influential people in the community may dominate the discussions
- It is sometimes difficult to get people to agree on issues and to work together
- Individual problems are not well addressed in a group
- People who are not members of the group will not be reached.

1.2.3 The school approach

Schools can be approached through head teachers or teachers. The extension work can be in the form of lectures, support to Young Farmers Clubs, or discussions held during parents' days. The pupils can be used as a channel for reaching the community and will also be influenced themselves, thus changing the behavior and attitudes of the new generation. Pupils can also be used to trigger discussions in their families.

Advantages of the school approach are as follows:

- Schools can afford to make demonstration plots available and these be seen by many people.
- It is possible to reach large numbers of people within a short time at minimal cost
- Pupils can be reached easily and are often very receptive to new ideas.

Disadvantages of the school approach are:

- Children are not decision makers in the home
- It will be a considerable time before the children become influential in their society.

1.2.4 Mass extension methods

Mass extension methods involve the use of the mass media, e.g. radio, posters, drama, television, newspapers, films, slide shows, to inform the public. Mass media are mainly used to create awareness. Advantages of mass extension methods are as follows:

- These methods can increase the impact of extension staff through rapid spread of information

- Many people can be reached within a short time, even in remote areas

Disadvantages of mass extension methods are as follows:

- The amount of information that can be transmitted is limited
- Radio and television reception is poor in some areas and the target group may not own sets, particularly TVs
- It is difficult to evaluate the impact since there is no immediate feedback
- Production of both programmes and printed materials is costly and requires special skills.

None of the above methods can be singled out as being the best one, all of them have their advantages and disadvantages. The choice of method depends on various factors such as

- The tenure system in the area
- Community organization
- Resources available for extension

2.0 The role of trees IN AGROFORESTRY LAND USE

Trees provide a wide range of products and services. They stabilize soils and ground water, protect water catchments, provide shade for man and animals, and mitigate climate change by absorbing greenhouse gases. Trees act as windbreaks that regulate wind speeds and reduce the destructive effect of winds. The shade provided by trees helps to lower temperatures and retain moisture in the immediate surroundings. This way trees play an important role in determining the microclimate of an area. Some trees enhance soil fertility by fixing atmospheric nitrogen into soil nitrates. Trees provide us also with fuel wood, timber, food, fodder, medicine, raw materials for craft and income.

2.1 Trees for food

Trees in agroforestry systems make supplemental, seasonal and emergency contribution to household food supplies. They provide fruits, vegetables and tubers, among others. These foods serve as appetizers, sources of vitamins and help maintain normal human health. Most of these foods from trees are eaten as snacks that are taken in between meals. They are often very useful during periods when people have less food. Some of the most common food trees include *Mangifera indica, Carica papaya, Balanites aegyptiaca, Ximenia americana, Tamarindus indica, Persea americana* and *Carissa edulis.*

Plate 4: Ripe fruits of orange (*Citrus sinensis*) growing on-farm after crop harvest

2.2 Trees for fuel

Many farmers in Kenya depend on wood for fuel. Most tree species can be used for fuel, but the quality varies greatly. Some species burn very fast and have low calorific value. Other species produce a lot of irritating smoke as they burn. Tree species that are appreciated for cooking are those that have heavy wood that burns slowly with a lot of heat and little smoke. Some of the tree species that can be cultivated for fuel wood include *Eucalyptus spp*. *Acacia spp, Grevillea robusta, Senna spp., Delonix regia* and *Croton megalocarpus*.

Plate 5: Fuelwood harvested from trees on farms

2.3 Trees for shade

Trees provide shade for human beings and livestock. The shading characteristics of different tree species are important in determining their suitability for different sites. For instance, trees with a dense shade all the year round are useful in homesteads and meeting places, while trees with less dense shade are preferred in other situations. Some of the trees with good shading properties include *Albizia gummifera, Bischovia javonica, Delonix regia*, and *Podocarpus falcatus*.

Plate 6: People rest under shade from an assortment of trees

2.4 Trees for timber

The need for timber and poles for construction is one of the most widespread reasons for which people plant trees. Due to growth form and rate of growth, exotic tree species are often more popular than indigenous trees. However, indigenous species tend to be more resistant to decay and termite attack. Some of the tree species commonly grown for timber include *Eucalyptus spp*. *Grevillea robusta, Gmelina arborea, Cupressus lusitanica, Markhamia lutea, Cinderella oleta* and *Maesopsis eminii*.

Plate 7: Sawn timber from mature *Grevillea robusta* trees in a tea growing area

2.5 Trees for fodder

Livestock require a good supply of protein to be able to digest carbohydrates effectively. However, commercial sources of protein such as concentrates are expensive and sometimes beyond the reach of many small scale farmers. Tree leaves and pods are good sources of protein. Some of the tree species commonly used as fodder include *Calliandra calothyrsus, Leucaena leucocephala, Gliricidia sepium, Sesbania sesban and Morus alba*.

