



Knowledge, Innovation, Excellence
NATURAL RESOURCES COLLEGE

AGROFORESTRY

Course Lecturer: Chrispin Chinangwa

BACKGROUND TO AGROFORESTRY

- Sustainable development means the development that meets the needs of the present generation without comprising the needs of the future generation to meet their own needs.
- Or is embarking on activities that raise the social welfare of the community at large with maximum resource conservation, maximum production and minimum degradation allowable with available economic, social and technological constrates.

Cont'

• TWO PRINCIPLES HELD IN SUSTAINABLE DEVELOPMENT

1. Everybody is entitled to a health and productive life in harmony with the nature
 2. Development today must not undermine that of the future i.e. present generation should be responsible enough in using the natural resources.
- But in Malawi we depend mostly on agriculture therefore to achieve sustainable development first and foremost our agriculture has to be sustainable.

WHAT IS SUSTAINABLE AGRICULTURE

- This is an agriculture that utilizes an understanding of natural occurring processes along with the latest scientific advances to produce integrated resource conservation and conserving farming system.
- To achieve sustainable agriculture we need to ensure that basic and fundamental changes to the way people live their lifestyle and their beliefs. Such fundamental changes may include:

Cont'

1. Environmental protection and resource conservation

- Health and safety are as important as productive agriculture itself because in the long run there are not conflicting goals that is production in future depends on measures taken now to conserve resources.
2. Pesticides, soil erosion and any other harmful processes should rather be prevented from occurring and not covered by band aid. (**Prevention is better than cure**).
 3. the farm is an organization and not a factory i.e. production on the farm and all resources are in alleys contributing to agricultural production but due to synergism of crop, animal, soil microorganisms and a farmer stewardship. Our main aim should not be only on agriculture but we should also consider natural resources not to be degraded
 4. Sustainable agriculture is viewed only as one way of improving farm production to achieve immediate goals. This concept and its pursuit must extend beyond the farm gate into the rest of the food and fibre system.

CHARACTERISTICS OF SUSTAINABLE AGRICULTURE

1. Ecological sound

This means that quality of natural resources is maintained and the vitality of the entire agro system is enhanced from human, crop, animal. This should be enhanced along with or through biological processes as environments.

2. Economically viable

This means the farmer can produce enough for self sufficiency and income gained can be used to warrant labour and input cost. This should be measured only in terms of direct farm produce but also in terms of functions. e.g. conserving resources and minimizing risks.

3. Socially just

This means that resources and power are distributed in such away that the needs of all members of the society are met and their right to land use, adequate capital, technical assistance and market opportunities are assured.

Cont'

4. Productive

This means that the sustainable agriculture should basically raise overall farm output.

5. Humane

All forms of life that i.e. plants, humans and microbes are to be respected in addition culture and spiritual integrity of the community is preserved and natured.

All these mean that sustainable agriculture and sustainable development entail anticipate and avoid rather than react and cure, which is called Proactive Approach. One of the ways of doing sustainable agriculture is practicing agro forestry

AGROFORESTRY

- Definition of agroforestry ranges from simple definitions like “trees on farms” to more complicated ones like:
- A collective name for all land-use systems and practices where woody perennial plants are deliberately grown on the same land management unit as agricultural crops and/or animals, either in a spatial mixture or in temporal sequence (Lundgren and Raintree,1987).

- A dynamic, ecologically based, natural resource management system that, through the integration of trees in farm and rangeland, diversifies and sustains smallholder production for increased social, economic and environmental benefits." (Leakey 1996)
- A land-use system in which trees or shrubs are grown in association with agricultural crops, pastures or livestock.
- A practice of deliberately growing or retaining trees or shrubs within agricultural or pastoral land use system, either under the same form of spatial arrangement or temporal sequence.

- More simply put, agroforestry is any use or planting of trees by farmers within the farm or homestead for a variety of purposes: wood, fodder, fruits, medicine, shade, soil improvement, water conservation and many others.
- This integration of trees and shrubs in the land-use system can be either a spatial arrangement, e.g. trees growing in a field at the same time as the crop, or in a time sequence, e.g. shrubs grown on a fallow for restoration of soil fertility (Ewnetu and Temu,1999).
- It is more than simply intercropping trees with food crops, it further combines crop and livestock production with forestry activities to improve or prevent further degradation of ecosystems (Bunderson *et al.*, 1995)

Features of Agroforestry

- Normally involves two or more species plants (or and animals), at least one of which is a woody perennial (trees, shrubs, palms, bamboos, vines etc)
- The trees and shrubs will have an impact on the other components in the land-use system.
- There are both ecological and economic interactions between the different components (the perennials and crops or livestock).
- An agroforestry system always has two or more outputs thus the system often involve management of trees and shrubs and utilization of their products

- The cycle of an agroforestry system is always more than one year
- Even the most simple agroforestry system is more complex, ecologically and economically than a monocropping system
- This integration of trees and shrubs in the land-use system can be either a **spatial arrangement**, e.g. trees growing in a field at the same time as the crop, **or in a time or temporal sequence**, e.g. shrubs grown on a fallow for restoration of soil fertility.

Components/Elements of Agroforestry

- Trees, or other woody perennials, seasonal plants and animals are called the **components or elements** of agroforestry
- For Agroforestry to be beneficial, the different components must have a positive effect on the entire land-use system through ecological and economic interactions between these components
- Consider **biophysical** and **economic** compatibility of any choice of components/elements
- Interactions can be **positive or negative**.

Economic interactions:

- **Complimentary interaction**-presence of one component increases yield of the other
- **Neutral interaction**-if presence of one component has no effect on the other
- **Competitive interaction**-presence of one component reduces the yield of the other

Ecological interactions

Ecological interactions in agroforestry are about

- **Climate**(light, temperature, humidity, wind)
- **Soil** (organic, nutrients, erosion)
- **Biological resources** (plants and animals)
- **Space** available for growth

Note that interaction of plants and animals alone is not enough to make up an agroforestry land use system, the presence of woody perennials is necessary for the system to be considered as agroforestry.

