TVET CERTIFICATE V in FORESTRY

FOREST MANAGEMENT PLAN ELABORATION

FORFM501

Elaborate forest management plan

Competence

Credits:5

Learning hours:50

Sector: Agriculture

Sub-sector: Forestry

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Purpose statement:

This module describes the skills and knowledge required to apply the elaboration of forest management plan. The skills of this module are of great importance to manage the biodiversity by applying sustainable forest management

The module will allow the learner to:

- Carry out the site study
- Determine the required cost and income in forest management plan
- Design forest management plan
- Establish monitoring and evaluation tools of the forest management plan implementation

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Total Number of Pages: 80

INTRODUCTION TO FOREST MANAGEMENT

Forest management is a branch of forestry concerned with overall administrative, legal, economic, and social aspects, as well as scientific and technical aspects, such as silviculture, protection, and forest regulation. This includes management for aesthetics, fish, recreation, urban values, water, wilderness, wildlife, wood products, forest genetic resources, and other forest resource values.[1] Management can be based on conservation, economics, or a mixture of the two. Techniques include timber extraction, planting and replanting of different species, cutting roads and pathways through forests, and preventing fire.

Objectives:

-To provide the maximum benefits to the greatest number of people for all time

-To maximize economic and social output in the forest plantation

--To maintain preferably increasing the forest capital by silvicultural operations

-To make a periodic and constant the wood income

-To ensure the entire forest vocational area a maximum rate of production

A FORESTMANAGEMENTPLAN

A forest management plan is a guide and a tool to help you make decisions, look at your options, and plan for the future. The plan may need to be modified as your ownership goals and objectives, and site conditions, change over time.

A forest management plan is a detailed written document that includes three important elements:

1. A detailed description of the property and the resources on the property,

2. A specific list of goals or objectives for management of the property, and

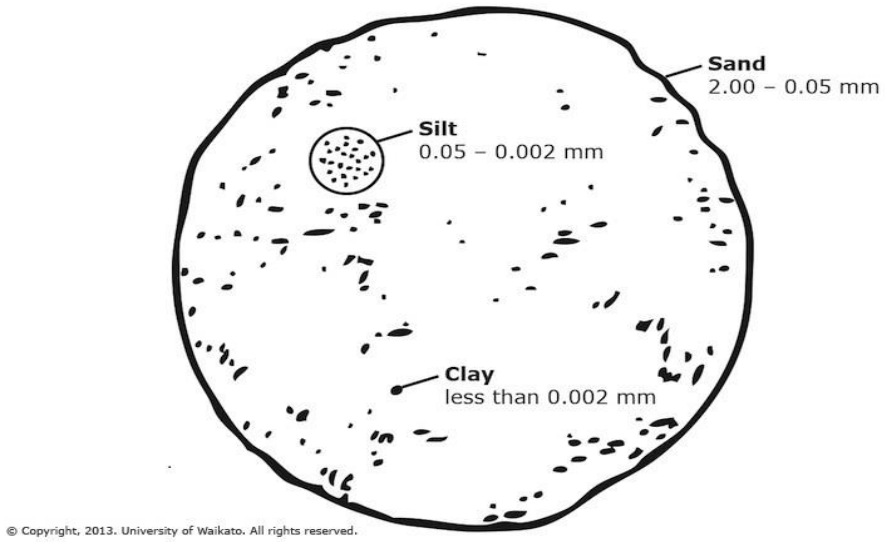
3. A schedule of activities to be performed on the property to help realize goals and objectives. There is no specific format for including these elements in a plan; however, all three must be covered to some level if the management plan is to be useful

Learning Unit 1 - Carry out site study

LO 1.1. Collect Edaphic and climatic data.

Topic1: Soil properties

All soils contain mineral particles, organic matter, water and air. The combinations of these determine the soil's properties – its texture, structure, porosity, chemistry and color.



a)Soil texture

Soil is made up of different-sized particles. Soil texture refers to the size of the particles that make up the soil and depends on the proportion of sand, silt and clay-sized particles and organic matter in the soil. Sandy soils feel gritty when rubbed between your fingers. Soils are made up of different combinations of sand, silt and clay particles. Soils that are a mixture of sand, silt and clay are called loams.

Soil texture can influence whether soils are free draining, whether they hold water and how easy it is for plant roots to grow.

- Sand particles are quite big. The pore spaces between the particles in sandy soils are also quite large. This allows water to drain quickly and air to enter the soil. Sandy soils tend not to get waterlogged in winter but can be subject to drought during summer.
- Silt particles are too small for us to see with our eyes. Silt soils have much smaller pore spaces but a lot more of them.
- Clay particles are smaller than 0.002 mm in diameter. Clay soils are poorly drained and hold on to the water in their pore spaces for much longer. However, they can become very hard if they dry out.

b)Soil structure

Soil structure describes the way the sand, silt and clay particles are clumped together. Organic matter (decaying plants and animals) and soil organisms like earthworms and bacteria influence soil structure. Clays, organic matter and materials excreted by soil organisms bind the soil particles together to form aggregates. Soil structure is important for plant growth, regulating the movement of air and water, influencing root development and affecting nutrient availability. Good quality soils are friable (crumbly) and have fine aggregates so the soil breaks up easily if you squeeze it. Poor soil structure has coarse, very firm clods or no structure at all.

c)Soil porosity

Soil porosity refers to the pores within the soil. Porosity influences the movement of air and water. Healthy soils have many pores between and within the aggregates. Poor quality soils have few visible pores, cracks or holes. The way in which a soil is managed can affect its porosity.

For example, look at areas around your school where students regularly walk. If the grass is worn away and the soil is exposed, it often looks different because it has been compacted and has had its structure and porosity altered. These are also areas where puddles form because the water is not able to drain away.

d) Soil pH

Soil pH is a measure of the acidity and alkalinity in soils. pH levels range from 0 to 14. The optimal pH range for most plants is between 5.5 and 7.0
Soil pH plays an important role in availability of nutrients essential for plant growth.

- **Measurement of pH**

A **pH meter** is a scientific instrument that measures the hydrogen-ion activity in water-based solutions,indicating its acidity or alkalinity expressed as pH.The pH meter measures the differenc in electrical potential between a pH electrode and a reference electrode, and so the pH meter is sometimes referred t as a "potentiometric pH meter".

Figure no 1: Ph meter

e) SOIL FERTILITY

Soil fertility is the capacity to receive, store and transmit energy to support plant growth. It is the component of overall soil productivity that deals with its available nutrient status, and its ability to provide nutrients out of its own reserves and through external applications for crop production.

Topic 2: Climatic data

- **Rainfall**

All plants /trees depend on the availability of water, nutrients and light as essential resources for growth. In tropical rain forests, these resources vary over spatial and temporal scales and, as a result, tree growth varies with resource availability. In general, tree growth increases with rainfall and decreases with drought.

Independently of rainfall, soil fertility can also affect tree growth rate with better growth on more nutrient-rich soils. Many tropical forests differ from temperate forests in their stocks and flows of biologically important nutrients both within and from biomass resources. In particular, humid tropical ecosystems are relatively rich in available N and growth rate is likely to be limited by P or other rock-derived nutrients.

- **Measurement of rainfall**

The standard instrument for the measurement of rainfall is the 203mm (8 inch) rain gauge. This is essentially a circular funnel with a diameter of 203mm which collects the rain into a graduated and calibrated cylinder. The measuring cylinder can record up to 25mm of precipitation

Figure 2: Raingauge

B.Temperature

Is a key factor in trees growth and development. Along with the levels of light, carbon dioxide, air humidity, water and nutrients, temperature influences plant/treesgrowth and ultimately crop yields .The other climatic data are rainfall ,relative humidity and wind and has greater importance's to the trees growth and vegetation's in general.

- **Measurement of Temperature**

We are used to expressing temperature with degrees Fahrenheit (F). Scientists often use degrees Celsius (C), but the Kelvin (K) is the SI unit for temperature. Thermometers can measure temperature because of thermal expansion. Thermal expansion is the increase in volume of a substance due to an increase in temperature**.**

Devices used for temperature measurement are different thermometers, thermocouples, or digital thermometers.

Figure 3: Thermometer

C. Relative humidity.

Relative humidity (RH) is the ratio of the partial pressure of water vapor to the equilibrium vapor pressure of water at given temperature

Figure 5: Hygrometer to measure RH

D. Wind.

The perceptible natural movement of the air especially in the form of current of air blowing from a particular direction**.**

Figure 5: Anemometer to measure wind

Topic 3: Geographical coordinate

A geographic coordinate system is a three-dimensional reference system that locates points on the Earth's surface. The unit of measure is usually decimal degrees. A point has two coordinate values: latitude and longitude. Latitude and longitude measure angles.

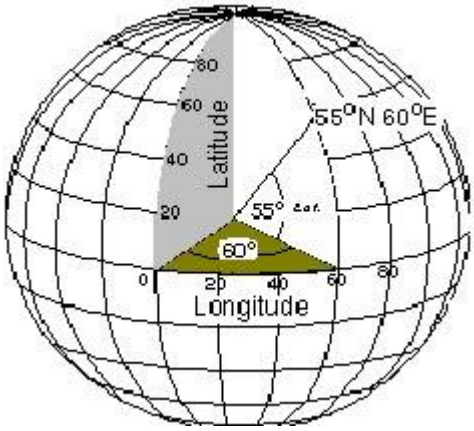


Figure 6: Latitude and longitude

a) Latitude

Is defined as the angle formed by the intersection of a line perpendicular to the Earth's surface at a point and the plane of the Equator. Points north of the Equator have positive latitude values, while points south have negative values. Latitude values range from -90 to +90 degrees. Lines of latitude are also called parallels because a particular value of latitude forms a circle parallel to the Equator.

b) Longitude.

A meridian, or line of longitude, is formed by a plane that passes through the point and the North and South poles. The longitude value is defined by the angle between that plane and a reference plane. The reference plane is known as the prime meridian. The most common prime meridian passes through Greenwich, United Kingdom. Other examples of prime meridians in use pass through Paris and BogotIs the measurement east or west of the prime meridian**.** Longitude is measured by imaginary lines that run around the Earth vertically (up and down) and meet at the North and South Poles. These lines are known as meridians. Each meridian measures one arc degree of longitude.

Longitude values range from -180 to +180 degrees.

Longitude is the measurement east or west of the prime meridian**.** Longitude is measured by imaginary lines that run around the Earth vertically (up and down) and meet at the North and South Poles. These lines are known as meridians. Each meridian measures one arc degree of longitude.

c) Altitude is a distance measurement, usually in the vertical or "up" direction, between a reference datum and a point or object.

- **Measurement of altitude**

An altimeter or an altitude meter is an instrument used to **measure** the **altitude** of an object above a fixed level. The measurement of altitude is called altimetry, which is related to the term bathymetry, the measurement of depth under water.

Figure 6. Altimeter

LO 1.2 – Estimate tree species productivity

Topic 1: Tree species identification / Dendrology

Dendrology is the word coming from two Latin words “Dendros” that means tree and “logos” that means science of or study of. So, the dendrology is the science and study of wood plants (trees, and shrubs). Tree is a large plant not exactly defined, but typically over 5meters in height at maturity, having a single trunk which grows in girth with age and branches (which also grow in circumference with age), while a shrub is a woody plant smaller than a tree (at maturity), and usually with several stems from the same base.

Dendrology is often confused with botany. However, botany is the study of all types of general plants while Dendrology studies only woody plants. Dendrology will include all woody plants (native and nonnative), that occur in the region.

Thus, dendrology may be considered as a subcategory of botany that specializes in the characterization and identification of woody plants.

Dendrology is a science that studies, identifies, and even names plants that have woody structural systems. Dendrology may not seem like the most interesting science at first glance, but it is grossly complicated and interesting.

Dendrology is a science that studies every part of every single tree. This information allows scientists to understand the root structure, why the leaves are the shape that they are, why the tree may bloom when it does, and even where the tree originated from and what other species it may be linked to.

There is no sharp boundary between plants **taxonomy** and dendrology:

Taxis: Latin meaning arrangement or order;

nomy*:* refers to knowledge.

So, taxonomy is the knowledge of order or classification of plants.

Plants taxonomy as science, finds, identifies, describes, classifies and names plants. Plants taxonomy is an old science that uses the gross morphology (physical characteristics, it means leaf shape, flower form, fruit form, etc) of plants to separate them into similar groups.