Plate 8: *Calliandra calothyrsus* and *Sesbania sesban* with Napier grass on fodder banks

2.6 Improved fallow species

Traditionally, communities used to leave agricultural land fallow for a period of time to allow for soil fertility build up. Today, leguminous shrubs are used to speed up the process. These shrubs fix nitrogen and add organic matter to the soil. Some of the shrubs commonly used as improved fallows include *Crotolaria grahamiana, Tephrosia vogelii* and S*esbania sesban*.

Plate 9: Improved fallow with *Sesbania sesban*

2.7 Trees for medicine

Traditional medicine is very important in most rural areas where conventional medicines are rarely accessible due to distance and high costs. Thus, access to a wide variety of trees, shrubs and herbs is vital for people using traditional medicine. Some tree species used for traditional medicine include *Trichilia emetica, Warburgia ugandensis, Prunus africana, Spathodea nilotica, Zanthoxylum gilletii and Olea capensis*.

(a)

(b)

Plate 10: (a) Young *Warburgia ugandensis* trees (b) a herbalist dispensing herbal medicine

2.8 Trees for fencing (Live hedges)

It is common practice to fence farms and homesteads using trees and shrubs. Some of the tree species that are commonly used include *Parkinsonia aculeata, Dovyalis caffra, Cuppressus lusitanica, Euphorbia tiirucalli* and *Thevetia peruviana.*

Plate 11: Live fence of *Thevetia peruviana*

2.9 Boundary markers

Trees are often used for boundary demarcation. Some of the species associated with this function include *Markhamia lutea, Casuarina spp, Croton megalocarpus, Grevillea robusta, Acacia spp.*

Plate 12: ***Grevillea robust* established on a farm boundary**

2.10 Trees for windbreaks

Windbreaks are plantings of trees, shrubs, or a combination of the two installed to reduce wind speed in an agricultural area for multiple purposes. This is an agroforestry practice which involves the intentional integration of woody and crop species for greater and more diversified use of resources compared to monoculture cropping, and provides potential for economic outputs from both the woody and crop components. The trees can be planted in single or multiple rows depending on farm size and the expectation for tree products. Suitable species for windbreaks may include *Grevillea robusta*, *Casuarina junghuniana*, Eucalyptus spp., *Croton megalocarpus*, *Croton macrostachyus* and *Schinus molle*.

Plate 13: *Grevillea robusta* are key windbreak tree species in tea growing areas

3.0 SELECTION OF AGROFORESTRY SPECIES

Successful growing of agroforestry trees and shrubs depends, to a great extent, on selecting the most appropriate species. To do this, land owners are guided by their own multiple needs, availability of plating materials, adaptation, ease of propagation and management, biological attributes, cash value and interaction with other crops and animals. Trees grown must also be compatible with defined agroforestry technologies. Thus, a farmer may opt for fodder, fuelwood, poles, soil fertility, etc. according to demand.

Some of the characteristics of a good agroforestry tree species that should be considered during selection include:

- Multiple uses, such as the ability to produce fuel wood, timber, poles, fodder, medicine and other products
- An open crown that allows light to penetrate to crops growing next to it
- An ability to sprout quickly after pruning or pollarding
- Good leaf littering making nutrients available at appropriate time in the cropping cycle
- Few and shallow lateral roots
- Deep thrusting tap roots
- Ability to fix nitrogen
- Resistance to drought, flooding, harsh climatic conditions and pests and diseases

4.0 TREE PROPAGATION AND ESTABLISHMENT

The components of any agroforestry system are trees/shrubs, crops and/or animals/pastures. The most significant component is the tree/shrub, and the success of any agroforestry practice depends to a large extend on the tree/shrub woody component, which must originate from a good and reliable source.

Good and reliable sources of planting materials are obtained from trees selected for specific or multiple products. Currently, KEFRI is the lead institution with good sources of seed from selected mother trees, seed stands and seed orchards for both exotics and indigenous. Seedlings for planting can also be obtained from well-established tree nurseries such as those of Kenya Forest Services, KEFRI and Ministry of Agriculture, Livestock and Fisheries.

PROPAGATION

Trees/shrubs can be propagated and established in many different ways including (i) the use of wildings, (ii) seeds, and (iii) cuttings (Figure 1).