- **Agroforestry aims at identifying positive interactions and maximize them while trying to reduce negative interactions.**

Multipurpose Trees and Shrubs (MPTS)

- A Tree in agroforestry is considered to be a **multipurpose tree** (abbreviated as **MPTS**) to show that the tree plays several roles in the agroforestry system.
- These roles are classified into **Production factor or products** and **service provision/services**.
- **Products**-fuelwood, fodder, food, medicinal, timber
- **Services**-soil conservation (fertility and erosion), microclimate, land demarcation, carbon sequestration, socio-cultural aspects)

MPTS

- Multipurpose trees are considered to be the ones that are deliberately grown, kept or managed for more than one use, of either production or service nature
- Among multipurpose trees are nitrogen-fixing trees which are able to fix nitrogen from the atmosphere through symbiotic microorganisms in roots and (sometimes stem) nodules and increase nitrogen in the soil through decomposition of the nodules and roots
- Nitrogen supply can have beneficial effect on the crops planted in association with these trees
- Furthermore, many of these trees mainly in the **Leguminosae** family are fast growing, have seeds in pods and produce fodder.

Explanation of terms

- **Woody plants** (also called **ligneous** plants) are plants that contain **lignin**, an organic substance that impregnates and unites the cells and fibres of the plant.
- Woody plants are perennial, with rare exceptions. Of course, woody perennials include all trees and shrubs with a **lifespan of more than a year**, but they also cover bamboos and palms.
- **Trees** are woody perennial plants having a single stem and form the majority of the ligneous plants

- **Shrubs** are small, usually multistemmed woody plants, while a **bush** is a low densely branched shrub.
- **Woody vines** (or lianas) belong to ligneous plants and generally require a support
- **Bamboos**, although they do not contain lignin are considered to belong to the same class as woody perennials in agroforestry

Agroforestry system

- Systems theory define a system as a set of related elements or a way of setting up a model based upon a real or invented situation.
- Systems theory group components together in an organised way. A group of interdependent components form a unit and work together.
- In systems analysis language, a *system* refers to a group of physical components, i.e., an assemblage of objects, connected or related in such a manner so as to form and/or act as an entire unit;

Thus an **agroforestry system** can be defined as a set of interdependent agroforestry components (woody perennials, with crops and/or animals) representing a current type of land use in a given locality or region.

Agroforestry practice

The term can be used to denote **functional** meaning-a specific land management operation of an agroforestry nature (Nair,1985)

Young (1989) uses structural aspects and says an agroforestry practice is a distinctive arrangement of agroforestry components in time and space

Agroforestry Technology : An agroforestry technology is a set of specifications for the roles, arrangement and management of MPTS and associated components.

- A technology is generally adapted to a particular site
- Technology or a set of technologies is used for agroforestry extension purposes. Thus, technology can be specific detailed arrangement of agroforestry components while a practice is used as a broader term.
- A practice or a technology become a system once they are well and commonly used in a given region in such a way that it forms a well-defined land use system for that region.

- Practice, technology or system are sometimes used interchangeably in agroforestry literature
- Once a technology has been in existence for a certain amount of time and is practised regularly by farmers, it is called a **traditional agroforestry practice**.
- Thus, a traditional practice is always a technology but technology is not always a traditional practice.

Agroforestry Intervention

- Agroforestry often uses an approach called Diagnosis and Design (D&D) with an objective of analysing farming systems by identifying possible constraints/problems and proposing agroforestry solutions that should deal with these problems.
- D&D is a systematic and objective methodology used to initiate, monitor and evaluate agroforestry programmes.
- An agroforestry technology that is proposed to alleviate some of the constraints identified by D&D exercise is called an **agroforestry intervention**.

Classification of AF systems

AF systems can be categorized according to the following sets of criteria:

- **Structural basis** – refers to the composition of the components, including spatial admixture of the woody component, vertical stratification of the component mix and temporal arrangement of the different components
- **Functional basis** – refers to the major function or role of the system, mainly of the woody components (these can be productive, e.g., production of food, fodder, fuel wood or service, e.g., windbreaks, shelterbelt, soil conservation etc)

Cont'

- **Socio-economic basis** – refers to the level of inputs of management (low input, high input) or intensity or scale of management and commercial goals (subsistence, commercial);
- **Ecological basis** – refers to the environmental condition and ecological suitability of systems, on the assumption that certain types of systems can be more appropriate for certain ecological conditions; there can be a set of AF systems for arid and semi-arid lands, tropical highlands, lowland humid tropics, and so on.

Structural Basis For Classification Of Agroforestry Systems

- **Presence**
- The three main agroforestry components, trees, crops and animals (or pastures) define the following structural categories, which are based on the nature and presence of these components:
 1. **Agro-silvicultural systems:** trees and seasonal crops
 2. **Silvo-pastoral systems:** trees and animals/pastures
 3. **Agro-silvopastoral systems:** trees, seasonal crops and animals/pastures

Other systems:

They are usually classified separately, although they belong, strictly speaking, to Silvopastoral systems.

- Apiculture in association with trees,
- Fisheries in association with trees (Aquaforestry),
- Entomoforestry (trees with insects).

Structural Basis For Classification Of Agroforestry Systems

- **Arrangement**
- Two aspects should be taken into account with regard to the arrangement of the components:
 1. **Space:** The spatial arrangement concerns the **physical location of the components on the plot**.
 2. **Time:** It is also important to describe the **temporal arrangement (or sequence) because the different** components may be on the plot at the same time, follow each other, or partially overlap in time.
- The arrangement is generally described according to the woody (trees) and non woody components but, in some cases, many components may be woody, like in plantations where
 - trees and perennial crops (e.g. shade trees on coffee) are grown in association, in multipurpose
 - woodlots or in certain home gardens.