Taxonomic categories are:

- ***Kingdom***
- ***Phylum /Division***
- ***Class***
- ***Order***
- ***Family***
- ***Genus***
- ***Species***

The largest groups into which living things (including woody plants) are divided are the Kingdoms. Kingdoms are subdivision into phylum, each phylum into classes each class into order, each order into families each family into Genus, each genus into species.

The species is the smallest unit of classification. A ***species*** is defined as a group of organisms that have many features in common, and that can interbreed to produce fertile offspring.

*Examples:*Mangoes, Oranges, etc. A species contains only one type of organism.

DEFINITIONS:

Broadleaf:A trees that have broad flat leaves of many different shapes, most are deciduous; Also called hardwood because most broadleaves trees have harder than conifers. example: oask, ash.

Conifer: A class of trees that are evergreen, have needle or scalelike foliage and cone like fruits, often called softwood. Example: pine

Evergreen: Trees that not lose all their leaves every year but go through a gradually replacement by dropping only their oldest leaves each year. Instead of being bore in winter, these threes haves leaves all year.

List of trees and shrubs by taxonomic family

- *Araucaria* – monkey puzzle trees
  - *Araucaria angustifolia* – Paraná pine

- *Araucaria araucana* – monkey-puzzle tree
- *Araucaria bidwillii* – bunya-bunya
- *Araucaria columnaris* – Cook pine
- *Araucaria cunninghamii* – Moreton Bay pine; hoop pine
- *Araucaria heterophylla* – Norfolk Island pine
- *Araucaria hunsteinii* – klinki

Cupressaceae: cypress family

- *Athrotaxis* – Tasmanian cedars
  - *Athrotaxiscupressoides* – pencil pine
  - *Athrotaxisselaginoides* – King Billy pine
- *Callitris* – cypress-pines
  - *Callitriscolumellaris* – white cypress-pine; Murray River cypress-pine; northern cypress-pine
  - *Callitrispreissii* – Rottnest Island pine
  - *Callitrisverrucosa* – mallee pine; sandhill pine; scrub cypress pine
- *Calocedrus* – incense cedars
  - *Calocedrusdecurrens* – California incense cedar
- *Chamaecyparis* – false cypresses
  - *Chamaecyparislawsoniana* – Lawson false cypress; Port Orford cedar
  - *Chamaecyparisnootkatensis* – Nootka false cypress; Alaska cedar; yellow cedar
  - *Chamaecyparisobtusa* – hinoki false cypress
  - *Chamaecyparispisifera* – sawara false cypress
  - *Chamaecyparisthyoides* – white false cypress; Atlantic white cedar
- *Cryptomeria* – Oriental cedars
  - *Cryptomeria japonica* – Japanese cedar
- *Cunninghamia* – cunninghamia
  - *Cunninghamialanceolata* – China fir
- *Cupressus* – true cypresses
  - *Cupressus arizonicastephensonii* – Cuyamaca cypress

- *Cupressus forbesii* – Tecate cypress
- *Cupressus leylandii* – Leyland cypress
- *Cupressus macrocarpa* – Monterey cypress
- *Cupressus sempervirens* – Mediterranean cypress; Italian cypress
- *Thujaplicata* – giant arborvitae

Pinaceae: pine family

- *Pinus* – pines
  - *Pinus albicaulis* – whitebark pine
  - *Pinus aristata* – bristlecone pine
  - *Pinus banksiana* – jack pine
  - *Pinus brutia* – Calabrian pine
  - *Pinus canariensis* – Canary Island pine
  - *Pinus cembra* – Swiss stone pine
  - *Pinus cembroides* – Mexican pinyon
  - *Pinus contortacontorta* – shore pine
  - *Pinus contortalatifolia* – lodgepole pine
  - *Pinus coulteri* – Coulter pine; bigcone pine
  - *Pinus echinata* – shortleaf pine
  - *Pinus edulis* – pinyon; Colorado pinyon
  - *Pinus elliotii* – slash pine
  - *Pinus flexilis* – limber pine
  - *Pinus glabra* – spruce pine
  - *Pinus halepensis* – Aleppo pine
  - *Pinus jeffreyi* – Jeffrey pine
  - *Pinus lambertiana* – sugar pine
  - *Pinus longaeva* – ancient bristlecone pine; Methuselah pine; long-lived pine
  - *Pinus monophylla* – single-leaf pine
  - *Pinus monticola* – western white pine

- *Pinus mugo* – mugho pine; Swiss mountain pine
- *Pinus muricata* – bishop pine
- *Pinus nigranigra* – European black pine; Austrian pine
- *Pinus nigrasalzmannii* – Cevennes black pine
- *Pinus nigrasalzmannii* var. *corsicana* – Corsican pine
- *Pinus palustris* – longleaf pine
- *Pinus patula* – jelecote pine
- *Pinus pinaster* – maritime pine
- *Pinus pinea* – European stone pine
- *Pinus ponderosa* – ponderosa pine
- *Pinus pungens* – table mountain pine
- *Pinus quadrifolia* – Parry pinyon
- *Pinus radiata* – Monterey pine
- *Pinus resinosa* – red pine
- *Pinus rigida* – pitch pine
- *Pinus sabiniana* – gray pine
- *Pinus serotina* – pond pine; swamp pine
- *Pinus strobiformis* - southwestern white pine
- *Pinus strobus* – eastern white pine
- *Pinus sylvestris* – Scots pine; Scotch pine
- *Pinus taeda* – loblolly pine
- *Pinus torreyana* – Torrey pine
- *Pinus virginiana* – Virginia pine
- *Pinus wallichiana* – blue pine; Bhutan pine; Himalayan pine

Podocarpaceae: podocarp family

- *Afrocarpus* – African podocarps
  - *Afrocarpusgracilior* – musengera; zigba
- *Dacrycarpus*
  - *Dacrycarpusdacrydioides* – kahikatea
- *Dacrydium*

- *Dacrydiumcupressinum* – rimu

- *Podocarpus* – Australasian podocarps
  - *Podocarpusgracilior* – fern pine
  - *Podocarpushenkelii* – long-leafed yellowwood
  - *Podocarpusmacrophyllus* – kusamaki; inumaki
  - *Podocarpusneriifolius* – oleander-leaf podocarp
  - Angiosperms

Hardwoods

Aceraceae: maple family

- *Acer* – maples
  - *Acer amplum* – broad maple
  - *Acer argutum* – deep-veined maple
  - *Acer barbatum* (*Acer saccharum floridanum*) – Florida maple; southern sugar maple
  - *Acer barbinerve* – bearded maple
  - *Acer buergerianum* – trident maple
  - *Acer caesium* – Himalayan maple
  - *Acer campbellii* – Campbell's maple
  - *Acer campestre* – field maple
  - *Acer capillipes* – Kyushu maple; red snakebark maple
  - *Acer cappadocicum* – Caucasian maple; coliseum maple; Cappadocian maple
  - *Acer carpinifolium* – hornbeam maple
  - *Acer caudatifolium* – Kawakami maple
  - *Acer caudatum* – tail-leaf maple
  - *Acer cinnamomifolium* – leatherleaf maple; Yunnan maple
  - *Acer circinatum* – vine maple
  - *Acer cissifolium* – vine-leaved maple
  - *Acer crataegifolium* – hawthorn maple; hawthorn-leaved maple

Agavaceae: agave family

- *Cordyline* – cordyline tree
- *Cordyline australis* – cabbage tree
- *Furcraea* – furcraea
  - *Furcraearoezlii* – furcraea tree
- *Nolina* – nolina trees
  - *Nolinarecurvata* – bottle palm; ponytail palm
- *Yucca* – yuccas
  - *Yucca aloifolia* – Spanish bayonet
  - *Yucca brevifolia* – Joshua tree
  - *Yucca elephantipes* – giant yucca
  - *Yucca gloriosa* – moundlily yucca
  - *Yucca torreyi* – Torrey's yucca; great yucca

Anacardiaceae: cashew family

- *Anacardium* – cashews
  - *Anacardium occidentale* – cashew
- *Cotinus* – smoke trees
  - *Cotinus coggygria* – common smoke tree
  - *Cotinus obovatus* – American smoke tree
- *Harpephyllum* – harpephyllum plum trees
  - *Harpephyllumcaffrum* – kaffir date; kaffir plum; South African wild plum
- *Mangifera* – mangos
  - *Mangiferacaesia* – jack; binjai; Malaysian mango
  - *Mangiferafoetida* – horse mango
  - *Mangiferaindica* – common mango; Indian mango
  - *Mangiferaodorata* – kuweni mango; kuwini; Saipan mango; fragrant mango
  - *Mangiferapersiciformis* – peach mango
  - *Mangiferasiamensis* – Thai mango
  - *Mangifera sylvatica* – Himalayan mango; pickling mango; Nepal mango

- *Metopium* – poisonwoods
  - *Metopiumbrownei* – black poisonwood
  - *Metopiumtoxiferum* – Florida poisonwood
- *Pistacia* – pistachios and terebinth
  - *Pistaciachinensis* – Chinese pistachio
  - *Pistaciaterebinthus* – terebinth; Old World turpentine tree
  - *Toxicodendron vernix* – poison sumac

Annonaceae: custard apple family

- *Annona* – custard apples
  - *Annona cherimola* – cherimoya
  - *Annona glabra* – pond apple
  - *Annona reticulata* – custard apple; bullock's heart; bull's heart; cashiman; sitaphal; shareefah
  - *Annona squamosa* – sweetsop; sugar-apple
- *Asimina* – pawpaws
  - *Asimina angustifolia* – slimleaf pawpaw
  - *Asimina incana* – woolly pawpaw
  - *Asimina obovata* – bigflower pawpaw
  - *Asimina parviflora* – smallflower pawpaw
  - *Asimina pygmaea* – dwarf pawpaw
  - *Asimina reticulata* – netted pawpaw
  - *Asimina tetramera* – fourpetal pawpaw
  - *Asimina triloba* – common pawpaw; prairie banana

Apocynaceae

- *Ilex opaca* – American holly
  - *Ilex verticillata* – common winterberry
  - *Ilex vomitoria* – yaupon; yaupon holly
- *Nemopanthus* – false holly trees
  - *Nemopanthusmucronatus* – mountain holly; alpine holly

Araliaceae: ginseng family

- *Aralia* – aralias
    - *Aralia elata* – Japanese angelica tree; Japanese aralia
    - *Aralia spinosa* – Devil's walkingstick
- *Cussonia* – cussonia trees
    - *Cussonia spicata* – spiked cabbage tree
- *Didymopanax* – didymopanax trees
    - *Didymopanaxmorototoni* – yagrumo macho
- *Meryta* – meryta trees
    - *Merytasinclairii* – puka; pukanui
- *Schefflera* – schefflera trees
    - *Schefflera actinophylla* – octopus tree; umbrella tree

Asteraceae: composite family

Baccharis

    - *Baccharishalimifolia* – eastern baccharis; groundsel bush; silverling
- *Brachylaena*
    - *Brachylaenahuillensis* – muhuhu
- *Lepidaploa*
    - *Lepidaploapolypleura*
- *Montanoa*
    - *Montanoahexagona*
    - *Montanoarevealii*
- *Telanthophora*
    - *Telanthophorauspantanensis*

Betulaceae: birch family

- *Alnus* – alders
- *Alnusacuminata* – Andean alder

- *Alnuscordata* – Italian alder
- *Alnuscremastogyne* – long peduncled alder
- *Alnusformosana* – Formosan alder; Formosa alder
- *Alnusfruticosa* – Siberian alder
- *Alnusglutinosa* – European alder
- *Alnusincana* – gray alder
- *Alnus japonica* – Japanese alder
- *Alnusjorullensis* – Mexican alder
- *Alnusmaritima* – seaside alder
- *Alnusnepalensis* – Nepalese alder
- *Alnusnitida* – Himalayan alder
- *Alnusoblongifolia* – Arizona alder
- *Alnusorientalis* – Oriental alder; Syrian alder
- *Alnusrhombifolia* – white alder
- *Alnus rubra* – red alder
- *Alnus rugosa* – speckled alder
- *Alnusserrulata* – common alder; hazel alder; tag alder; smooth alder
- *Alnussinuata* – Sitka alder
- *Alnussubcordata* – Caucasian alder
- *Alnustenuifolia* – mountain alder; thin-leaf alder
- *Alnusviridis* – green alder

Bignoniaceae: trumpet creeper family

- *Amphitecna* – calabash
  - *Amphitecnalatifolia* – black calabash
- *Catalpa* – catalpa trees
  - *Catalpa bignonioides* – southern catalpa
  - *Catalpa speciosa* – northern catalpa
- *Handroanthus*
  - *Handroanthusheptaphyllus*
  - *Handroanthusimpetiginosus* – purple tabebuia; purple trumpet tree
- *Jacaranda* – jacaranda trees