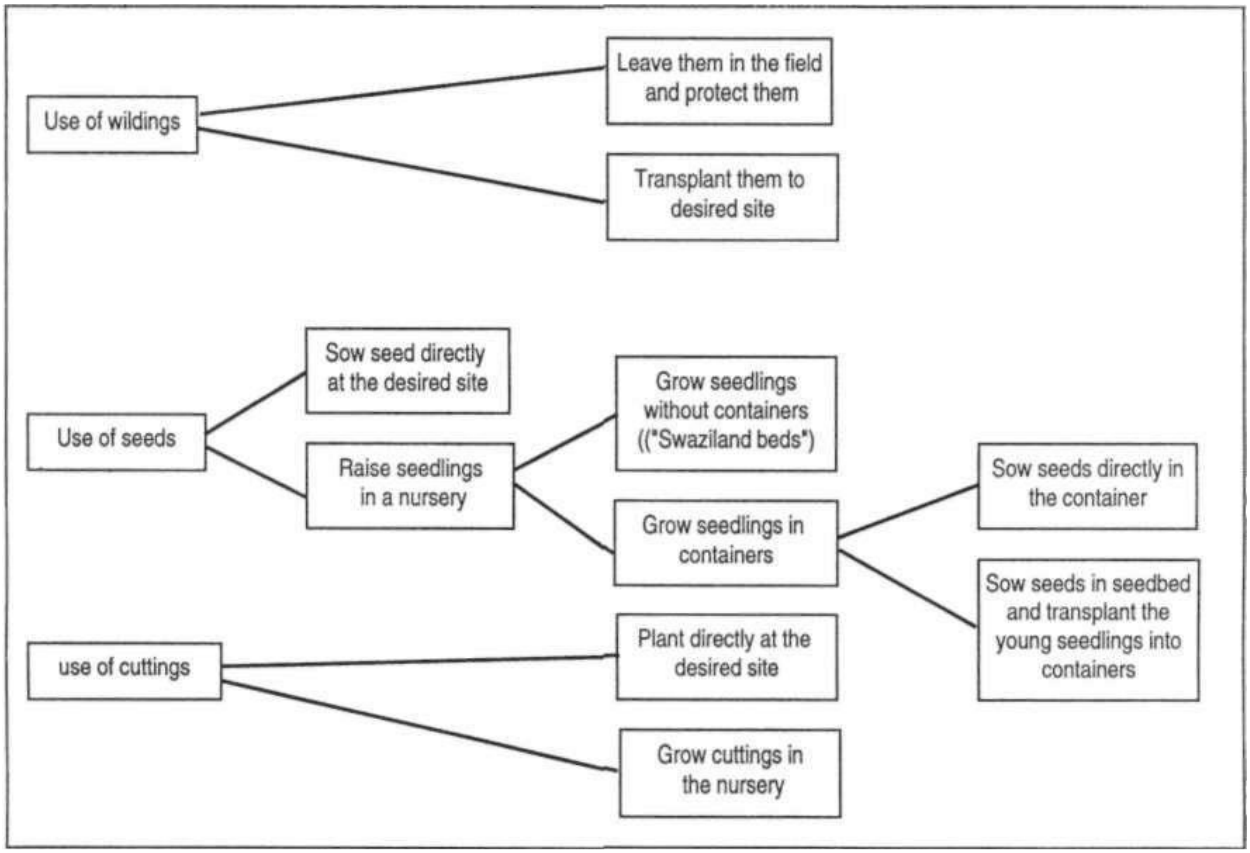

figure 1: Methods of propagation (*Source: Tengnas, 1994*)

4.1 Use of wildings

Wildings are seedlings that have grown naturally from dispersed seeds. Such seedlings are usually found under mature trees or far from the mother trees if the seeds were dispersed by

birds, wind, etc. The growth of more trees may be promoted by protecting young seedlings that have come up naturally. Wildings may also be uprooted and transplanted to desired planting sites as may be found appropriate. Transplanting is commonly done when the seedlings are about 25 cm in size. Some of the trees that have been propagated using wildings are *Grevillea robusta* and *Cordia abyssinica*.

Plate 14: Wildings of Oleleshwa (*T. camphoretus*) regenerating from a charcoal burning site

4.2 Use of seeds

Seeds may be sown directly at the desired sites or may be raised in a tree nursery.

4.2.1 Direct sowing of seeds

Direct seed sowing at the desired site is an important method for species and technologies that require very many trees or shrubs e.g. live fences or woodlots. It can be done in places where a species is well adapted and high potential areas, such as the high potential highlands, the Lake Victoria Basin and the humid coastal strip.

Advantages

- A labour saving method. It eliminates the time needed for raising seedlings in a nursery and planting out the seedlings.

- Direct sowing increases the number of nitrogen fixing nodules on N-fixing trees and shrubs. Nodule formation of *Leucaena leucocephala* has been shown to be suppressed in containerized seedlings, and most nodules can be lost during transplanting as well as during pricking out from the sowing beds.

Disadvantages

Germination rates of seeds can be very low and long due to:

- Seeds being buried or washed away by rain
- Insects and animals feeding on the seeds
- Poor viability of the seeds
- Sudden changes in weather conditions

A lot of expensive seed can be wasted and therefore, direct sowing should only be done if the seeds are plentiful, inexpensive and germination is known to be good.

Direct sowing is done as follows:

- Seeds should be clean, free of dirt and disease, unbroken, and from a reliable source.

Plate 15: Removing dirt and broken pieces from *Cuppressus lusitanica* seed

- Pre-treatment of some seeds is necessary.
- Planting of seeds is done at the beginning of the long rains,
    - Plant 2-3 seeds per hole if germination is known to be good.
    - Plant 3-5 seeds per hole if germination is known to be poor
    - If more than one seed germinates, the extra seedlings can be transplanted for gapping elsewhere.