Four categories of arrangements

1 Mixed/Zonal Arrangement

1.1 Mixed: the different components are not geometrically arranged, but appear in an irregular manner.

- Some examples are: scattered trees dispersed on cropland,
- Home gardens, or aquaculture in mangrove areas.

1.2 Zonal: the different components are geometrically arranged; for example,

- rows of trees and alleys of seasonal crops,
- windbreaks, hedgerows,
- rows of trees on terrace

2 Dense/Scattered Arrangement

2.1 Dense: the components are close together throughout the plot; for example, in a forest garden, in alley cropping.

2.2 Scattered: the components are far from each other: isolated trees in a pasture, for example, or scattered trees in crop land.

Four categories of arrangements

3. Single Strata/Multi-strata Arrangement

3.1 Single Strata: there is only one tree layer, for example, alley cropping, live hedges; or windbreaks with only one species.

3.2 Multi-strata: there are several tree layers, for example, in many home gardens or forest gardens, in multipurpose woodlots; or in windbreaks with two or more species having different dimensions.

Four categories of arrangements

4. Simultaneous/Sequential Arrangement

4.1 Simultaneous: the different components are present on the same plot at the same time.

- Examples: trees in a pasture, trees in association with perennial crops. This type of arrangement can also be called coincident.

4.2 Sequential: the different components are not present on the plot simultaneously but they follow each other, for example, a tree fallow alternating with classical agricultural land-use. Components can also overlap partially in time, for example, tree planting for an improved fallow before the end of the agricultural cycle.

Cont'

In the case of sequential arrangements, one of the following categories must be applied:

- **Separate, or relay arrangement:** the woody and non woody components do not overlap in time, for example, in shifting cultivation, fallowing, and all systems on a total rotation.
- **Overlapping Arrangement:** the crop cycles of the woody and non woody components partially overlap. Either one may be present first.
Examples: multipurpose woodlot in which seasonal shade-tolerant crops are introduced, or tree plantations for improved fallow before the end of the crop's cycle.

Cont'

- **Interpolated or Intermittent Arrangement:** the woody component is always present and the non woody component is only present during certain periods, for example, in the case of animals grazing under trees on a seasonal basis or the irregular renewal of a part of the underwood in a home garden.
- **Concomitant Arrangement:** the woody component is always present and the seasonal component is only present at the beginning or end of the woody component's crop cycle.
Some examples are: crops grown in association with trees until canopy closure is achieved (taungya), beehives set up in an already productive orchard.

National aims for the promotion of agroforestry

- Improve food security
- Agricultural sustainability
- Conservation of natural resources

Problems to be addressed

- Small farm holdings
- Declining soil fertility
- Increasing soil erosion
- Rising costs of farm inputs
- Poor animal nutrition
- Accelerated deforestation and overgrazing
- Fuel wood shortage

Best practices being promoted in Malawi

BEST BET TECHNOLOGIES

- These are Agro forestry practices that have been widely accepted by local farmers. Some of these technologies are:

A. Dispersed Systematic Interplanting (DSI)

Design specification

- Trees are planted at a wider spacing

Purpose

1. To improve soil fertility
2. To meet fuel, fodder and other household needs

Cont'

- Common species used in DSI are;
Acacia, *Polyacantha*, *Acacia galpini*, *Faidherbia Albida* (Msangu).
- All are fast growing and indigenous to Malawi
- *Faidherbia Albida* drop nutrient rich leaves by the start of the rains, its bear canopy and leaf fall at this time offer light and soil conditions ideal for good crop growth.
- Spacing is regular for uniform coverage to allow other farm operations.
- Planting seedlings at 2.5m (high density) maximize benefits at an early stage.
- As trees grow they form branch and bush hence thinning and pruning are encouraged.

Cont'

- Spacing of seedlings
 - 10x5 =200trees/ha, tree canopy 3m
 - 10x10 =100trees/ha, tree canopy 5m
 - 10x20 =50trees/ha, tree canopy 8m
 - 20x20 =25trees/ha, tree canopy 3m
- Tree planting schedules
 - Aug-Nov: nurseries
 - Nov-Jan : Outplanting
 - Jan-Aug: field management

B. Annual undersowing

Purpose

- Restore soil productivity (soil fertility/soil and water conservation)
- Fuel wood

Design specification

- Yearly intercropping of shrub in maize fields
- Shrub is planted within two weeks after planting maize

Recommended species

- Tephrosia species *Tephrosia Vogelli*
- *Cajanus cajan*
- *Sesbania sesban* (Jerejere)

- The biomass is incorporated during ridging, this continues every year

Cont'

Planting requirements

- *Cajanus*: 7.5kg/ha
- *Sesbania* 2kg/ha
- *Tephrosia* 5kg/ha
- Plant on ridges 75cm apart; 90cm on ridge

Management

- Shrub benefits from all crop management activities
- Direct sowing
- Harvest grain and seed when ready
- Harvest biomass in readiness for new season

Procedure

- Plant maize first, two weeks after germination directly sow shrubs at 2 stations in between maize stations that are 90cm apart, for **Sasakawa**
- 1 station between maize plant if fertilizer is not used or parallel to maize plant if fertilizer is used.
- Weed them together with maize and harvest maize in April.
- Cut and shrubs down in May /June and allow them to dry up to September, spread the biomass in the furrows and start ridging to incorporate them. Take all the woody parts out of the field and use them as firewood.

BENEFITS OF UNDER SOWING

1. Fast restoration of soil fertility and structure from high biomass yield, deep roots break through hard pans to improve water infiltration and root development in crops.
2. Soil and water conservation from good vegetative cover and litter combined with suppression of weeds.
3. Abundant fuel wood though of low quality.
4. **T. vogelli** is also used and control pests such as stock boiler, aphids, leaf eaters and fleas.
5. Leaves of *T. Vogelli* are crushed and mixed with maize in granaries to prevent weevils.