- *Jacaranda mimosifolia* – blue jacaranda; black poui
- *Kigelia* – sausage trees
  - *Kigeliaafricana* – African sausage tree
- *Markhamia* – markhamia trees
  - *Markhamia lutea* – markhamia; Nile tulip tree; siala
- *Paulownia* – paulownia trees
  - *Paulownia tomentosa* – empress tree; princess tree; foxglove tree; paulownia
- *Radermachera* – radermachera trees
  - *Radermacherasinica* – China doll tree; serpent tree
- *Spathodea* – spathodea trees
  - *Spathodeacampanulata* – African tulip tree
- *Tabebuia* – trumpet trees
  - *Tabebuia caraiba* – yellow tabebuia
  - *Tabebuia chrysantha* – golden trumpet
  - *Tabebuia chrysotricha* – golden trumpet
  - *Tabebuia heterophylla* – pink trumpet tree
  - *Tabebuia rosea* – rosy trumpet tree
  - *Tabebuia roseo-alba* – ipê-branco; lapacho blanco
- *Tecoma* – tecoma trees
  - *Tecoma stans* – yellow elder; yellow bells

Bombacaceae: bombax family

- *Adansonia* – baobab trees
  - *Adansoniadigitata* – African baobab; monkeybread tree
  - *Adansoniagrandidieri* – Grandidier's baobab
  - *Adansoniagregorii* – boab; Australian baobab
  - *Adansoniamadagascariensis* – Madagascar baobab
  - *Adansoniaperrieri* – Perrier's baobab
  - *Adansoniarubrostipa* – fony baobab
  - *Adansoniasuarezensis* – Suarez baobab

- *Adansonia za* – za baobab

- *Bombax* – bombax trees
  - *Bombax buonopozense* – Gold Coast bombax; red-flowered silk cotton tree
  - *Bombax ceiba* – cotton tree; tree cotton
- *Ceiba* – ceiba trees
  - *Ceiba pentandra* – kapok tree; ceiba
  - *Ceiba speciosa* –

Bourreria – strongbarks

- *Bourreria ovata* – Bahamian strongbark
- *Bourreria radula* – rough strongbark

- *Cordia* – cordia trees
  - *Cordia alliodora* – capaprieto

Caricaceae: papaya family

- *Carica* papaya

Casuarinaceae: casuarina family

Casuarina – beefwoods

- *Casuarina cunninghamiana* – Cunningham beefwood
- *Casuarina equisetifolia* – Australian pine; horsetail casuarina; horsetail tree
- *Casuarina glauca* – Brazilian beefwood

- *Cercidiphyllum japonicum* – katsura tree

Chrysobalanaceae: coco plum family

- *Chrysobalanus* – chrysobalanus trees
  - *Chrysobalanusicaco* – coco plum
- *Maranthes* – maranthes shrubs
  - *Maranthescorymbosa* – merbatu; sea beam

- *Maranthespanamensis* – corozo; palo de gusano
- *Maranthespolyandra* – pera morada; Mayan pear

Main article: List of Clusiaceae genera

- *Clusia* – clusia trees
- *Clusiarosea* – Florida clusia; rose clusia

- *Calophyllum* – calophyllum
  - *Calophyllumcalaba* – Maria tree; Santa Maria tree
- *Garcinia* – garcinia trees
  - *Garcinia mangostana* – mangosteen

Combretaceae: combretum family

- *Conocarpus* – buttonwoods
  - *Conocarpus erectus* – button mangrove; false mangrove; Florida buttonwood; grey mangrove; Zaragoza mangrove
- *Laguncularia* – laguncularia trees
  - *Lagunculariaracemosa* – white mangrove
- *Terminalia* – terminalia trees
  - *Terminalia catappa* – Indian almond
- *Davidsonia* – Davidson's plum trees

  - *Davidsoniajerseyana* – Davidson's plum; Mullumbimby plum
  - *Davidsoniajohnsonii* – smooth Davidson's plum
  - *Davidsoniapruriens* – North Queensland Davidson's plum

Ebenaceae: ebony family

- *Diospyros* – ebony and persimmons
  - *Diospyros digyna* – black sapote
  - *Diospyros ebenum* – ebony; Indian ebony
  - *Diospyros kaki* – Japanese persimmon
  - *Diospyros texana* – Texas persimmon
  - *Diospyros virginiana* – American persimmon; eastern persimmon

Euphorbiaceae: spurge family

- *Aleurites* – aleurites trees
  - *Aleurites fordii* – tung tree
  - *Aleurites moluccanus* – candlenut
- *Drypetes* – drypetes trees
  - *Drypetesdiversifolia* – milkbark
  - *Drypeteslateriflora* – Guiana plum
- *Euphorbia* – spurge trees
  - *Euphorbia candelabrum* – candelabra tree
  - *Euphorbia ingens* – candelabra tree
  - *Euphorbia cotinifolia* – Caribbean copper plant
  - *Euphorbia tetragona* – naboom
  - *Euphorbia tirucalli* – pencil tree
- *Gymnanthes* – gymnanthes trees
  - *Gymnanthes lucida* – crabwood
- *Hevea* – rubber trees
  - *Heveabrasiliensis* – Pará rubber tree; rubber tree
- *Hippomane* – hippomane trees
  - *Hippomanemancinella* – manchineel
- *Manihot* – cassava
  - *Manihot esculenta* – cassava, manioc; manihot
  - *Manihot grahamii* – wild cassava; Graham's cassava
- *Sapium* – tallow trees
  - *Sapiumsebiferum* – Chinese tallow tree
- *Savia* – maidenbushes
  - *Saviabahamensis* – Bahamian maidenbush

Fabaceae: legume family (peas)

- *Acacia* – acacias and wattles
  - *Acacia albida* – winter thorn acacia
  - *Acacia aneura* – mulga acacia
  - *Acacia angustissima* – prairie acacia
  - *Acacia baileyana 'Purpurea'* – purple-leaf acacia

- *Acacia choriophylla* – cinnecord
- *Acacia crassifolia* – butterfly-leafed acacia; bauhinia-leafed acacia
- *Acacia dealbata* – silver wattle
- *Acacia farnesiana* – sweet acacia
- *Acacia greggii* – catclaw acacia
- *Acacia koa* – koa
- *Acacia longifolia* – Sydney golden wattle
- *Acacia macracantha* – longspine acacia
- *Acacia mearnsii* – black wattle
- *Acacia melanoxylon* - Australian blackwood
- *Acacia pendula* – weeping acacia
- *Acacia pycnantha* – golden wattle
- *Acacia tortilis* – umbrella tree; tortilis
- *Acacia tortuosa* – huisachillo
- *Acacia xanthophloea* – yellow-fever tree

- *Albizia* – silk trees and false acacias
  - *Albiziajulibrissin* – silk tree; mimosa; pea shame
  - *Albizialebbeck* – lebbeck; woman's tongue
  - *Albiziasaman* - saman, rain tree and monkeypod
- *Caesalpinia* – bird-of-paradise trees
  - *Caesalpiniaechinata* - pau ferro, brazilwood, pau-brasil, pau de Pernambuco, Pernambuco tree, Nicaragua wood and ibirapitanga
  - *Caesalpiniamexicana* – Mexican bird-of-paradise tree
  - *Caesalpiniapulcherrima* – red bird-of-paradise tree; flowerfence poinciana

- *Cassia* – senna
- *Cassia leptophylla* – gold medallion tree
  - *Cassia marilandica* – wild senna
  - *Cassia occidentalis* – coffee senna
- *Erythrina* – coral trees
  - *Erythrina caffra* – coastal coral tree

- *Erythrina coralloides* – naked coral tree
- *Erythrina falcata* – Brazilian coral tree
- *Erythrina humeana* – Natal coral tree
- *Millettialaurentii* – wenge

- *Mimosa* – mimosas
  - *Prosopis glandulosa* – honey mesquite
  - *Prosopis juliflora* – thorny kiawe; algaroba
  - *Prosopis pallida* – kiawe
  - *Prosopis pubescens* – screw bean; tornillo

Lauraceae: laurel family

- *Cinnamomum* – cinnamon and camphor
  - *Cinnamomumaromaticum* – cassia
  - *Cinnamomumcamphora* – camphor tree; camphor laurel
  - *Cinnamomumverum* – cinnamon tree
- *Laurus* – true laurels
  - *Laurus nobilis* – poet's laurel; sweet bay laurel
- *Licaria* – licaria trees
  - *Licariatriandra* – Florida licaria
- *Nectandra* – nectandra trees
  - *Nectandracoriacea* – lancewood
- *Persea* – bay trees
  - *Perseaamericana* – avocado; alligator pear; ashue
  - *Perseaborbonia* – red bay
  - *Perseapalustris* – swamp bay
- *Sassafras* – sassafras trees
  - *Sassafras albidum* – sassafras
- *Umbellularia* – umbellularia trees
  - *Umbellulariacalifornica* – California laurel

Malvaceae: mallow family

- *Hibiscus* – hibiscus trees
  - *Hibiscus mutabilis* – Confederate rose; cotton rose
  - *Hibiscus syriacus* – Rose-of-Sharon; althea
  - *Hibiscus tiliaceus* – seaside mahoe; sea hibiscus

Meliaceae: mahogany family

- *Cedrela* – cedrela trees

o *Cedrelaodorata* – Spanish cedar; cedro hembra

- *Melia* – berry mahoganies

o *Melia azedarach* – chinaberry

- *Swietenia* – baywoods
  - *Swietenia macrophylla* – American baywood
  - *Swieteniamahagoni* – mahogany
  -

Moraceae: mulberry family

- *Antiaris* – antiaris trees
  - *Antiaristoxicaria* – upas; ipoh; dart-poison tree
- *Artocarpus* – breadfruits and jackfruits
  - *Artocarpusaltilis* – breadfruit
  - *Artocarpusansiophyllus* – entawak
  - *Artocarpusheterophyllus* – common jackfruit
  - *Artocarpushypargyraea* – kwaimuk
  - *Artocarpus integer* – chempedak
  - *Artocarpuskemando* – pudau
  - *Artocarpuslakoocha* – lakoocha
  - *Artocarpusnitidus* – butong
  - *Artocarpusodoratissimus* – marang
  - *Artocarpus rigidus* – monkey jackfruit
  - *Artocarpussarawakensis* – pingan

- *Artocarpussericicarpus* – pedalai

Ficus – fig trees

- *Ficusaltissima* – council tree
- *Ficus aspera* – lofty fig; clown fig
- *Ficusaurea* – Florida strangler fig
- *Ficusauriculata* – Roxburgh fig
- *Ficusbenghalensis* – banyan fig; Bengal fig; Indian fig; East Indian fig; Indian banyan
- *Ficusbenjamina* – weeping fig; Benjamin's fig
- *Ficuscallosa* – kalukoi
- *Ficuscarica* – common fig
- *Ficuscelebensis* – Celebese fig
- *Ficuscoronata* – creek sandpaper fig
- *Ficusdeltoidea* – mistletoe fig
- *Ficuselastica* – rubber tree; rubber fig
- *Ficuserecta* – inu-biwa; Japanese fig
- *Ficus fistulosa* – yellow-stem fig
- *Ficusfraseri* – shiny sandpaper fig
- *Ficusglomerata* – cluster fig
- *Ficuskurzii* – thick-rinded fig
- *Ficus laevigata* – Jamaican cherry
- *Ficus lutea* – kaffir fig
- *Ficuslyrata* – fiddle-leaf fig
- *Ficusmaclellandii* – banana-leaf fig
- *Ficus macrophylla* – Moreton Bay fig
- *Ficusmauritiana* – Mauritian fig; Maldive fig
- *Ficusmicrocarpa* – Chinese banyan tree; laurel fig; fig laurel
- *Ficusmysorensis* – Mysore fig
- *Ficusnekbudu* – Zulu fig
- *Ficusneriifolia* – narrowleaf fig; willow-leaf fig; oleander-leaf fig
- *Ficus nota* – tibig

- *Ficusobliqua* – small-leaf fig
- *Ficuspetiolaris* – rock fig; lava fig
- *Ficusplatypoda* – desert fig; Australian fig
- *Ficuspseudopalma* – Philippine fig
- *Ficus religiosa* – sacred fig; bo tree
- *Ficusribes* – walen; gooseberry fig
- *Ficusrubiginosa* – Port Jackson fig; little-leaf fig; rusty fig
- *Ficusseptica* – angular-fruit fig
- *Ficussycomorus* – sycamore fig
- *Ficus triangularis* – triangle fig
- *Ficusvariegata* – variegated weeping fig; cauliflorus fig
- *Ficusvirens* – white fig
- *Ficuswatkinsiana* – Australian strangler fig
- – red mulberry