Some species that have been propagated through direct seed sowing are *Croton megalocarpus*, *Acacia mearnsii*, *Balanites aegyptiaca*, *Caesalpinia decapetala*, *Sesbania* spp., *Leucaena* spp., *Thevetia peruviana*, *Eriobotrya japonica* and *Cajanus cajan*. Generally, seeds should be sown at a depth about twice the seed diameter.

4.2.2 Raising of seedlings in the nursery

An alternative to direct sowing is raising the seedlings in a nursery. Seedlings may be grown without containers in “Swaziland beds” or in containers. In the case of the later, seeds may be

sown directly in the container, or sown in a seedbed and the young seedlings later transplanted into containers.

Nursery raised seedlings have an advantage over direct sowing of seeds due to the initial care they receive. Their production is more labour-intensive than direct sowing, but have higher initial growth rates in the field, especially in marginal lands. Seedlings must be started in the nursery at least 4 months before out planting (6 months in arid/semi-arid lands and 9 months to one year in high, cold areas). The duration taken in the nursery also depends on the species growth rate.

Plate 16: Seedlings receive more care in the nursery than those that germinate in the field

The seedlings can be started either bare root or in containers:

4.2.2.1 Bare root seedlings

Bare root seedlings have higher survival rates in areas with more than 1,200 mm annual rainfall than they do in marginal lands. Thus, this method is not recommended for arid/semi-arid lands. Also, some species such as *Grevillea robusta* and *Acacia albida* do no establish well as bare root seedlings.

Advantages of bare root stock

- Cost, time, and labour required in the nursery is less than that for growing containerized seedlings.
- Many seedlings can be transported easily in a small space and little weight is involved.

Disadvantages of bare root stock

- Nursery location must be in a relatively good site.
- Roots can be easily damaged during transportation
- Survival rates are lower than containerized seedlings.

How to raise bare root seedlings

(a) Planting seeds

- Wet seedbed before planting
- Use dibble planting stick to prick planting holes
- Spacing between seeds should be 8 cm.

(b) Removing for planting

- Water the seedbed
- Cut around each seedling and soil out of bed.
- NEVER remove seedlings by just pulling them out.
- Wrap seedlings and soil in leaves, grass or paper for transporting.

4.2.2.2 Containerized seedlings

This method can be used successfully in all areas and is the best method of establishment for arid/semi-arid lands and marginal areas.

Advantages of containerized seedlings

- High survival rates of seedlings
- Seedlings develop well-formed root systems
- Seedlings can be transported to out planting sites long before planting
- Spread of disease in nursery is easier to combat than with bare root seedlings.

Plate 17: Loading of Eucalyptus seedlings for transport to await rains in desired planting site

Disadvantages of raising of containerized seedlings

- Containers can be difficult to obtain or expensive.
- Growth of nitrogen-fixing nodules on roots of leguminous species can be suppressed by the containers.
- Forest soil can be very difficult and costly to obtain.
- They are bulky to transport (i.e. 10 seedlings may weigh 15 kg)
- Labour-intensive in the nursery.

Containers can be milk packets (opened at both ends, washed and dipped in used oil to deter termites, tied banana leaves, maize husks, tin cans or polythene tubes. The seeds can either be started in seedbeds and pricked out (transferred) to containers or directly sown into containers.

The following is an example of how to directly sow seeds into containers:

(i) Fill containers with mixture of forest soil and sand
(ii) arrange them under a shade in lines
(iii) water the soil before planting the seeds
(iv) Prick a shallow hole in the soil and plant the seed. Put at least two seeds per container. If both germinate, one should be transferred to another container

Plate 18: Pricking of a shallow hole for seed(s) planting

(v) Water the seeds daily if there is no rain, gradually decreasing as the time for out planting nears.

(vi) Out planting – always remove the container unless it is made up of leaves, grasses, etc. or unless its retention is recommended to control termite damages as in dry areas.

Plate 19: Watering of seeds when there is no rain

4.3 Use of cuttings

Most plants are raised from seeds. However, vegetative propagation can be an effective way of raising plants. Vegetative propagation includes the use of cuttings, grafts, layers, suckers, and tissue culture. A cutting is a section of stem that will root when it is placed in the soil. Only certain species have the ability to reproduce this way, and the method can only be recommended for a limited number of tree species. Among these species are: Finger euphorbia, *Euphorbia tirucalli* used as a live hedge in drier areas, *Erythrina abyssinica*, *Gliricidia sepium*, *Morus alba*, Ficus spp., Commiphora spp. and *Moringa* spp.

Advantages of using cuttings

- Good for growing identical trees with desired characteristics
- They have faster initial growth rates than seedlings and can start with a 2-m long cutting, thus escaping grazing damages
- It can save the cost of buying seeds and the labour of collecting seeds as well as reducing nursery production costs.

Disadvantages of using cuttings

- Cuttings are bulky to transport
- Not a very well-known practice; care must be taken to do it correctly.