C. Improved Fallow

Purpose

- Speed up soil regeneration

Recommended species

- Tephrosia species
- Cajanus cajan
- Sesbania sesban

For long term

- Gliricidia sepium
- Acacia species
- Leucaena species

Cont'

Field management

- Year 1
Under sow shrubs with cereal crop on every ridge
- Year 2
Leave shrubs only in the field, Collect seed, Bury biomass as one management
- Year 3
Resume crop cultivation
- Year 4
Under sow shrubs with cereal crop on every ridge

Cont'

- Improved furrow can be divided into two;
- **(i) Fallow with short leaved shrub**
- First year intercrop with maize and second year abandon cultivation. Leave trees in the second year to restore fertility. Cut down the shrubs to ground level and bury the leaves and carry the woody material for fuel. Third year resume annual cropping and the fourth year resume what was done in the first year.
- **(ii) Fallow with long lived trees**
- First year and second year interplant the crops with the trees as there is no/little competition since trees are still young.
- Third year and beyond leave trees to grow until they reach harvesting time for desired wood products. Cultivation is restored after harvesting the trees.
- The procedure of sowing and species used are the same as those of annual under sowing. This yield more biomass but requires more land during the first time for fallow. There is also loss of yield during furrow period and gives more time to root knot.
- **Examples of improved fallow of maize with *Tephrosia vogelli***

1 st year	2 nd year	3 rd year	4 th year
Tephrosia + maize	Tephrosia	Maize	Tephrosia + maize

D. Regeneration of natural trees

Purpose

- Encourage farmers to protect natural trees in the fields for household use

Recommended species

- Choice depends on farmer and natural woodlands
 - Acacia species
 - Brachystegia species
 - Fruit trees eg. Ziziphus, Uapaca, Ficus

Tree management

- No nurseries
- Weeding
- Protection from animals/fire etc

Other available technologies and practices (for your individual reading and note taking)

These are not widely adopted because of the complexity and management intensive needs of the methods.

1. Alley cropping/hedgerow intercropping

This is interplanting maize with agro forestry species row by row. A practice where the crops are grown between the lines of the trees/ shrubs that are in hedge rows and crops in alleys.

Purpose

- Improve soil fertility and crop yields

Recommended species

- G. sepium, Leucaena species, Senna spectabilis

Shrub management

- Use nursery seedlings
- Plant ever 5th furrow
- After year 1 need to coppice/ pruning as new growing season begin
- Can be repeated during the growing season

Cont'

2. Live fence

Planting trees around homes and gardens and are used to protect animals and thieves' .e.g. common species are sisal.

3. Homestead planting

Planting trees around homes for shed, for fruits or wind break. Common species are Cinderella.

4. Green manure/ fodder banks

Agro forestry species are grown on separate field to be feed to animals or for manure making during times of needy. Animals are usually under zero grazing. Species include leucaena.

5. Woodlot

Trees are planted on a separate field to establish a forest; it could be a source of fuel wood, timber, non timber products. Common species are *senna siamea*.

6. Contour vegetation strip

AGROFORESTRY TREE/ SHRUB ESTABLISHMENT AND MANAGEMENT

Species Selection

Three factors to consider for species selection

1. Objectives
 - Multiple uses
 - N₂-fixation, Deep rooting
 - Coppicing, Fast growth
 - Light crowns
 - High acceptance
 - Site-specific
2. Ecological characteristics
 - Soil
 - Climate
3. Tree/ shrub characteristics

CHARACTERISTICS	USEFULNESS/EFFECT
Height of the tree	Ease/difficulty to harvest tree fodder/pods
Stem form	Important for the production of poles/posts and timber
Shape and size of tree crown	Quantity of fodder and mulch products, light penetration
Rooting pattern (deep, superficial spreading)	Competitiveness with other components (resource sharing with crops), suitability for soil conservation
Leafiness and chemical and physical composition of leaves and pods.	Quantity and quality of fodder and mulch. Suitability for soil fertility improvement.
Presence of thorns	Suitability for living fences but not for alley cropping

CHARACTERISTICS	USEFULNESS/EFFECT
Physical quality of the wood	Depends upon usage for firewood, construction wood or other
Flowering and fruit bearing cycle, seasonality and frequency	Important for pod/seed production; if frequent and/or at early stage of life cycle, can compete with leaf and wood production as resource-absorbing.
Deciduous nature	Seasonal fodder; of further interest when this deciduous nature is not exhibited in the same season as crops.

CHARACTERISTICS	USEFULNESS/EFFECT
Ecological range, adaptation to site	Suitable for extreme conditions and for the reclamation of wasted lands.
Nitrogen fixation	Suitable for the improvement of soil fertility
Good response to management techniques	Suitable for alley cropping, mulch, fodder, firewood and all productions requiring pruning
Vigour and resistance to pests and diseases	Very important whatever the conditions/production purpose.

Tree propagation and Out-planting

- Seed collecting
- Seed treatment and handling
- Tree seed requirement
- Nursery management
- Tree out planting and management

SEED SELECTION

- **Planning for seed selection**
- Most plants used in agro forestry produce seeds though the vegetative parts, some species can be used because they are able to germinate. When a branch of a tree is used in propagation, it is known as **Trancheon**.

Cont'

- **Procedures of seed selection**
- Assess the tree species and quantity to collect according to current demand and seed availability.
- Plan seed procurement in participatory manner with the field staff and the farmers so that the demand is well understood.
- Provide details on each type of seed including when, where, how much, who collected the seed
 - When- at what time and date the seeds were collected
 - Where- indicate the place the seeds were collected
 - How much- how many seeds have been collected
- Determine seed maturity
- Identify storage needs
- Make a checklist for equipment needed e.g. equipment needed for storing the seeds.
- Estimate seed yield and maturity by conducting surveys with experienced personnel.