Moringaceae: moringa family

- *Moringa* – moringa trees
  - *Moringa oleifera* – horseradish tree; olive moringa; moringa

Myrtaceae: myrtle family

- *Agonis* – peppermint myrtles
  - *Agonisflexuosa* – Western Australian peppermint; Swan River peppermint; Australian willow myrtle
- *Callistemon* – callistemon trees
  - *Callistemon viminalis* – weeping bottlebrush
- *Calyptranthes* – mountainbays and lidflowers
  - *Calyptranthesacevedoi* – Puerto Rico mountainbay
  - *Calyptranthespallens* – pale lidflower
  - *Calyptrantheszuzygium* – myrtle-of-the-river
- *Corymbia* – corymbia trees
  - *Corymbiaficifolia* – red-flowering gum
- *Eucalyptus* – eucalyptus trees

- *Eucalyptus caesia* – silver princess mallee
- *Eucalyptus camaldulensis* – red river gum
- *Eucalyptus cinerea* – silver dollar tree
- *Eucalyptus citriodora* – lemon-scented gum
- *Eucalyptus cladocalyx* – sugar gum
- *Eucalyptus deglupta* – Mindanao gum
- *Eucalyptus globulus* – bluegum eucalyptus
- *Eucalyptus grandis* – rose gum eucalyptus
- *Eucalyptus marginata* _jarrah
- *Eucalyptus nicholii* – willow-leafed peppermint gum
- *Eucalyptus polyanthemos* – silver dollar gum
- *Eucalyptus rhodantha* – rose mallee
- *Eucalyptus robusta* – robust eucalyptus
- *Eucalyptus rudis* – flooded gum (desert gum)
- *Eucalyptus saligna* – saligna eucalyptus
- *Eucalyptus sideroxylon* – pink-flowering ironbark
- *Eucalyptus spathulata* – narrow-leaf gimlet

- *Psidium* – guavas
  - *Psidium friedrichsthalianum* – Costa Rica guava; cas guava
  - *Psidium galapageium* – Galapagos guava
  - *Psidium guajava* – apple guava; common guava
  - *Psidium guineense* – Guinea guava
  - *Psidium havanense* – Cuban guava
  - *Psidium littorale* var. *cattleianum* – strawberry guava;
  - *Psidium littorale* var. *littorale* – lemon guava
  - *Psidium longipes* – long-stalk stopper; mangroveberry
  - *Psidium montanum* – mountain guava
  - *Psidium sartorianum* – Sartre guava

Rhamnaceae: buckthorn family

- *Colubrina* – nakedwoods
    - *Colubrina arborescens* – greenheart; coffee colubrina
    - *Colubrina asiatica* – Asian nakedwood
    - *Colubrina elliptica* – soldierwood
    - *Colubrina cubensis* – Cuban nakedwood
    -

Rhizophoraceae: mangrove family

- *Rhizophora* – true mangroves
    - *Rhizophora apiculata* – bakauminyak
    - *Rhizophora mangle* – red mangrove

Rosaceae: rose family

- *Amelanchier* – serviceberries (juneberries or shadbushes)
    - *Amelanchier alnifolia* – saskatoon
    - *Amelanchier amabilis* – lovely shadbush
    - *Amelanchier arborea* – downy serviceberry
    - *Amelanchier asiatica* – Asian serviceberry
    - *Amelanchier bartramiana* – mountain serviceberry; alpine serviceberry
    - *Amelanchier canadensis* – eastern serviceberry; shadblow serviceberry
    - *Malus baccata* – Siberian crabapple
    - *Malus coronaria* – sweet crabapple
    - *Malus domestica* – orchard apple
    - *Malus floribunda* – Japanese flowering crabapple
    - *Malus fusca* – Oregon crabapple; Pacific crabapple
    - *Malus ioensis* – prairie crabapple
    - *Malus sieversii* – Asian wild apple
    - *Malus sylvestris* – European wild apple
- *Prunus* – cherries, plums, peaches, apricots, almonds and cherry laurels

- *Prunus alleghaniensis* – Allegheny plum
- *Prunus americana* – American plum
- *Prunus amygdalus* – almond
- *Prunus andersonii* – desert peach
- *Prunus angustifolia* – Chickasaw plum
- *Prunus armeniaca* – apricot
- *Prunus avium* – sweet cherry
- *Prunus capollin* – capulin
- *Prunus caroliniana* – Carolina cherry laurel
- *Prunus cerasifera* – cherry plum
- *Prunus cerasus* – sour cherry
- *Prunus domestica* – garden plum
- *Prunus emarginata* – bitter cherry
- *Prunus fasciculata* – desert almond
- *Prunus fremontii* – desert apricot
- *Prunus hortulana* – prairie plum; hortulana plum
- *Prunus ilicifolia* – holly-leaved cherry
- *Prunus insititia* – damson plum; bullace
- *Prunus laurocerasus* – common cherry laurel
- *Prunus lusitanica* – Portuguese cherry laurel
- *Prunus lyonii* – Catalina cherry
- *Prunus maackii* – Amur chokecherry
- *Prunus mahaleb* – mahaleb
- *Prunus maritima* – beach plum
- *Prunus mexicana* – Mexican plum
- *Prunus mume* - Chinese plum; Japanese apricot
- *Prunus munsoniana* – wild goose plum
- *Prunus myrtifolia* – myrtle-leaved cherry laurel
- *Prunus nigra* – Canada plum
- *Prunus padus* – bird cherry
- *Prunus pensylvanica* – pin cherry; fire cherry
- *Prunus persica* – peach

- *Prunus pumila* – sand cherry
- *Prunus salicifolia* – willow-leaf cherry
- *Prunus serotina* – black cherry
- *Prunus serrulata* – Japanese cherry
- *Prunus spinosa* – European sloe
- *Prunus subcordata* – sierra plum
- *Prunus subhirtella* – autumn cherry
- *Prunus umbellata* – flatwoods plum; hog plum
- *Prunus virginiana* – chokecherry

Rubiaceae: madder family

- *Blepharidium*
  - *Blepharidiumguatemalense*
- *Coffea* – coffee trees
  - *Coffea arabica* – coffee; Ethiopian coffee
- *Casasia* – casasia trees
  - *Casasiaclusiifolia* – seven-year apple
- *Cephalanthus* – cephalanthus trees
  - *Cephalanthusoccidentalis* – button bush

Rutaceae: citrus famil

- *Calodendrum* – calodendrum trees

- *Calodendrumcapense* – Cape chestnut

- *Citrus* – oranges, lemons, limes, grapefruits, and kumquats
  - *Citrus aurantiifolia* – lime
  - *Citrus aurantium* – sour orange
  - *Bumelia* – bume*Citrusgrandis* – shaddock; pumelo
  - *Citrus japonica* (*Fortunella japonica*) – kumquat
  - *Citrus limon* – lemon
  - *Citrus medica* – citron
  - *Citrus paradisi* – grapefruit

- *Citrus reticulata* – mandarin
- *Citrus sinensis* – sweet orange

Sapotaceae: sapodilla family

- *Bumeliacelastrina* – saffron plum bumelia
- *Bumelialanuginosa* – gum bumelia
- *Bumelialycioides* – buckthorn bumelia
- *Bumeliatenax* – tough bumelia

- *Chrysophyllum* – chrysophyllum fruit trees
  - *Chrysophyllumcainito* – star apple
  - *Chrysophyllumoliviforme* – satinleaf
- *Dipholis* – bustics
  - *Dipholissalicifolia* – willow bustic
- *Manilkara* – manilkara trees
  - *Manilkarabahamensis* – wild dilly
  - *Manilkarabidentata* – ausubo; balata
  - *Manilkarazapota* – sapodilla

Solanaceae: nightshade family

- *Nicotiana* – tobacco
  - *Nicotiana glauca* – tree tobacco
- *Solanum* – nightshades and potatoes
  - *Solanum erianthum* – potato tree; mullein nightshade

Sterculiaceae: sterculia family

- *Brachychiton* – bottle trees
  - *Brachychitonpopulneus* – bottle tree
  - *Brachychitonpopulneus* × *acerifolius* – flame tree
  - *Brachychitonrupestris* – Queensland bottle tree
- *Cola* – cola trees
  - *Cola acuminata* – cola nut tree; kola tree
- *Dombeya* – dombeya trees
  - *Dombeya rotundifolia* – South African wild pear

- *Dombeya wallichii* – pink-ball; tropical hydrangea

- *Firmiana* – parasol trees
  - *Firmiana simplex* – Chinese parasol tre

Theaceae: tea family

- *Camellia* – camellias
  - *Camellia japonica* – Japanese camellia; camellian rose
  - *Camellia sinensis* – tea camellia; tea plant

Topic 2. Forest plantation structure.

a) Tree spacing

TABLE 1. COMMONLY USED SPACING FOR SOME TREE SPECIES AND NUMBER OF SEEDLINGS NEEDED PER HA

Tree species	**Recommended spacing meters (m)**	**No of seedlings per ha**	**10% of beating up**	**Total required seedlings**
Callitrisrobusta	2.0m ×2.0m	2,500	250	2,750
Cedrela serrata	2.5m ×2.5m	1,600	160	1,760
Entandrophragmaexcelsum	2.5m ×2.5m	1,600	160	1,760
Pinus patula and cypres	3.0m ×3.0m 2.7m ×2.7m 3.0m ×2.5m	1,111 1372 1333	111 138 134	1,222 To be calculated
Eucalyptus spp	3.0m ×2.0m 3.0m ×2.5m 3.0m ×3.0m	1667 1333 1111	To be calculated	To be calculated
Maesopsiseminii	3.0m ×3.0m	1,111	111	1,222
Other Hardwoods	3.0m ×3.0m 4.0m ×3.0m	1111 833	111 To be calculated	1222 To be calculated

B) Site layout

A site layout plan shows a detailed layout of the whole site and the relationship of the proposed works with the boundary of the property. The choice of where and what to plant depends on the purpose of the plantation, on who the land and the trees belong to and on other possible uses of the land. The first step is to find out what the needs of the local populations are. What are the benefits they expect? Who in the local community benefits from a plantation and who might not benefit from it? How will the plantation affect other land-uses like food production or grazing? What are the potential conflicts in connection with

the plantation? These factors have to be discussed until all concerned reach agreement. These discussions are very important and should start early during the planning of the plantation. Plantation programs which will result in reduced benefits for the population are not likely to succeed. More tree planting projects fail because of problems with the people involved than because of technical mistakes.

When you start the technical planning take a close look at the area. Decisions have be made on:

- What regeneration method to use (whether to plant, rely on natural regeneration or seed directly on the site)?
- What tree species to establish (matching species to planting purpose and site)?
- Whether to plant a single tree species or a mixture of several?
- What type of planting stock to use (bare rooted, potted seedlings or stumps, small or large seedlings)?
- What planting pattern to use and how many seedlings to plant?
- When to plant?
- How to protect the seedlings?

To make the right decisions you have to get to know the area. Start by drawing a simple map of the plantation site and calculate the area available

Planting pattern to use and how many seedlings to plant.

The most commonly used planting patterns are square spacing or triangular spacing where the distance between the rows are the same as along the rows. If strip clearing or weeding are used, a rectangular pattern, where trees are closer in the rows, than between the rows might reduce labour input. For very harsh climates and on poor soils, it might be appropriate to plant in clusters.