How to establish from cuttings:

(i) The mother tree must be healthy and of good agroforestry form. Cuttings are bulky to transport. Therefore a few trees can be planted and maintained near-by that will be used primarily for producing cuttings for the farmer.

(ii) The cuttings are made from young, healthy branches, usually between 1-2 cm in diameter.

(iii) The section to be used for the cutting is separated from the main by two, clear-angled cuts.
- The length can be from 20 cm to 200 cm
- The cutting should contain several nodal points from which branches and roots will sprout
- Remove flower buds and leaves as they tend to inhibit vegetable sprouting.

(iv) The cutting is placed crown side up in the soil with at least two nodal points in the ground.

(v) Cuttings must be started in either well-watered (but not water-logged) soil until the roots sprout, or

(vi) Cuttings must be started:
(a) in sandy soil or in sand box and then transplanted to the permanent growing site
(b) directly where the trees are desired, if the soil is a bit sandy.

vii) If cuttings are not planted right away, they should be wrapped, stored in a cool dry place, and planted within a few days time.

FIELD ESTABLISHMENT

Time of planting

Tree seedlings are best planted out at the onset of the long rains. The rains should be well established, and it is recommended that the soil be moist to a depth of at least 20 cm at the time of planting. Tree planting is best done on a cloudy day. Since tree planting usually coincides with peak period for other farm work, as much preparation as possible should be made in advance to await implementation.

Site preparation

Good and timely land preparation is key for plant survival. Where possible, complete deep ploughing and harrowing can be undertaken to improve on water infiltration and reduce the cost hole digging. Where that is not possible, a hole of 30-40 cm deep and equally wide should be dug for each seedling. In this way, the soil is loosened and the roots can establish easily. The topsoil should be separated from the subsoil, and when the hole is filled up again the topsoil should be put back first since it is usually more fertile. The holes can either be dug at the time of planting or in advance. Digging holes in advance has the advantage that it saves labour during the tree-planting period and if the soil is loosed early it may trap and retain more moisture. If the soil at the planting site is poor it can be improved with manure, compost or other organic matter.

Spacing

The spacing to be applied depends on the species and the end use of the product/service intended. Trees intended for short rotation for firewood, biomass and pulpwood are usually planted closely ranging from one metre to 2 m. Those for posts/poles and peeler logs range from 2 m to 3 m. These can later be thinned to wide espacement to cater for sawn wood. For fruit trees the spacing ranges from 4 m to 12 m depending on the species and the site conditions.

Care of seedlings

Seedlings should, ideally be about 30 cm high when they are planted out. Smaller seedlings may compete less successfully with weeds. Also, since their stems are not yet very woody, they are easily damaged during transport. Overgrown seedlings are also easily damaged during handling and may have lost vigour due to many root-pruning operations due to a too-small root ratio compared to the shoot. In order to avoid damaging them, seedlings grown in pots should not be carried by the shoot but rather by holding the pot.

Plate 20: Overgrown seedlings that are easily damaged during transportation

Plate 21: Potted seedlings carried by holding the pot

If seedlings are raised without containers, care should be taken to retain soil around the roots when the seedlings are planted out.

How to plant out
The following should be observed:

After planting, the soil surface in the pot should be level with the overall ground level in the nursery, neither deeper, nor higher up.

If the seedling was grown in a pot, the pot should always be removed. Otherwise the pot may restrict the growth of the roots eventually strangulating the seedling and severely reducing its growth.

Plate 22: Removal of the pot before planting

After refilling the hole, pack the soil firmly around the seedling's root mass and make sure that there are no pockets of air in the soil. Water if there is no rain. However, heavy rainfall should be timed to avoid the process of watering individual seedlings.

Mulch near the seedling to reduce evaporation of moisture and to suppress weeds.

Application of a small amount of fertilizer or manure will help tree seedlings to get a good start.

Plate 23: Packing of the soil firmly around the seedling's root mass

Care of seedlings after planting

Weeding

Regularly spot-weed around the seedling for at least a year after planting. Weeding reduces competition for nutrients and moisture and dramatically enhances growth.

Plate 24: Weeding to reduce competition for moisture and nutrients, and enhance growth

Protection

Protection against livestock trampling and browsing is important, as is protection against fire during the dry season.

(a) (b)

Plate 25: Protection against browsing and trampling by livestock and wildlife

Mulching

Mulching helps retain moisture and suppress weeds, but may also attract termites. If termites attack young trees, an application of ash can help. Leaves of neem, *Azadirachta indica*, also act as termite repellants. If a few valuable seedlings are attacked by scales or aphids, wash them with a strong solution of detergent (e.g. Omo) and water the tree if the soil is dry.

For those of those species that tend to bend or produce many branches in the early stages, e.g. *Cordia abyssinica* and Acacia spp, train up a stake and side pruned them for better performance.

Watering and water harvesting
Seedlings should be watered soon after planting if there is no rain.