Cont'

- **Steps to ensure high quality seeds**
- Verify species of targeted trees by sending a specimen to herbarium for identification.
- Locate sites that have similar climatic conditions to those where trees will be grown to ensure environmental adaptability.
- Identify robust trees (mother trees) that are good seed producers and of good health.
- Avoid collecting seeds from trees that are young, diseased, poorly shaped and low seeds producers as the traits may be carried on into the new generation.
- Fuel wood trees should have abundant branching.
- Trees for folder should be shorter with a large crown and dense foliage while timber trees should be tall, cylindrical and straight with light branching and no forks.

SEED COLLECTION

- The Forest Research Institute of Malawi (FRIM) is mandated by law to collect, process, store and sale seeds to the public. However different species/ seeds are adapted to different environmental conditions therefore local seed collection is encouraged because it allows self reliance and reduce expenses.
- **seed provenance** is a particular site where seeds are collected

Cont'

- When collecting the seeds, select several mother plants and collect seeds from them to ensure **genetic variability** but when collecting choose a mother plant with similar characteristics. A good mother plant should have the following characteristics;
- Of collect age to produce viable seeds
- Health and disease free to avoid transmission to the younger plants
- Must have height above average in the stand
- Must have cylindrical stem and should be straight.
- Should have well developed crown i.e. should have con shaped.
- When collecting seeds make sure that the seeds are mature, this can be verified by their response to dispersal agents.

METHODS OF SEED COLLECTION

- **Natural or Induced fruit/seed fall**
This is the simplest method as no special skills are needed only a bloom, rake, sieve and seed containers are used.
Large plastic sheets, canvas or blankets may also be spread under the trees for collecting seeds.
Trees are shaken to help seeds to fall down.
- **Picking fruits from trees**
Poles fitted with hooks are used to dislodge seeds/ fruits. Fruits can be picked directly when trees are small or short
- **Climbing the tree**
Ladders are used to climb the trees. It is a dangerous method since the person collecting the seeds/ fruits can fall down.

Cont'

After collecting the seeds put them in the bag, it is important to label the bag. The following information is labeled;

- Provenance
- Date of collection, year and month
- Species name
- Type of seed i.e. seed orchard, natural stand or breeding seed
- Exact location and reference to enable user of the map to locate that site
- Latitude/ longitude and altitude of the site
- Average rainfall and climatic zone
- Number of seed trees and areas in hectares

SEED TREATMENT

- Seed for sowing is pre-treated differently depending on the type. Seed is usually pre-treated to enhance the process of germination. The common methods of pre-treating seeds are:

1. Soaking

Seed placed in water for 12 to 24 hours to soften the seed coat. Discard all floating seeds. After this treatment the seed is ready for immediate sowing.

Cont'

2. No treatment

This is the way of using the seed without tampering with their status.

3. Removing the fresh pulp

This requires taking out the fleshy pulp outside the seed and dry them in the sun. Common species are *zyzigium cordatum*

4. Nicking (cracking)

This is the process where by the seed coat is deliberately opened up to allow water to enter into the seed and facilitate germination. It is also called **seed scarification** and is used with the smaller seeds using a nail, a cropper/ rubbing over a rough surface.

Common species for nicking are *acacia polyacantha* and *A. galpini*.

SEED HANDLING OR PROCESSING

- Handling generally depends on a type of seed
- Leave the seeds in the sun to dry up on a raised platform for 2 – 3 days for thorough drying. Operations involve threshing or pounding to release the seeds. Then winnowing and manual cleaning are done to remove chaff. Place the seeds in suitable container, airtight and plastic bags. Good storage conditions ensure longevity of stored seed

Types of seeds

1. Orthodox or normal types of seeds;

- These are seeds that can be easily stored. They can be grouped into

• Pod fruits

They are dried so that they open up quickly to release seeds. Cover them at night to avoid moisture reabsorption. Examples are *faidherbia albida* (msangu) and *afelia quanzensis*. After drying the pods, the pods are bitten up to release the seeds.

• Capsule fruits

Collect capsules shake them on the sieve to separate seeds and the chaff from the capsules.

• Hard coated fruits

Soak them in water for several days to soften the prickly covered seed coat then beat the fruit against a stone to release the seed or extract the seed using a secateur.

• Pulpy fruits

Pound them in a mortar, wash the seeds (stones), air dry the seeds (stones) and separate the debris manually.

Cont'

2. Recalcitrant (difficult) seed

- Naturally they have a short life span (few hours or months). Sow them immediately after collection to avoid the seeds from dying. Examples include *azadirachita indica* and *uapaca kirkiana*.
- Recalcitrant (difficult) seed respire actively therefore they require good ventilation and medium good temperatures of about 15 to 20 degrees Celsius. They also have high moisture content and require storage in cloth bags to facilitate aeration.
- Make sure the seeds are not closely packed to avoid heat generation which activates germination.

VIABILITY TEST

- This is process of determining the potential or ability of the seed to germinate.

- **Soaking**

Take a bucket full of water and soak the seeds in there. Those that float have a low viability while those that sink to the bottom will germinate

- **Germination test**

- Germination % = $\frac{\text{number of seeds germinated}}{\text{Total number of seeds planted}} \times 100$

Cont'

- There is a guide which is used to decide how many seeds should be planted per planting station using germination percentage

Germination %	Number of seeds per planting station
Over 90 %	1 seeds per planting station
60 – 89 %	2 seeds per planting station
40 – 59 %	3 seeds per planting station
25 – 39 %	4 seed per planting station
Less than 25 %	The seeds are not viable

ASSESSMENT OF SEED PURITY

- The seeds should be pure from leaf, twig particles and a seed of weeds or other tree species.

Aim of seed purity

- To determine the composition by weight of the seed sample
- Purity also influences the number of seeds per kilogram.