The appropriate spacing varies with the site, the purpose of the plantation and the species chosen. It is also a compromise between expected yield and the cost of establishing the plantation. Wider spacing (more than 3x3 m) is preferred:

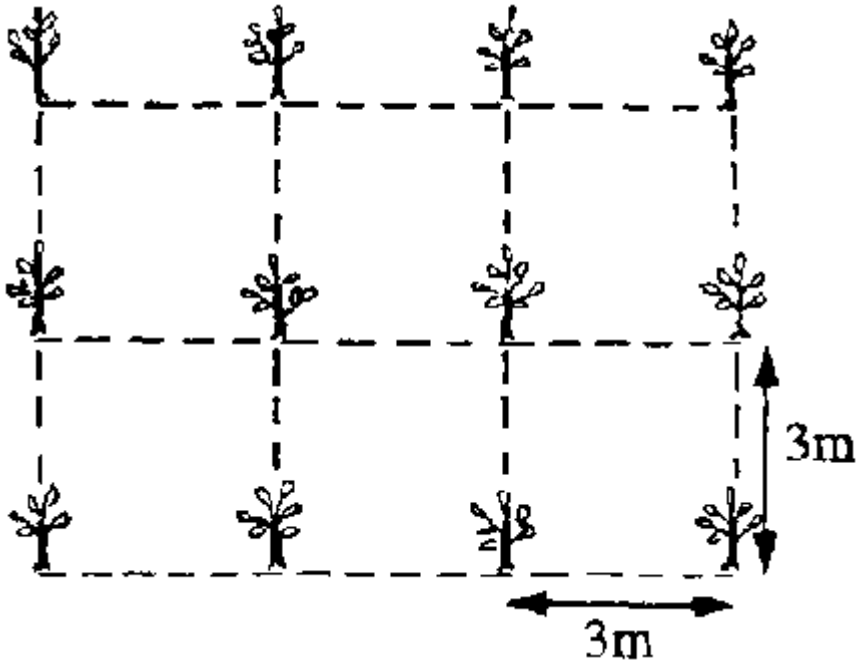
- for fruit trees;
- when planting on agricultural or grazing land;
- to reduce the cost of planting;
- in arid areas to avoid competition for water and nutrition
- to reduce the number of thinnings (if the aim of the plantation is large diameter timber).

Closer spacing (3x3 m or closer) is preferred:

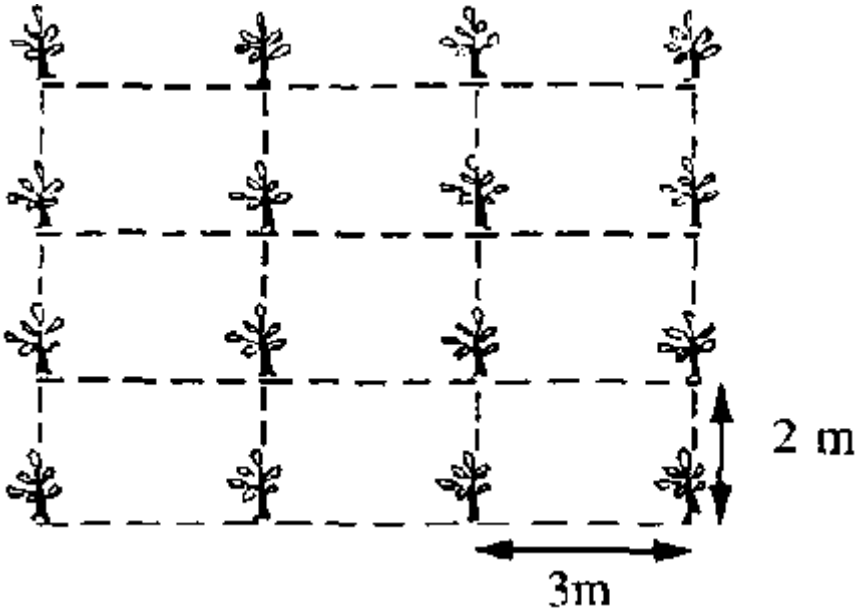
- to avoid expensive replacement planting;
- to give early soil cover;
- when weed competition needs to be suppressed by early tree canopy closure;
- for slow-growing species when aiming for good quality sawlogs, i.e. small branches/knots;
- when there is a market for smaller dimension wood from thinnings;
- for fast-growing species such as Willows and Eucalyptus, when using short rotation to produce mostly smaller dimension wood (e.g. for fuel).

On dry sites most trees are now planted with an average of 3 or 4 meters between trees (i.e. 1100 or 625 trees/ha, respectively). On fresh sites in tropical highlands and in temperate climates a spacing of 2 square meter (i.e. 2500 trees/ha) is common. The table on the following page can be used when calculating how many seedlings will be needed for a site.

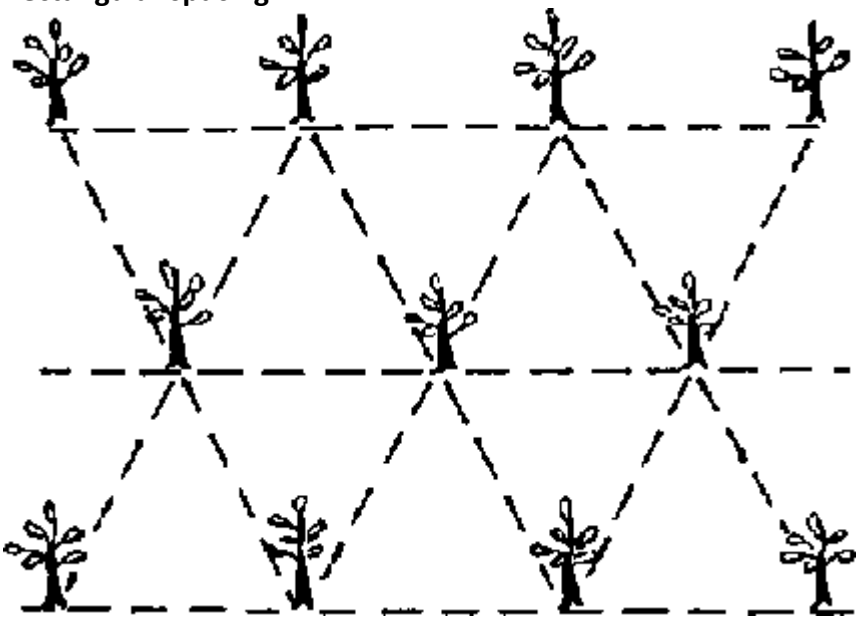
Spacing



- Square spacing



- **Rectangular spacing**



- **Triangular spacing**
- **Calculating the number of seedlings needed**
- If you know how many plants you want to plant per hectare, you can calculate the square spacing using the formula:
- $\sqrt{\text{V } 10{,}000/\text{number of seedlings per ha}} = \text{Square spacing (m)}$
- If on the other hand you know what spacing you want, you can calculate the number of seedlings needed using the formula:
- 10,000/(distance a x distance b) = Number of seedlings per ha

Spacing between lines (m)	Spacing within lines (m)	Space per seedling (m2)	Seedlings per hectare
1	1	1	10000
2	2	4	2500
2.5	1.6	4	2500
3	3	9	1111
4	2	8	1250
4	4	16	625

Table 2: Seedlings production by unit of surface

Topic3. Tree species growth rate.

A. Fast growing species:

a)Eucalyptusspp

b)Alnusspp

B. Medium growing tree species

a)Grevillearobusta

b)Acaciaspp

c)Cassia spp

d)Casuarina spp

e)Markhamiaspp

f)Cedrelaspp

g)Maesopsiseminii

C. Low growing species

a)Pinusspp

b)Callitrisspp

c)Cupressus spp

d)Araucaria spp

Topic 4: High Forest stand.

A high forest is a type of forest originated from seed or from planted seedlings. In contrast to a low forest(also known as a coppice forest), a high forest usually consists of large, tall mature trees with a closed canopy. High forests can occur naturally or they can be created and/or maintained by human management. Trees in a high forest can be of one, a few or many species. A high forest can be even-aged or uneven-aged.Even-aged forests contain trees of one, or two successional age classes (generations). Uneven-aged forests have three or more age classes represented.

- **Coppice forests**: is a forest regenerated from vegetative shoots that may originate from the stump and/or from the roots, depending on the species.

There are different forms of coppice forests: simple coppice, coppice with standards, coppice selection, pollarding and short rotation coppice.

- Simple coppice is a forest management system in which trees are systematically and repetitively cut and regeneration is vegetative, by means of sprouting or suckering (often from the stump, alternatively from roots). Simple coppice is applied especially on broadleaved tree species that can withstand repeated cutting, such as oaks, sweet chestnut, hornbeam, linden, eucalypts, ash, alders, black locust, poplars.
- Pollarding consists of cutting the tops of trees as to stimulate production of numerous straight shoots on the top of the cut stem . The shoots grow out of reach of browsing animals and flooding waters, these representing the main reasons for pollarding. Most typical pollards exist today along riversides and meadows. The most common species used are poplars, ash, willows, plane-trees, beech, chestnut, mulberry, oaks, linden, elms, black locust, maples, hornbeam and hazel.

short rotation coppicesome fast growing tree species can be cut down to a low stump (or stool) when they are dormant in winter and go on to produce many new stems in the following growing season.

- Coppice selection system: In a coppice selection system, a target diameter is fixed according to the size of aimed wood product, followed by an estimate of the age at which material of this size will be produced. This age determines the rotation, which is divided into a number of felling cycles (for instance: a rotation of 30 years includes three felling cycles of 10 years). The total area of forest under CSS is divided into annual coupes equal in number to the number of years in the felling cycle.
- Coppice with standards Coppice with standards is a silvicultural system in which selected stems are retained, as standards, at each coppice harvest to form an uneven-aged overstorey which is removed selectively on a rotation consisting of a multiple of the coppice cycle.

The table below show the development stages of futaie and their characteristics .

Stage of development	Mean Diameter	Characteristics
Recruit	-	Level of herbaceous stratum No competition between tree
Cover	-	Branches torch between them
Perch low	< 10 cm	The tree make the competition on high and nutrients The competition on low branches High grawing in height
High perch	10 – 20 cm	High competition The stem begin to stand out
Young futaie	20 – 25 cm	Low growing in height High growing in diameter
Mean futaie	35 – 50 cm	Growing in diameter continue The economic value increase highly
Old futeie	>50 cm	Final stage of development in managed forest

Table 3: Tree stages development and their characteristics

Topic 5. Forest volume estimation.

A. Total volume of stand

Estimates of volumes for different types, qualities and sub-samples of stands are essential for effective forest production management. These estimates will assist in the determination of potential product harvests, but may also be useful for estimating the amount of carbon locked up in the forests - important in green-house gas studies and fire research. Estimates of stand bole volume integrate information on stand structure - and stocking or stand basal area, stand height and stand taper. They may also incorporate information about harvesting practice if harvestable volume is used.

In estimating stand volume, it is essential to realize that:

- the estimate is based on a sample
- the intensity of sampling on an area basis may be very low, even very much less than1%
- within the area selected as the sample, one subsamples further both in selecting the trees to sample for volume and in selecting the points of measurement on the individual sample trees.

Thus, the 'blow-up' factor in estimating stand volume (in expanding the estimate from the sample to the population) is great. In addition, at each stage of sampling, errors can arise from various sources. All of these factors combine to impose limitations on the inferences that can be drawn about the population. Keep in mind that an estimate of volume within ± 10% of true is good, and yet a 10% error in the estimate will throw out a cutting program by one year in a ten-year cutting cycle

The formula used to calculate tree volume:

The volume of a part (or frustum) of a second degree paraboloid is particularly important in forest mensuration because many logs and sections of trees approximate this shape. Several basic formula are used to measure log volume.

Assume that S is the basal sectional area, s is the top basal area, s0.5 is the mid-section sectional area, and H the height or length, then the volume (V) is given by:

- **Smalian's formula**: V = H x (S + s) / 2
- **Huber's formula**: V = H x s0.5
- **Newton's formula**- Assuming D is basal diameter, d is top diameter and d0.5 is mid-section diameter:

  V = H x (D^2 + 4 x d0.5 + d^2) x (PI / 24

- Log volume is not measured directly but is calculated using log mid-diameter and log length using Huber's formula:

- $V = \frac{\pi d^2}{4} \times L$
- where:

  V = volume in cubic meters

  π = 3.1416

  d= diameter at breast height

  L = length in meters

- $(V = \frac{\pi d^2}{4} \times L) N$:

This formula is used to calculate totol volume of stand where N is numbers of trees composed the stand .

B. Mean height

The mean tree height of forest stands is a crucial stand characteristic in forest planning. Currently, the mean tree height is determined by field measurements or by photogrammetric measurements utilizing aerial photographs.

C. Averagebasal area of stand

Basal area is the common term used to describe the average amount of an area (usually an acre) occupied by tree stems. It is defined as the total cross-sectional area of all stems in a stand measured at breast height, and expressed as per unit of land area (typically square feet per acre). To standardize measurements, tree diameter is typically measured at 4.5 feet from the ground, or approximately breast height. This is referred to as diameter at breast height (DBH). Basal area is a useful index for understanding forest-wildlife habitat relationships and making timber harvest decisions. For example, percent canopy cover is correlated with basal area in pine forests. Greater pine basal area equals greater tree canopy cover; thus, as both increase, less sunlight reaches the ground. This lack of sunlight impedes growth of grasses, forbs (nonwoody, broadleaf plants), and shrubs that provide important food and cover for some species of wildlife. Also, high basal area may lead to a decrease in tree growth and vigor from the increased competition for crown space, nutrients, and moisture.