Plate 26: Watering of newly planted seedlings when there is no rain

Where it is necessary to plant trees in ASAL areas, e.g. fruit trees near houses or along streams or shade trees around homesteads or at meeting places, water-harvesting techniques, if effectively and correctly applied, can improve seedling performance.

Planting in waterlogged areas
In waterlogged areas, such as marshy low-lying areas of farmlands, only those trees that are known to tolerate such conditions should be planted. Among such species are *Sesbania sesban*, *Syzygium guineense* and *Eucalyptus camaldulensis*, *E. globulus* and *E. microtheca*. Cut back competing natural vegetation growth periodically. In these wetlands, raised mounds can be done to keep the seedlings above the semi-permanent water level.

Pest and disease control

Trees/shrubs also suffer from a range of invasion and disease infection. To guard against this, there is need for frequent scouting to detect any such problems before spreading out. It is easier to deal with such problems when spotted on a few trees than in a whole plantation. Once a problem is detected the causative agent can be taken to the nearest agrovet, KEFRI Centre or KFS for advice on management protocol.

5.0 Tree management practices

The most common tree management practices on farms include: Pruning, Lopping, Pollarding, Coppicing, and Thinning.

5.1 Pruning

This is the removal of branches from the lower part of the tree crown near the stem. Too much pruning may reduce the growth vigour of some tree species. The best time for pruning is towards the end of the dry season. The objectives of pruning are fourfold:

- To reduce shading of crops growing near the tree
- To improve the quality of the trunk for poles and timber
- To harvest branches early for fuel and fodder
- To concentrate growth on the terminal buds

For instance, the first pruning for Grevillea should be done at age 4 - 5 years.

5.2 Lopping

The difference between lopping and pruning is that branches are not cut from the base, but is rather haphazard. It is usually carried out

- To obtain green foliage for fodder.
- To reduce shading of crops.

5.3 Pollarding

Pollarding refers to cutting off all the branches and the crown of a tree leaving a stem of about 2m. Not all tree species can withstand pollarding. It is normally carried out

- To obtain an early harvest of fuel wood or fodder or for biomass transfer
- To produce trees that are beyond the reach of livestock hence minimizing the need for protection from browsing
- To reduce shading of crops
- To promote the growth of the bole for timber or poles through the regeneration of the tree crown.

Some commonly pollarded species include *Balanites, Bridelia micrantha, Casuarina, Cordia abyssinica, Croton, Erythrina abyssinica, Acacia albida, Ficus sycomorus, Grevillea robusta, Jacaranda mimosefolia, Markhamia lutea* and *Morus alba*.

5.4 Coppicing

Is the practice of felling a tree in order to allow it to sprout. Coppicing is only applied to those tree species that regenerate after being felled. Some people regard coppicing as a method of propagation since it substitutes for the task of planting a new tree after a mature one is felled. Some commonly coppiced species include *Calliandra calothyrsus, Senna siamea, Senna spectabilis, Gmelina arborea, Eucalyptus* spp., *Leucaena* spp. and *Markhamia lutea.*

Systematic coppicing is applied as the management technique in alley cropping i.e. the stump sprouts and grows alongside the crop, while the foliage obtained from the mature tree is recycled to the soil.

Plate 27: Coppicing of *Calliandra calothyrsus* for fodder and mulch production

5.5 Thinning

Trees may be planted in a dense stand to promote straight growth and small branches. However, they must be thinned later on to promote the enlargement of the girth. Thinning is the removal of some trees to increase the spacing between individual trees. This might involve removing every second or two out of every three trees. Thinning can also be done by removing the poorly growing trees. Thinning is generally common in woodlots in order to obtain fitos, fuel wood or construction poles by way of an early harvest. The other trees can be left to grow into big trees for timber.

5.6 Root pruning

Just as a tree crown can be managed to reduce competition between trees and crops, tree roots can be managed for the same purpose. Trees with lateral roots that can compete with crops can have their roots pruned by digging a trench of 50cm – 100cm in depth, along the edge of the woodlot where the woodlot borders the cultivated area. The roots that are encountered in the process of digging are cut to reduce competition with crops.

6.0 COMMON AGROFORESTRY PRACTICES AND TECHNOLOGIES

Agroforestry is beneficial to the farmer if the net effect of tree-crop/animal/pasture interactions is positive. To achieve this, the right tree species, right crops, right spatial arrangement and right management practices must be identified and applied. The following are some of the most common agroforestry technologies:

6.1 Trees in cropland

This technology consists of trees kept singly or in clumps (woodlots) dispersed in cropland with an aim of obtaining other valuable products such as fruits, poles, firewood, fodder, gum, materials for basketry, medicine or to support apiculture. The most widely used species include various fruit tree species, *Ficus sp., Markhamia lutea, Albizia sp. Grevillea robusta, Casuarina sp, Acacia mearnsii, Cordia abyssinica* and *Croton microstachys*. Establishment of woodlots within farmlands is common with *Eucalyptus* sp, *Markhamia lutea*, *Casuarina* sp., *Senna siamea* etc. The most favoured species are those that can coppice. Trees in cropland are expected to improve mineral nutrition, ameliorate the site with humus and pump up nutrients from below the crop root level. By mulching the top soil, the water infiltration and holding capacity is improved. Trees reduce soil erosion. The improved productivity and sustainability is mainly achieved through diversification of production and complementary nature in the integrated system of crops and trees.