ASSESSMENT OF MOISTURE CONTENT

- Reducing moisture content reduces respiration and thus slows down ageing of the seeds which prolong viability. When the seed is stored at below 8 % moisture content it reduces insect activity, so sealed storage is safe at 4- 8 % moisture content. Insects fail to damage the seed because it is hard.
- Moisture content is calculated by weighing the seeds before and after oven drying.

SEED REQUIREMENT

- This depends on the number of trees the farmer wants to have in his planting side and the germination percentage and the viability of the seeds.
- This is necessary for planning processes. This requires the advice of the extension worker since it is difficult to count other small seeds and they can just be weighed

Cont'

• CALCULATION OF SEEDS NEEDED/ REQUIRED

- To plan tree planting programme, know the following;
 1. Number of plants/ seedling required.
 2. Yield of fruits from the trees
 3. Number of seeds per kg
 4. Germination percentage

Example 1

- A farmer wishes to plant *acacia polyacantha* (mthethe) at 2m by 2m spacing. She has an area of 0.75 ha. Calculate her seed to the nearest kg, given that *acacia polyacantha* has 9900 seeds per kg and requires three seeds per pot. Allow 25 % contingency (losses).

Solution

- $1 \text{ ha} = 10,000\text{m}^2$
- $\frac{10,000\text{m}^2}{2\text{m} \times 2\text{m}} = 2,500 \text{ trees per hectare}$
- $2\text{m} \times 2\text{m}$
- $2,500 \times 0.75 = 1,875 \text{ planting stations required}$
- $1,875 \times 3 \text{ seeds per pot} = 5,625 \text{ seeds}$
- $\frac{5,625 \text{ seeds}}{9,900 \text{ seeds per kg}} \times \text{kg} = 0.568 \text{ kg or } 568 \text{ g of seed}$
- $568 \times 1.25 \% (25 \%) = 710 \text{ g of seed.}$

Example 2

- A farmer wishes to plant trees around the perimeter of his farm using *afzelia quanzensis* at a spacing of 3m. The total perimeter is 1,800 meters. Calculate the amount of seed required to the nearest gram given that *afzelia quanzensis* has 350 seeds per kg and needs 2 seeds per pot. Allow extra 15 % for losses.

Solution

- $\frac{1,800 \text{ m}}{3 \text{ m}} = 600 \text{ trees for the entire perimeter.}$
- $600 \times 2 \text{ seeds/ pot} = 1,200 \text{ seeds}$
- $\frac{1,200 \text{ seeds}}{350 \text{ seeds per kg}} \times \text{kg} = 3.428 \text{ kg or } 3428\text{g of seed}$
- $3428 \times 1.15 \% (15 \%) = 3942 \text{ g of seed.}$

SEED STORAGE

- process of preserving food from the time of collection to the time of sowing. Storage is important as time of seed maturity and collection does not necessarily coincide with the time of sowing.
- Store seeds in cool dry places @ room temp with airtight containers.
- Moisture content of 8% gives 70% viability for 5 yr
- Easily stored seeds are called **orthodox** seeds
- Seeds with short life span and need to be sown while fresh are called **recalcitrant** seeds e.g. Nimu

Checklist for storage

- What conditions are best for the type of seed and its expected viability
- Discard empty or damaged seed
- Use clean airtight containers to minimize fungi and insects attack and ensure that seeds are properly dried.
- Mix the seeds with ash, this is because ash absorb moisture
- After kept seed for a long period of time, open seed containers when it is necessary.
- Label containers with species name, date and provenance of collection.
- Specify length of its viability and quantity of the viable seed per kg.

Tree Nursery management

- A nursery is a small, well protected site where tree seedlings are raised and managed b4 they are transplanted out in the field.
- Most trees spp do not survive well if grown directly in the field. Tree seed is expensive to extract and easily perishable
- Therefore, site must be well selected to avoid undue interference and to ensure that the tree seedlings raised are healthy and later planted out in larger locations where less care and protection is required

Principles of Nursery establishment

- Nursery establishment (Location)
- Nursery land preparation
- Soil media and seed bed preparation
- Seed pre-treatment procedures
- Sowing and seedling management

Factors to consider for site selection

- Ease of accessibility
 - Good roads
 - Near planting site
- Proximity to a water source
 - Permanent & reliable water source
 - Watering is laborious
- Protection against animals, extreme weather and humans
 - Fencing
 - Shade

Cont'

- Slope and drainage of soils at the nursery site
 - Flat and gently sloping (1-5%) areas
 - Too steep areas require terracing
 - Well drained soil avoid logging
- Climate
 - Similar to where seedlings will be planted
 - Avoid flooding areas

Types of Nurseries

Raised beds for bare root seedlings

- Simplest method
- Beds of soil raised up to 20cm, 1 – 1.2 m width, length depends of space and amount of seedling required
- Bed contains well mixed planting media.
- Leveling and watering is essential b4 sowing

Potted seedlings

- Planting media filled in Polythene tubes or 'pots'

Cont'

Raised beds for bare root seedlings

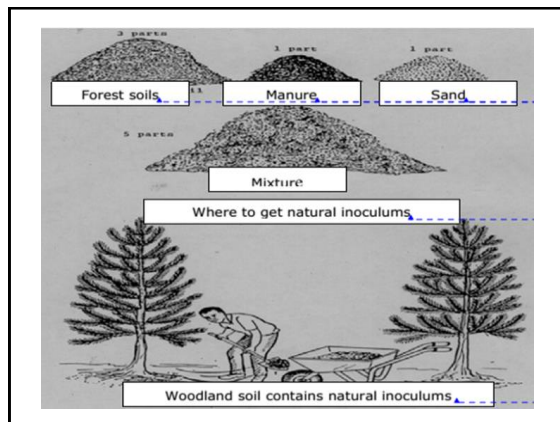
Advantages of raised beds	Disadvantages
Cheap	Difficult to root prune, hence more prone to root damage
Does not require skill	Lower survival rate after transplanting
Easy to sow with small seeds	Difficult to weed
Raise large number of seedlings on a small area	