LO 1.3. Inspect the severity of pests and disease

Topic1. The severity of pests and diseases

When carrying out the site study, it is advisable to inspect the severity of pests and diseases, and this will help landowners in forest management to make decisions which are more interconnected with forest status

Figure 6.**Pests anddiseases diagnosis**

A.Disease Diagnosis

Trees pathologists take many different approaches to diagnosing plant disease problems. The first step is to decide whether the problem *is* a plant disease. The broadest definition of plant disease includes anything that adversely affects plant health. This definition can include such factors as nutrient deficiencies, lawnmower damage, air pollution, and pathogens.

Many novices use the picture-book method of diagnosis: looking at textbook pictures of problems and attempting to match the problem with the picture. “The Ortho Problem Solver” and the APS Plant Disease Compendia series are examples of texts that have many useful, high-quality color pictures. Although this method is useful for simple and common problems, it is usually inefficient and inaccurate for more complex or difficult problems.

Another simple technique, used by “The Ortho Problem Solver,” is the checklist. Through a series of 70 questions, a person builds a case history of the problem. The questions include the kind, age, and size of the plant. The plant’s location, location of the property, and relationship to other plants also are part of the checklist. Information on the recent weather and soil conditions, soil coverings, and recent care also are needed. Describing the overall condition of the plant is very important.

Symptoms and signs are used to diagnose the condition of a plant. *Symptoms* are the physical characteristics of disease expressed by the plant. Symptoms can include wilt, galls, cankers, rots, necrosis, chlorosis, and general decline

B. Observation

Correct identification of insect pests is necessary in order to avoid economic damage being sustained and retain beneficial insects. Often it may be difficult to identify the insects causing the particular damage. If this is the case, the next option available is to examine the symptoms of crop damage. Use the diagnostic tool to help to identify the insect pest causing the damage.

Insects can damage tree throughout the growing season but seedlings and podding tree are most at risk. It is also important to assess any crop damage as soon as it is observed, and determine if further damage is likely to occur. Options available for the control of the particular insect pest can then be explored.

Figure 7: Observation of pests

C. **sampling of pests and diseases**

Integrated Pest Management strategies require detailed studies which can be broken down into three steps: (i) a precise description of pest population dynamics in space and time in order to assess damage thresholds, to determine key points for control (possibly by modelling), and to evaluate control efficiency; (ii) a general survey to estimate the variability in the first step between seasons or across a region; and (iii) the control strategy, including a survey by the grower of population dynamics. Each of these steps requires particular sampling methods that differ in accuracy: precise measurements for detailed studies, less precise measurements but which can be used on a larger scale for variability evaluation in the second step, and quick and simple methods for final use by the growers. Pest and disease intensity may be quantified

using two different measurements: (i) estimation of the population size, e.g. number of aphids per leaf, number of fungal spores in a cubic meter of air, etc.; and (ii) quantification of the injury caused to the host plant, e.g. the proportion of leaf tissue infested by larvae, the relative leaf area covered with disease symptoms, etc. The methods should be easy to use, allow rapid estimation, be applicable over a wide range of conditions, and most of all, be accurate and reproducible. They are three common methods of sampling which are random sampling, systematic sampling and stratified sampling.

D.Propagation factors

Wind: Is a propagation factor when it moves pollen grains of a diseased to a healthy one or moving seeds of diseased trees from one area to another.

Animals: the effect of animals in diseases transmission is observed when spreading cow dung containing seed or when seeds stick on their skin hairs and fall everywhere.

Tools: Tools propagate tree diseases when they are used in different site without being cleaned.

Pests: propagate tree diseases when they are looking for nutrients from flowering plants or sucking tree sap.

Planting materials and seeds: Transmit tree diseases when they are collected from diseased tree for example grafting materials, cutting or seed from diseased trees.

Topic 2. Pests anddiseases classification

Like all living things, trees are susceptible to disease. A tree needs a good supply of light, water, carbon dioxide and nutrients from the environment for optimum growth. A lack of one or more of these may lead to reduced growth and put the tree under stress. If a tree is stressed then it may not have the energy required to manufacture important defences and can become vulnerable to disease.

If a diseased tree eventually dies it can sometimes be difficult to diagnose the original cause because problems are often complex and cumulative. For example, a tree could be weakened by drought and then become the victim of a fungal attack; environmental factors such as temperature, storm wounds or pollution may play a part; or sometimes more than one disease may be present.

Tree disease can stem from fungal, bacterial or viral sources.

D.1. Fungal

The main types of fungal decay are brown rots and white rots.

Brown rots will attack the cellulose and hemicellulose in wood leaving only the lignin. The decayed wood becomes brown and cracked in a brick-like form, timber value is lost and the tree may become brittle and unstable.

White rots attack all parts of the wood, turning it into a pale spongy mass.

Fungal diseases are often only detected once the fruiting body of the fungus is visible, by which time it may be too late to act. Honey fungus *(Armillaria spp.)* is an example of a white rot fungus which causes the roots and butts of live trees to rot.

However, it is important to note that not all fungi damage trees. Many types of fungi enjoy a mutually beneficial (symbiotic) relationship with trees, whereby the fungi obtain energy from the tree sugars made during photosynthesis and the tree benefits from the absorption of additional nitrogen and phosphorous due to the fungal action in the soil.

D.2. Bacterial and viral infections

Various kinds of bacteria can also cause disease in trees. Oak decline is a complex disorder or syndrome in which bacteria, along with other damaging agents such as insect infestation or weather damage, interact to bring about a serious decline in tree condition. There are two kinds of decline: acute and chronic.

Acute oak decline affects mature oaks and bacteria is thought to cause symptoms of stem bleeding where dark, sticky fluid oozes from cracks in the tree trunk. Both of Britain's native oak species – pedunculate oak and sessile oak – are affected.

Chronic oak decline may take many years to kill a tree. Early symptoms include deterioration of the foliage; leaves may be smaller than normal, pale or yellowish. In some cases the foliage may be sparse over the entire crown and death of twigs and branches follow.

The two most important notifiable diseases in Britain today are sudden oak death caused by the pathogen *Phytophthora ramorum* and red band needle blight caused by the fungus *Dothistromaseptosporum* which affects Corsican pine.

D.3. Physiological plant disorders

Are caused by non-pathological conditions such as poor light, adverse weather, water-logging, phytotoxic compounds or a lack of nutrients, and affect the functioning of the plant system. Physiological disorders are distinguished from plant diseases caused by pathogens, such as a virus or fungus.While the symptoms of physiological disorders may appear disease-like, they can usually be prevented by altering

environmental conditions. However, once a plant shows symptoms of a physiological disorder it is likely that, that season's growth or yield will be reduced.

- **Topic 3.Pests anddiseasescontrol methods**

After collecting data on pests and diseases, the decision on control based on their types is crucial. There are two possibilities of fighting against pests and diseases which are curative treatment and preventive treatment.

1.Preventive treatment

This technique is aiming at fighting the pests and diseases before they occur in the field, some activities of preventive treatment are:

- Sanitation in a forest
- Sowing on time
- Use of resistant seeds

Adequate fertilization

- Mixing tree species
- Pruning and thinning

2. Curative treatment

This is a treatment which is done after the occurrence of pests and diseases in a field

It includes the use of pesticides, biological control, physical removal etc

LO 1.4–Identification of land use systems

- Content/Topic 1. Land use property.

LAND:the surface of the earth identified by specific boundaries, including the airspace above that portion of surface, the minerals beneath it, and surrounding biodiversity, erections and developments on that surface. In legal terms, it is an immovable and permanent asset inclusive of rights associated with the surface of the earth from the center to the infinite sky

Land use

The concept of land use refers to a series of activities done to generate one or more products or services.

The same land use can occur on several different parcels of land, and reciprocally, the same land may have several uses.

A. Land use property

In Rwanda, the Forest land uses are divided into three main categories according to the properties

- State Forests
- District forests
- Private forests

- **State forest**: a forest on State land planted by the State, Government Project, planted through community work or any other organ, a natural forest, forest planted along State roadsides, along the shores of rivers and lakes, a forest transferred to the State and any other un owned forest. The State forests shall comprise the following three (3) categories: 1° protected forests; 2° production forests ; 3° forests reserved for research

Characteristics.

The goal is to satisfy the general interests

It must produce the most wood needed and generating more general interest

It requires sufficient capital

- **Private forest:** a forest planted by an individual, the State, planted through community work or by any other person on private land, planted by a group of people with or without legal personality on their land. Private forests comprise the following two (2) categories: 1° small production planted forests which do not exceed two hectares (2 ha); 2° large production planted forests exceeding two hectares (2 ha).

Characteristics:

Private want to minimize income in the function of rent capital to the high rate of interest.

Every farmers who has 2ha is required to develop a forest management plan and submit it for approval of the provincial officer.

For individual or grouped foresters holding over 2ha are subjected to prescribing rules for conservation and exploitation.

- **District forest**: a forest located on a District land and that was planted by the District, a District project, planted through community work or planted by any other organ partnering with the District, a forest along the District roads or forest that has been transferred to the District. District forests shall comprise the following categories: 1° production planted forests; 2° protected forests meant to maintain and safeguard environment.

  Characteristics.

One parts of the forest products is consumed by the farmers

- Topic 2. Forest stand description

Forest – A plant association predominantly of trees or other woody vegetation, a collection of stands.

Stand – An aggregation of trees or other growth occupying a specific area and sufficiently uniform in species composition, size, age, arrangement, and condition as to be distinguished from the forest or other growth on adjoining areas.

B.1. Stand Composition – The composition of stands is conceived of as being either pure or mixed. These are defined as: (a) Pure Stand – A stand in which at least 80% of the trees in the main canopy are of single species. (b) Mixed Stand – A stand in which less than 80% of the trees in the canopy are of a single species.

B.2. Stand Density – The density of stocking expressed in number of trees, basal area, volume, or other criteria, on a per-acre basis. In addition stocking is further modified and defined as:

Fully stocked stands – Stands in which all the growing space is effectively occupied but which still have ample room for development of the crop trees.

Overstocked stands – Stands in which the growing space is so completely utilized that growth has slowed down and many trees, including dominants, are being suppressed.

Understocked stands – Stands in which the growing space is not effectively occupied by crop trees. 1/ All definitions employed were taken from or are modifications of those given in Forest Terminology.

B.3. Stand Form – Stands are usefully described and considered from the standpoint of the age classes of which they are composed. Generally, two stand forms are recognized. These are: (a) Even-aged stands – Stands in which there exists relatively small age differences between individual trees. (b) Uneven-aged stands – Stands in which there exists relatively large age differences between individual trees. At least 3 age classes are present. A similar meaning is allaged stand. (c) Two-aged stands – Stands in which there are two distinct age classes.

B.4. Stand Origin – Stands may be classified by origin; whether from seed or sprouts and suckers, or a combination of the two. Also descriptive of origin are natural or planted, and virgin or second growth.

B.5. Stand Location – Of interest silviculturally is the topographic location of the stand. Generally, two broad topographic positions are recognized, upland or bottomland.

B.6.Forest area

done for different categories such as forest and non-forest or different forest types. Forest area estimation is also a crucial input to all quantifications or estimations of "deforestation". A clear definition of "forest" is required in any case. For the determination of forest area there are at least two basic approaches:

- delineation (mapping) from remote sensing imagery, or
- Statistical sampling (either in the field or from remote sensing imagery).

Mapping can either been done automatically (in the presence of suitable algorithms) or manually. Various sources of error are associated with this exercise but the result is a map that shows the spatial arrangement of the forest patches.

Statistical sampling is a different approach that produces an overall estimation – but not a map. It has the advantage that the precision in terms of the standard error is easily quantified (if statistical sampling has been used) and gives information about the reliability of the estimation.

- Topic 3. Land use conditions.

Agriculture: the land of lower slope or medium slope must be used in crop production

Forestry : For high land or degraded soil

Pasture: Is the land of medium slope in order to produce fodder for livestock

Wetland: is protected area to conserve water and wild animals.

Learning Unit 2 – Determine the required cost and income in forest management plans

LO 2.1 –Estimate the cost of tools, equipment and materials

Topic 1. Identification of tools equipment and materials.

When choosing tools and equipment factors must be taken into consideration: Availability of tools or equipment, Financial capacity, site size, opportunities,operations ,price, environmental conditions, social conditions, precision, speed of use . robustness.