Plate 28: Bean crops under an assortment of tree species in an agroforestry system

6.2 Hedgerow intercropping

In hedgerow intercropping systems, arable crops are managed in the spaces (alleys) between the rows of planted trees. The woody plants are cut regularly to provide leaves and twigs which are used as mulch on the crop alleys to reduce evaporation from the soil surface, suppress weeds and add nutrients and organic matter to the topsoil. Trees within the system also provide other products. When leguminous trees are used, the soil is enriched with fixed nitrogen compounds. Other trees such as *Casuarina* and *Alnus* sp., though not legumes, do fix nitrogen that enhances soil fertility. Trees or shrubs used for this purpose should withstand regular cutting and trimming. Some of the species which have been applied in the system include *Calliandra calothyrsus, Leucaena leucocephala*, *Senna siamea*, *Gliricidia sepium*, and *Morus alba*. The species used for this system also serve well as fodder trees

Plate 29: Hedgerows of *Sesbania sesban* and *Calliandra calothyrsus* intercropped with green vegetables

6.3 Improved fallow

In this technology, nitrogen-fixing trees (shrubs) are planted in the cropland between rows of crops. Once the crops are harvested the shrubs are left for one or two more seasons to fix nitrogen, add humus and shelter the land from erosion as it could be under natural fallow. When the two seasons are over the shrubs are clear felt and the land cultivated. The biomass received is used as firewood and fodder. The most widely used species are; *Tephrosia* sp, *Calliandra* sp, *Crotolaria* sp, *Sesbenia* sp, *Glericidia sepium* and *Leucaena* species.

6.4 Multipurpose woodlots

These are small plantations of less than 10 ha, often much less, that are established by the individual farmer for the production of poles, fuel, fodder and possibly other products. The

products supply the farmer's own needs with excess for sale, and such woodlots may be established on unused or degraded land with a view to rehabilitating it.

Plate 30: A woodlot of Blue gum (*Eucalyptus grandis*)

6.5 Trees in home gardens

A home garden can be defined as a farming system which combines different physical, social and economic functions on the area of land around the family home. The system involves planting of trees and shrubs within the home compound with the intention of getting other valuable products and services. The trees may be grown together with arable crops, vegetables and herbs or are set in specific areas. The trees grown include ornamentals, fruit trees, fuelwood and fodder. Variable fruit trees such as *Mangifera indica, Citrus sp. Carica papaya, Persea americana,* and *Psidium guajava* are commonly maintained within the home compounds. Apart from providing the fruits, the trees also provide shade and other products. Other trees which flower regularly such as *Callistemon viminalis, Spathodea nilotica, Jacaranda mimosifolia* and *Hibiscus sp* are usually planted in home compounds. Occasionally, the home gardens will also include species for pole, fuelwood and fodder such as *Eucalyptus, Markhamia* and *Calliandra* sp. Trees that attain great heights under good conditions such as *Eucalypts* or *Acrocarpus fraxinifolia* are often planted at strategic positions as markers which can be used for directing others. Before planting trees in the homestead, it should be noted that tall trees must be kept away from buildings lest any calamity befalls them smashing the houses.

Plate 31: Tree-crop mixtures in a multipurpose homegarden

6.6 Live (living) fences

Live fences are used to protect people and their dwellings, crops, animals and other property. They may also provide fuel wood, fodder, food and act as windbreaks or enrich the soil depending on the species. Living fences are permanent densely spaced single or multiple lines of woody plants. They are regularly pollarded and trimmed. The attribute of the plants used in the system is mostly their impenetrability. Living fences are relatively cheap to establish, efficient and has long life if well managed compared to barbed wire or chain link. Most of the species used are thorny which protects them from browsing animals. The species widely used for live fences include *Dovyalis caffra, Parkinsonia aculeata, Acacia mellifera, Caesalpinia spp., Lantana camara, Cupressus lusitanica, Euphorbia tirucalli, Gliricidia sepium, Thevetia peruviana*, and *Erythrina abyssinica.*

6.7 Biomass transfer

The technology involves raising of shrubs in hedges, trimming the biomass, transfer and digging it into the soil to rot and provide manure. The most widely used species are; *Tithonia* sp, *Lantana* sp, *Gliricidia sepium, Thevetia peruviana*, *Calliandra* sp, and *Leucaena* sp. The technology is labour intensive.