Potted seedlings

Advantages of potted seedlings	Disadvantages
Very high survival of seedlings	It is an expensive method
High quality seedlings are raised	More labor required
Seedlings retain moisture for a long time and can withstand dry spells after being transplanted in the field	Time consuming, requires skills

Preparation of nursery planting media and filling of the polythene pots (tubes)

- Have the materials for preparing the planting media in place:
 - Forest soil, Sand, Manure
- Forest soil, rich in organic matter, is collected and mixed with sand and compost manure in the ratio of 2:1:1, respectively. The sand facilitates water drainage and easy seed germination.
- Pot filling
 - Wet mixture slightly with water
 - Completely fill the tube and press slightly



Sowing of seed

- Placing of seed into soil medium for germination either on raised beds or polyethylene tubes
- In some cases, the seed that is sown in flat beds can later be transplanted or 'picked out' and planted in the polyethylene tubes immediately after germination (usually when they are 3-5cm tall).
- After sowing the nursery beds or pots must be watered immediately and covered with grass to reduce water evaporation.
- The covering material should be removed just after germination.



Raised bed ready for sowing of tree seeds (left) and Gliricidia seed sown in polythene tubes (right)

Cont'

Several methods could be used in sowing the seeds as follows:

1. Broadcasting method

Process of scattering seeds over wide surface area without making holes or drills.

Used when seeds are very small in size, have low germination percentage and do not need tubes. Can be done by the following ways;

– Using hands

Seeds taken by hand and gently spread over the nursery bed.

– Using watering cane

Place seed in watering cane filled with water and stir for thorough mixture. Water over the seed bed to sow. Stir intermittently to avoid seed settling down or sticking onto the sides of the cane.

– Using a sieve

Mix the seed with the fine sand in the ratio 1:10 and sieve the seed onto the bed. Common species that is sowed using broadcasting method is bluegum. Once the seeds have germinated, after two weeks transfer the seedlings into a polythene tubes for easy management. This process is called **picking out**.

Cont'

2. Direct sowing

This is when we put the seed at the point where we want the tree to grow. It uses the seeds of high viability/ germination percentage. Examples of species that can be used are Nandolo and *Tephrosia vogelli*

3. Sowing in pots or tubes

It requires putting the treated seed in the tubes according to the results of germination test. Water the tubes until the mound is gone on the polythene tube then make holes on the soil in the tubes which are 2 – 3 times the size of the seed and 2 – 3 cm deep using the length of the metatarsal of the fore finger. Put the light number of the seed in each hole according to germination percentage then water again. Typical species used are msangu, Mthethe and nkuyu.

Nursery operations

- **Shading**
 - Apply grass cover to retain moisture so as to facilitate quick germination
 - Grass cover must be removed just after germination to avoid etiolation
- **Watering**
 - provides moisture necessary for germination and growth of the seedlings - seedlings produce shoots, bushy and lateral roots
 - At least twice per day, usually until after 4 weeks
 - Done in morning and evening when it is cool
 - Frequency and amount is affected/influenced by; current weather conditions, presence/absent of shed, and size and age of seedlings

Cont'

- **Weeding**
 - Process of removing unwanted plants because they harbour pest or diseases, they also increase competition for nutrients, water, sunlight etc.
 - The nursery bed and surroundings must be constantly kept free of weeds
- **Root pruning**
 - process of cutting the roots that grows deep into the ground out of the tube
 - done six weeks after germinating. This exercise forces the seedling to produce short compact and fibrous/lateral root system.
 - Methods include: lifting, Cutting Insitu, and air pruning

Cont'

- **Grading**
 - Grading is a process of separating big and strong seedlings from smaller and weaker ones.
 - Done 2 weeks after germination
 - Prevents shedding among seedling, overcrowding and eases process of resowing
- **Hardening off**
 - management technique applied prior to transplanting to prepare the seedlings for the harsh field conditions.
 - done by gradually reducing the amount of water supplied to the seedlings by reducing the watering frequency per week. A period of 6 wks
 - One of the purposes of this technique is to encourage the seedling to develop a robust root system that can efficiently exploit the limited resources-especially water.
 - The survival of newly planted trees under water stress field conditions depends on the effectiveness of the growers' hardening techniques.

Germination period				Hardening period	
Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Water 3 times per day		Water once per day	Water once in 3 days	Water when plants show wilting signs	

Cont'

- **Thinning**
 - This is the process of removing extra plants on a planting station to reduce competition for resources.
 - The removal of extra relatively weak or diseased seedling from the planting station or tubes.
 - This is also done two weeks after germination. Some have used health ones to transplant into tubes whose seeds have not germinated leave one seedling per tube

Cont'

- **Disease and pest control**
 - The commonest disease in young seedlings is damping-off. This is a fungal infection which results in seedlings becoming thin at the base and falling off.
 - The disease can be avoided by reducing the amount of watering. If few plants get infected, the disease spreads quickly with excessive watering.
 - As a rule, all infected seedlings should be removed from the nursery and destroyed.
 - Ensuring good drainage and aeration or avoiding water logging helps to keep seedlings from fungal infections.
 - Lowering the density of seedlings in the seedbeds and weeding are recommended to avoid deleterious competition in the nursery.

Tree out planting

- This is the transfer of seedling from the nursery site soon after hardening off and putting into the planting field. It should be done on a day when it is expected to rain.
- For seedlings in polythene tubes carry them with the tubes and soil intact. For those from seed bed or nursery beds use a knife to cut a soil cube which should embody the root for every seedling. Place the out planted seedlings next to each pit.
- **N.B.** Please water the seedlings before out planting for easy transplant. Use a wheelbarrow or oxcarts to carry the seedlings.