Some of those material ,tools and equipment are: Calculators, Paper sheet, Computer, GPS, Compass, Relascope, Caliper, Tape measure, Clinometers, Haga, Panga, Hoes ,Pens, Pegs, Ranging poles ,Forest map, Spade, Axe, Pruning saw, Bow saw, Two man saw, Sprayer, Duster Secateur,wheelbarrow, Ladder, Pruning knives Slashers etc.

Topic 2. The cost estimation of tools ,equipment and materials.

The Costestimationof tools, equipmentandmaterials should be calculated according to the conditions of market and the factors above.

Example of tools to clear 1ha on land with natural vegetations with 25 workers

Tools/Equipment /Materials	Quantity	Cost of one item	Total cost
Rope	2rools	2500	5000
Tape measure	2	5000	10000
Axe	5	5000	25000
Slasher	25	2000	50000
Rods	10	1000	10000
Panga	10	1500	15000

TOTAL COST= 115000 RFWRS

LO 2.2–Estimate the required human resources

Topic 1. Estimation principles.

A. Man day:*man-day* (plural *man-days*) One person's working time for a ***day***, or the equivalent, used as a measure of how much work or labor is required or consumed to perform some task.

B. Man hours: A man-hour is the amount of work performed by the average worker in one hourIt is used for estimation of the total amount of uninterrupted labour required to perform a task. For example, researching and writing a college paper might require eighty man-hours, while preparing a family banquet from scratch might require ten man-hours.

One work-day is 8 hrs

One work-week is 40 hrs

One man-month is 160 hrs for some project

Topic 2. Estimation of labor force criteria

A. Forestmanagement area

Forest management area must manage forest on a long term, sustained yield basis. They must also consider a broad range of forest values and social economic and environmental factors such as watershed, environment, and wildlife habit. Forest management planning consistent with the government commitment to sustainable resources development. In addition, forest management holders are require providing opportunities for public consultation during the development of a forest management plan for the area.

B. **Management activities**

The forest management activities include:

(i) forest fire protection;

(ii) supervision of forest

(iii) veldt management;

(iv) research support on indigenous forests;

(v) wildlife management;

(vi) silviculture;

(vii) anti-poaching activities; and

(viii) community participation.

These activities are are carried out under the supervision of the respective foresters of each forest reserve. Each forester has a small team of permanent workers that is complemented by casual workers during these operation.

C.Educationlevel oflaborforce:

Human resources are the most valuable and productive resource. Countries depend on the health, strength and skills of their workers to produce goods and services for consumption and trade. The advance of complex organizations and knowledge requirements, as well as the introduction of sophisticated machinery and technology, means that economic growth and improvements in welfare increasingly depend on the degree of literacy and educational attainment of the population. People's predisposition to acquire such skills can be enhanced by experience, informal and formal education, and training

LO 2.3 – Estimate forest financial income

Topic 1.The types of forest products**.**

Forest product such as fuelwood or other are gathered and traded at generally destined for urban consumers. Forest also provide the row materials for artisan and processing activities. Forest products are traded in both local and urban markets and are sold to meet both rural and urban consumer needs. There are no studies which access the socio-economic importance of the no timber forest products trade to rural households and communities and there are also no studies which evaluate the importance of this trade to regional economics. There are few studies which focus on the income earned from gathering of the forest products. Thus the discussion focuses largely on marking.

The degree to which these different forest products are marked the depends on the needs for cash, the accessibility of markets, the quantity of product that are available for the collection and sale. Forest products are sometimes marked to meet specific cash needs. Sale is a predominantly seasonal activities, which is at its height during agricultural slack period, when less times is required for farming activity and the need for cash is high. Same researchers suggest that specific cash needs also helps determine the prices that are accepted or offered at different markets level.

- Examples of the forest products:
    - Firewood
    - Charcoal
    - Timber
    - Posts
    - Poles
    - Stakes
- Other forestproducts

    O Resin

O Gum

O Tannin

O Wax

O Latex

O Essential oils

O Tar

oFlavonoid

Topic 2. Estimation of expected forest production.

Accurate estimation of forest biomass size and regional distribution is a prerequisite in answering a long-standing debate on the role of forest vegetation in the regional and global carbon cycle. Appropriate biomass estimation methods and available forest data sources are two key factors for this purpose. Among the estimation methods, the continuous Biomass Expansion Factor ; defined as the ratio of all stand biomass to stem volume or biomass) method is considered to be the best.

Topic3. Estimation forest financial cost/expenses and income of the forest product

The financial income must be estimated by observing products and services that can be derived from the forest. Forest products are those tangible things that come from forest, while forest services are those intangible products that come from the forest.

Example: Kamonyi district would like to conduct the silvicultural practices in its forests such as clearing and thinning on **20ha** established on **2x2m** between trees. After three years of plantation, the district forest officer planned the complete clearing where one worker is tasked **400m²/day** and the cost of man day is **1000** Rwandan Francs.

During 30 years go **20,000** poles have been removed for thinning ,the team of **5** persons were removing 10 poles per day, with **1000** Rwandan Francs of expenses for one worker and the value produced for one pole equals to **10000** Rwandan Francs after **25 years** ,the forest covered **10000m³** and the cost of one stere was **10000** Rwandan francs.

Other expenses of forest guards are **10,000,000** Rwandan francs.

Note: In this example you can calculate the **cost** of clearing and thinning,

The **benefits** from poles and steres, the **expenses** and then **income** from this forest.

LO 3.1– Establish forest management objectives

Topic 1.Objectif formulation

The objectives are expressed in measurable units. Objectives can be thought of as specific target for obtaining the goals .for example suppose one of your goal is generate income from harvested timber. An objective of this goal might be to generate an average of 100000Rfrs per year over the next ten years. Determining your goals and objectives is the most important step to forest management planning .Your goals and objectives shape the management of your forest and thus also shape of your management plan.

objectives are predictive statements describing the specific outcomes that a forester is intended to achieve; they are a benchmark by which to measure progress towards the achievement of larger goal.

A. General objectives:

To meet the people 'need for fire wood , timber, and other forest products and contribute to food production in effective interaction between forestry and farming practices.

- To conserve the ecosystems and genetic resources.
- **Specific: What is to be done** in terms of observable aspects of what the forester will be able to do
- **Measurable:** can be observed or counted during or after the the implem*entation*
- **Achievable/Attainable/Action oriented**: It is about the feasibility of the task minding about the resources, and time frame it may take to achieve the objective. (Is the task feasible?)
- **Realistic/Reasonable/Relevant: (**Are the sufficient resources available?)**,** Is the objective aligned with the implementation plan?
- **Time-bound/ Time-restricted**:is appropriate to the time and scope. can be achieved by the end of management activities?

B. Specific objective: Harvest 30 acre of mature pine timber by sealed bid sale thought a forest consultant in 15 years.

Topic 2.Hypothesis formulation.

Hypothesis are testable explanations of a problem, phenomenon or observation that can be tested by further investigation. Both quantitative and qualitative research involves formulating a hypothesis to address the research problem. Hypothesis that suggests a causal relationship involves at least one independent variable and at least one dependent variable.

The common forms of hypothesis are: simple, complex, alterative etc

Eg: Refusing the silvicultural operations in plantation of pines leads to harvest poor quality of timbers.

LO 3.2 – Conduct forest inventory and resources

Topic 1. Identification of tools and materials

Topofil	Rope
Diameter tape	Ranging pole
Chainsaw	Bark gauge
Blume Leis	Axe
Compass	Pens
Dendrometers	Forest map
GPS	Handbook
Caliper	Calculator
Haga	Computer
Relascope	Communication tools
Panga	Transport means
Markers	PPE
Dendrometer	Laser

Topic 2. Labor and personal recruitment

For labor and personal recruitment must focus on reading and writing in order to facilitate forest inventory activities and must vary according to the function and intensity of work.

Topic3. Sampling of forest stand

Introduction to forest inventory

Protection and rational utilization of natural resources become more and more important in order to meet the increasing demand for raw wood material and agricultural crops. Among the resources, forests are important not only as a source of wood but as the means of protecting the hills thereby regulating stream flow, and reducing the rate of soil erosion, among many others. Maximum advantages and benefits from forests can only be secured provided that the existing forests are properly managed. Sound forest management depends on the quantity and quality of information available on the forest. Basic data and information is required if a renewable natural resource such as forest is to be managed in a reasonable and sustainable manner. This information is obtained from forest inventories.

Forest inventory is described/defined in different forms by different authors, but essentially with more or less the same meaning.

Forest inventory: is the activity of data collection that helps generating the required information base on the forest resource within an area of interest. Forest inventory: is a tool that provides the information about size and shape of the area as well as qualitative and/or quantitative information of the growing stock.

Forest inventory: is the tabulated, reliable and satisfactory tree information, related to the required units of assessment in hierarchical order. It is an attempt to describe quantity, quality, and diameter distribution of forest trees and many characteristics of land upon which trees are growing.

Types of forest inventory:

- ✓ **Complete enumeration:** Is often not feasible or prohibitively or prohibitively expensive , but may be justified for specific objectives such as the sale of variable timber for final harvest, this type of forest inventory consist to measure each stem /tree one by one until all surface.
- ✓ **Forest inventory by sampling** : It consist to divide the forest into small part called sample plots.

Other types of forest inventory are: Operational inventory ,Management inventory, Reconnaissance inventory.

A. Sampling the forest

A.1. Sample form

In forest invent inventory three forms are generally used such as square, rectangular and circular but the most preferred in current practices is circular for its following advantages:

1. Reduce the number of trees within plot
2. This form is easy than the rest of others two
3. It is easy to define

A.2. Sample size

The sample size determination is the act of choosing the number of observation to include in statistical sample.

Factors influencing sample size

1. The density of stand for inventory
2. The shape of sample plot
3. Location of the land
4. Means
5. Time in which inventory is supposed to be accomplished
6. Precision required

A.3.Sampling rate

During forest inventory the whole forest is sampled but all samples are not supposed to be considered for economic and task minimization related issues, for this some sample out a hundred samples are considered for data collection.

B.Sampling techniques

They are three common methods or techniques of sampling which are random sampling, systematic sampling and stratified sampling.

Key terms

Population:In statistics, a population is a complete set of items that share at least one property in common that is the subject of a statistical analysis.

Sample:A subset containing the characteristics of a larger population. Samples are used in statistical testing when population sizes are too large for the test to include all possible members or observations. A sample should represent the whole population and not reflect bias toward a specific attribute.

a statistical sample is a subset drawn from the population to represent the population in a statistical analysis. If a sample is chosen properly, characteristics of the entire population that the sample is drawn from can be inferred from corresponding characteristics of the sample.

B.1. Random sampling

Is a sampling method in which all members of a group (population or universe) have an equal and independent chance of being selected.

B.2. Systematic sampling

A method of choosing a random sample from among a larger population. The process of systematic sampling typically involves first selecting a fixed starting point in the larger population and then obtaining subsequent observations by using a constant interval between samples taken. Hence, if the total population was 1,000, a random systematic sampling of 100 data points within that population would involve observing every 10th data point.

B.3. Stratified sampling

The process of dividing a population into smaller subsets for sampling purposes. In statistics, stratified sampling is a method of sampling from a population.

In statistical surveys, when subpopulations within an overall population vary, it is advantageous to sample each subpopulation (stratum) independently. Stratification is the process of dividing members of the population into homogeneous subgroups before sampling. The strata should be mutually exclusive: every element in the population must be assigned to only one stratum. The strata should also be collectively exhaustive: no population element can be excluded. Then simple random sampling or systematic sampling is applied within each stratum. This often improves the representativeness of the sample by reducing sampling error.

C. Safety and first Aid instructions.

1.The employers must provide training to their employees prior to any task.

2. Each employer must instruct new employees in safe practice.

3. The employers must provide PPE to employees to ensure their safety.

4. Employees have a right to refuse to undertake work that they consider likely to result in serious harm.

5. Employees must report all injuries to his employers or supervisors without delay and regardless the nature of injuries for getting emergence cares.

6. A meal break

7. A daily or nightly sleep period

8. Provision of first AID kit nearby by the employer

- Topic 4.Selection of mature trees

As trees become older and grow taller, they increase their relative fitness to competing trees or to other life forms. The general characteristics of mature trees are diameter and height.

- Topic 5. Collect the data

Trees parameters: There are three basic parameters commonly measured to characterize the size of single trunk tree which are: height, diameter. circumference, basal area, crown surface.

Stand revolution:is a period where forest or stand have harvested and replaced by the same species(reconversion) or other species (conversion).

Filling format of data record: Before understanding the design of any recording document, attention should be drawn to the specific data to be recorded. Keeping in mind the simple rule that result to be obtained by means of data processing can never be better or more reliable than the basic input data itself ,a determined effort should be made to improve the quality of the data to be recorded .