6.8 Boundary planting

Boundary planting commonly involves planting of a single or two lines of trees to demarcate the boundaries of a farm or plot. The trees may be widely or closely spaced depending on its association with crops and should be long lived. Deeply rooted species that compete less with crops are preferred. Within a species, narrow crowned forms if available could be suitable as they shade less area. Examples of trees used in the system include *Cupress*us *lusitanica,*

Syzygium spp., *Eriobotrya japonica, Grevillea robusta, Markhamia lutea, Albizia spp, Gmelina arborea, Hakea saligna, Morus alba, Spathodea campanulata, Prunus africana and Syzygium cuminii.*

This system usually requires consultation with the next land owner because they will interfere with crop growth on both sides, unless the land is bordering a common utility such as a road. Some products, e.g. fruits might attract other people on the other side of the boundary and cause frictions unless good neighbourliness exists.

Plate 32: Boundary planting with *Grevillea robusta*

6.9 Windbreaks

Windbreaks are often, but not always located along the boundaries. They are usually wider plantings of 4 to 12 rows of trees. Their main purpose is to protect homes, crops, pastures, soil and water resources from wind damages. The windbreak should be established across the path of prevailing winds. To strengthen the windbreaks there are multiple rows of trees mixed with shrubs. Species used in the system include *Grevillea robusta*, *Cupressus lusitanica*, *Markhamia lutea* and *Eucalyptus sp*. Windbreaks may only be planted in large farms, where the portion taken by the trees is negligible compared to the arable area, or unless trees are targeted as part of the major products.

6.10 Trees in pastures and rangelands

The system involves silvopastoral practices combining woody plants with grasses and other herbaceous fodder plants. On rangelands, the major activity is to protect naturally occurring trees and shrubs of particular value for animal fodder. The same trees maintained in the rangeland may provide fuelwood, fruits, honey, medicines, gums, resins and fibres. Suitable tree species in pastures and rangelands include *Schinus mole, Faidherbia albida, Salvodora persica,*

Combretum molle, Boscia coriacea, Dichrostachys cinerea, Acacia polyacantha, Acacia gerradii, Tamarindus indica, Acacia tortilis and Balanites aegyptica. For the cut-and –carry practices, species such as *Leucaena leucocephala, Gliricidia sepium* and *Calliandra calothyrsus* may be used. Some trees are mainly grown to provide shade for animals, enhance grass growth under the canopy and provide medicines to animals.

Plate 33: Trees in pastures and rangelands

6.11 Trees on stream valleys, gullies and floods plains

Trees and shrubs planted along the banks of water courses will assist to control erosion and other negative effects. The main attributes of trees and shrubs that may be planted along the water courses is their ability to withstand water-logging and ease of regeneration. Tree species which could be considered for such sites include *Bamboo* sp., *Populus ilicifolia* and *P. alba*. Other tree species *include Acacia albida, Acacia gerradii, Acacia polyacantha, Acacia elatior, Acacia xanthophloea, Ficus sycomorus, Garcinia livingstonii, Vitex doniana, Syzygium guinense, Terminalia brownii, Phoenix reclinata, Phoenix dactylifera, Hyphaene coriaceae, Trichilia ementica, Tamarindus indica and Conocarpus lancifolius*. Gullies which have been formed by past erosion activities may be controlled by planting trees. Trees for gullies should grow on poor soils.

(a) (b)

Plate 34: Trees along river (stream) banks

6.12 Trees in public centers

Trees are established as part of public centers to provide beauty, ameliorate the environment, and serve as windbreaks, shade, noise absorbers, air cleaners, and ornamental. Trees in centres mainly occur along avenues, highways and major roads, ornamentals around buildings, live fences, flower gardens, recreational parks, Botanical gardens, arboreta and forest reserves around the centres. Fuel wood plantations from urban forestry also help meet some of the energy requirements. Some schools have reduced cost drastically by using their own fuelwood sources.

6.13 Trees in wastelands

Plate 35 Soil damp at mining site

Plate 36 Gullies left after mining

Most mining areas, quarries and heavily eroded gullies have limited agricultural value unless ways of converting them to forest lands is worked out. Most trees required for such sites must be

having the ability to add their own nutrients to the infertile soil. Nitrogen fixing trees, mainly acacias and casuarinas have been used successfully. In Kenya, *Casuarina equisetifolia* has performed well at Bamburi near Mombasa. In stony sites with little soil between the rocks, trees such as *Mangifera indica, Terminalia brownii, Combretum* spp, *Dodonea viscosa, Euphorbia tirucali, Psidium guajava, Callitri*s spp, *Acacia horkii, Acacia drepanolobium, Ximenia americana* and *Carissa edulis* can be handy in revegetation.

7.0 CONCLUSION

In Kenya, while the gazetted forest area appears to be fixed and might only go down with time, agroforestry is the in-thing that will allow the country to meet its target of 10 % forest cover and go beyond. This is possible given that agroforestry is driven by individual, community and commercial interests. To support the course, the sector is being supported by well identified and demonstrated:

- Array of tree species suitable for growing in various ecological zones
- Technologies for establishment of trees with crops/livestock
- Approaches for capacity building to attain the goals
- Expanding markets for agroforestry products
- Mobilization of resources to promote the practice in the country
- Supportive policies to encourage the practice of agroforestry.

8.0 REFERENCES

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