PITTING

- This is the process for making holes in the planting field in readiness for transplanting seedlings. Refilling of the holes is done within the six weeks of hardening off and put a pointer in the middle of the hole.
- Pits / holes should be 60 cm by 60 cm by 60 cm. At village level this is determined by twice the length of the new hoe.
- The pit spacing should be 2.5 m by 2.5 m for big trees species such as msangu, mthethe e.t.c. for early results in crop field.
- For wood lot it can be as close as 1m by 1m. dig the pit and separate top soil and sub soil, put top soil on the upper side and sub soil on the lower side. Leave the pit open for one to two weeks so that the sun can heat the inner side to kill pests and diseases.
- Then refill the pit starting with the top soil, soon after top soil is put back, insert the marker to indicate the middle of the pit, and then continue refilling with the sub-soil until a small mound is made.

Cont'

PLANTING

The process of putting the seedlings into the pits. This should be done on the wet day or wait on the rainy day. Gently flatten the mound using hoe or planting trowel. Remove the marks and make the hole that exactly fits the tube or the soil cube.

Thread around the newly planted seedling so that soil in the tube gets in touch with the soil in the pit. It also removes air spaces that can accumulate water and suffocates the roots.

Tree management

Management - includes all silvicultural activities between the establishment of the seedlings and the replanting or regeneration after felling/harvesting

- Management /maintenance activities:
 - protection and guarding (fire/animals/etc)
 - replanting; weeding; pruning; thinning; coppicing; pollarding
 - Fertilization and manure application

Cont'

BEATING UP

The replacement of seedlings that have died with the extra ones following planting. It is done using extra seedlings in the nursery within six weeks after planting. This is encouraged if the survival rate is less than 80%.

WEEDING IN THE FIELD

The removal of unwanted plant in the field. For those seedlings in the crop field, weeding is done at the same time when the crops are been weeded. For those in the woodlot, weed when the weeds appear.

Methods of weeding

There are several methods that are used. Some of them are chemical, biological, physical, mechanical and cultural control methods.

Weeding is important because it reduces the risk of fire and competition for resources.

PROTECTION

Small trees need protections from animal damage and fire, for those in crop field avoid feeding the livestock as they can trample over them, avoid setting fire and construct a micro fence around individual trees and keep the field debris free. This is done during the dry season.

For woodlots make fire breaks of at least 1m all round.

Cont'

THINNING IN THE FIELD

Thinning is a silvicultural operation that reduces the number of trees in a field, systematically or selectively. It targets diseased, drying, the dead, very thin or branchy trees.

Thinning increases light penetration to develop crown and accelerate diameter growth, increase the % of trees reaching maturity, improve wood quality, encourage root development, maintain ground cover for erosion control, and reduce competition.

It gives out firewood at an early stage, you need to completely uproot the thinned plants. Thinning modifies the initial spacing with the objective of maximizing the final desired product, ie, timber, biomass, fruits, etc.

Cont'

PRUNING IN THE FILED

Pruning is a systematic removal of branches in order to improve tree form or wood quality. Means neatly cutting of the lower branches up to 2m of live and good trees close to the trunk to avoid formation of knots on the trunk. Close spacing is also appropriate, to allow self-prune.

Pruning results in creating easy access for thinning operations, Provision of fodder, leaf mulch, fuelwood, and produce knot-free timber,

Cont'

Coppicing

Involves cutting the tree down to its stump and allowing it to regrow

It normally sends up a number of shoots instead of the original single stem.

Regrowth after coppicing is vigorous because the tree's root system has already been well established.

Mostly in alley / boundary / hedge row planting

In alleys – done prior to rainy season and mid way growing season

Cont'

Pollarding

Involves cutting off the crown of the tree, leaving it to send out new branches from the top of the remaining stem;

new shoots are high and therefore more apt to be protected from animal and fire damage.

Vertical pollarding is similar to pruning of branches along the stem.

Good in parklands/range lands/Boundary planting/Crop fields

BENEFITS/USES OF AGROFORESTRY

- 1) Increase supply of fuel wood for domestic purposes
- 2) Fertility improvements which improve crop yield. This is achieved in the following ways;
 - i. The organic matter decompose to release soil nutrients
 - ii. Leguminous plants fix nitrogen in the soil
 - iii. There is reduction of run off which may cause soil erosion.
- 3) Fodder for animals; providing high protein value feed and this can be used as emergency feed in dry season/drought period.
- 4) Trees provide fruits for food and sale
- 5) Reduction of deforestation rates.

LIMITATIONS OF AGRO FORESTRY

- 1) **Land holding size**
 - Some technologies require more land
- 2) **Availability of seeds**
 - Not enough seeds are found for some important species.
- 3) **Benefits take time to be realized**
 - Some farmers are discouraged since the benefits takes time to be realized.
- 4) **Climate condition in some places**
 - Some important species do not survive in climate conditions as different tree species grow well under different climatic condition.
- 5) **Taboos**
 - Taboos associated with some tree species which may be so important in agro forestry, so some species can be denied by some farmers because of some comments by other people about them.

HOW IS AGRO FORESTRY DONE

Community Participation

This is a process whereby communities are made aware that they themselves have the ability and energy to take an initiative to improve their own lives. They can identify their own needs and take appropriate actions but they need to engage the extension worker as a facilitator to the process.

• Essential elements of community participation

- a. Start where the communities are
- b. Study their cultural practices and consider them
- c. Work with local leaders at all times
- d. Work through existing communities structures
- e. Initial activities should show quick results to stimulate confidence
- f. Work with them only to stimulate action
- g. Ensure that costs and benefits are shared equally

• Challenges Faced in community participation

- **Technology complexity**
 - If complex technology is brought to the farmers it will be difficult for them to understand it hence the farmers will not be able to adopt it.
- **programme flexibility and rigidity**
 - Are you flexible enough to change the programme or not
- **resource requirements**
 - Does the project have enough resources as required?
- **benefits characteristics**
 - Is it short term benefits or long term benefits?
- **administrative characteristics**
 - Being in power where people fight for power