- Topic 6. Estimation of forest volume.

A. Total volume of stand: The volume of the selected tree is then determined and the stand volume estimated by inflating the sample tree volume by the number of trees in the stand.

$V = v * N$

stand volume = G x h x Stand FF.

Huber's formula: $V=\pi xh/4\ xdm^2$

Smalian'sformula :$V=\pi xh/8\ (do^2+df^2)$

Newton's formula: $V=\pi xh/24\ x\{do^2+df^2+(4xd^2m)\}$

B. <u>Estimate stand basal area</u> (G in m^2/ha) using angle-count sampling or other simple technique.

C.**<u>Mean height</u>.** The arithmetic mean of the height of all trees in the stand is a useful measure of stand height in even-aged stands. In small stands, the height of every tree could be measured, added together and divided by the total number of trees to derive the mean height.

C.1. Direct method:

It involves climbing or using height measuring rods. It is rarely used and only for small trees.

C.2. Indirect method:

- ✓ Using geometric principle
- ✓ Using trigonometric principle

Method using geometric principle

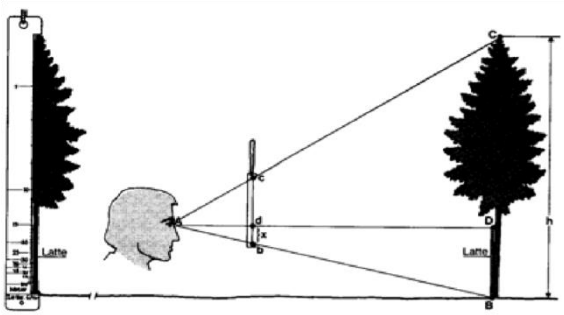
A christen hypsometer or ruler of a certain length (30cm for example) and a pole of constant length/height used to estimate/measure tree height.

Technique:

Place a pole of known length at upright position against the tree to be measured. Hold ruler (of known length) vertically and parallel to the tree to be measured.

Find the sighting position by moving back and forth and/or right and left so that the top of the ruler exactly aligned with the tip of the tree and the bottom of the ruler with the base of the tree.

Take ruler reading in line with the top of the pole. Then apply the following formula.



(Tree height measurement technique by geometric principles)

ΔABC ≅ ΔAbc

(BD/BC) ≅ (bd/bc); (bc/BC) = (bd/BD)

Tree height (BC) = Known ruler length (bc) X Known length of pole (BD)

Ruler reading on the pole (bd)

Advantages:

+ No distance measurement is required

+ Height reading is not influenced by slope

Drawbacks:

- In dense forest it is difficult to find suitable point of observation - Only with a steady hand can serious misreading be avoided.

Methods employing trigonometric principles

The followings are some of the instruments used to measure tree height based on trigonometric principles.

Suunto hypsometer

Silva hypsometer

Haga altimeter

Blume-leiss

Sunto clinometers: measure inclination angle in degree or percent

General steps (for the first 4 instruments mentioned above)

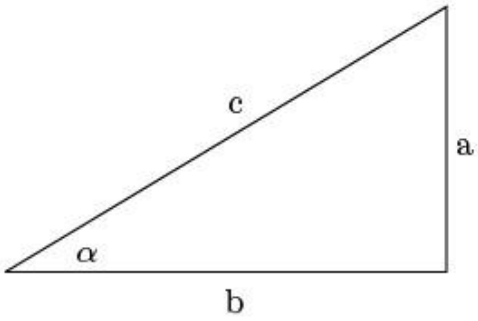
Stand at a fixed horizontal distance from the base of the tree (usually 10, 15, 20, 25 meters, and so on)

Sight at the top of the tree and read the value ‘A’ (top reading)

Again sight at the bottom of the tree and read the value ‘B’ (bottom reading)

Then the total height of the tree is top reading ‘A’ minus bottom reading ‘B’

Bottom reading +ve or –ve (above and below eye level)

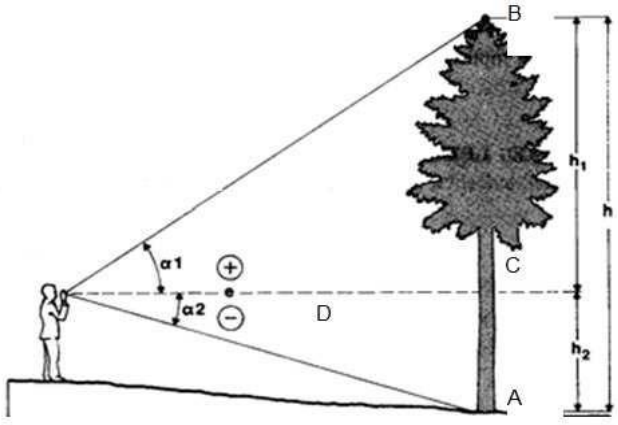


Sin α = opposite / hypotenuse; (a/c)

Cos α = adjacent / hypotenuse; (b/c)

Tan α = opposite / adjacent; (a/b)

Case 1: If the observer is on a flat terrain



(Tree height measurement on a flat terrain.)

Tan α1 = BC / D BC = tan α1. D tan α2 = AC / D AC = tan α2. D

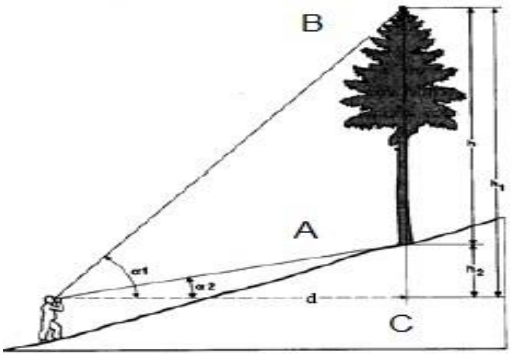
AB (height) = BC + AC

AB = tan α1. D + tan α2. D AB = D (tan α1 + tan α2)

Case 2: upslope

AB = BC - AC
AB = tan α1. D - Tan α2. D

AB = D (tan α1 - tan α2)



(Tree height measurement on uphill terrain)

Case 3: down slope,

When the tree base is below the eye level of the observer

AB = AC + BC

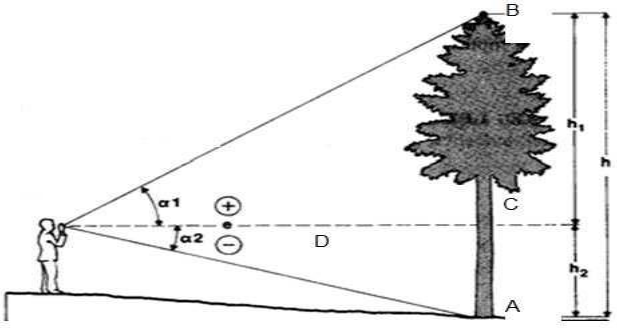
AB = tan α1. D + tan α2. D

AB = D (tan α1 + tan α2)

Clinometer method

It follows the same principles as above, but in this case we measure/read the inclination angle and then calculate height after knowing the horizontal distance between the observer and the tree.

(Tree height measurement using clinometers)



- If measured in percent:

Ht = $\frac{(TR - BR)}{100}$ x D

D. Conversion method: relating to convert the volume into steres where o.75 in mainly used Or if measured in degree: H = D (tan α1 +/- tan α2)

LO 3.3 – Establishment of forest schedule activities and forest operational plan

Topic 1. Chronology of forest management activity

Your management plan should include specific activities that will be conducted to help meet your objectives. The timing of activities should be as specific as possible and should reflect your management priorities. In general, activities for the next 10-20 years should be discussed in detail. Longer term plans may be mentioned but probably will remain vague. The planning process is ongoing; expect to plan again in about 10 years, or sooner if the property experiences significant changes.

Example:

Activities	Period
Reforest bear spaces areas	15/04-15/05/ 2020
Old forest stand reconversion/conversion	15/6 -30/11/2035
Soil erosion control in forestry	01/12 -30/12/2035
Establish Silvicultural treatments schedule	02/01/2036 – 03/01/2036
New plantation	10/04 -10/05 /2036
Forest guard strengthening	10/05/2036

Topic 2. Repartition of the forest.

- ✓ **Repartition according to the species**, the forest can be composed by one species or many species(pure or mixed)
- ✓ **Repartition according to the regime**: it can be full growth, or coppices or coppices under full growth.
- ✓ **Repartition according to the development stages**. Where forest is divided into stages of growing .eg: cover , low perch .recruit, etc
- ✓ **Repartition according to property:** it can be private, state, or district forest

Topic3 . Elaborate forest management recommendations

1. Encourage the interaction and collaboration of the different forest owners and strengthen the network of stakeholders involved in forest protection and everyday risk and crisis management

2. Encourage the development of forest-sector businesses and activities

3. Get local councillors involved in forest protection

4. Consolidate and improve perceptions about risk within the whole.

5. Adapt and simplify legislation

6. Develop regional decision support tools related to multi risks for forest owners so that they can integrate risks into their forest management more easily.

7. Apply common protection measures to an area at risk8. Implement a system to assess the efficiency of the protection measures taken, independent of the risk management system

9. Develop lasting monitoring tools in order to raise the alarm and ensure that measures are taken ;monitor the development of hazards and adapt the protection methods to the degree of risk and to global change (see below) ; improve knowledge about risk.

10. Incorporate contingency plans into crisis management

11. Develop and make available knowledge and data related to risks in order to build up a reference data set.

12. Develop risk management training program within the educational sector related to forestry.

Learning Unit 4 – Elaborate monitoring and evaluation tools of the forest management plan implementation

LO 4.1 – Identify forest status baselines

Topic 1. Forest status base line parameters determination

- ✓ **Area:** Area-determinations and mapping are just a few of the many aspects of forestry requiring spatial information. The Forest Products Measurements group is responsible for determining the

methodology to correctly locate and determine the size of timber units. Sufficiently accurate areas are often required to calculate volume correctly or to determine area needs for forest management.(An area of forest for which an approved).

- ✓ **Density**. Tree density gives foresters an idea of how closely trees are growing in a given area. This value is always expressed as trees per hectare. The tree density is not an exact number of all of the trees in the region, but it serves as an estimate.

D = N/ha

- ✓ **Tree species:** In botany, a tree is a perennial plant with an elongated stem, or trunk, supporting branches and leaves in most species. Rwanda harbours very diverse flora due to a considerable geo-diversity and a climatic gradient from west to east. The number of vascular plants is estimated at around 3000 species originating from the different bio-geographical regions (Fischer and Killmann 2008).

Rwanda constitutes the eastern limit for plants from the Guineo-Congolian region. An example of these tree species are:

Local nameScietific names

Amapera *Psidium guajava*

Avoka Persea gratissima

Calliandra Calliandracalothyrus

Cassiya Callitrissp

Cassiya Cassia spectabilis

Umubunda Casuarina cunninghamia

Gereverya Grevillea robusta

Igifenesi Artocarpus

Icyayi Camellia thea

Ikawa Coffee Arabica

Itunda Cyphomandrabetacea

Indimu Citrus Lemon

Ipapaya Carica papaya

Jacaranda Jacarandamimosifolia

Itenderwa/umukunde CajanusCajan c, indicus

Umunoferiya Eriobotrya japonica

Umutimaw'imfizi Annona reticulate

Umwembe Mangiferaindica

Indigenous Tree

Local name scientific name

Akaziraruguma Begonia meyerijohanni

Amadwedwe Euphorbia grantii

Bambuwa Coryza sumatrensis

Barakatsi Acacia tree

Bugangabukare Hygrophilaauriculata

Iboberi Morus alba

Icyicamahirwe Tithniasp

Icyuyuyu PavoniaUrens

Icyumwa Trichodesmazeylanicum

Idaforoma Vinca rosea

Idoma Vernonia aenulans

Igicumucumu Botrioclineugandensis

Igicunshu Coleus kilimandschari

Igihungeri Protea madiensis

Igitenetene *Kalanchoe sp*

Ikinyondonyondo *Kalanchoe sp*

EXAMPLE OF FORESTRY TREE SPECIES.

Species (specific name) **Common name**

Cupressus lusitanica Chrismas tree

Callitrisrobusta Cypress pines

Pinus patula *Pine*

Pinus oocarpa *Pine*

Pinus caribaea *Caribbean pine*

Eucalyptus robusta *Eucalyptus*

Ecalyptussalgna *Eucalyptus*

Ecalyptusmaidenii *Eucalyptus*

- ✓ **Forest establishment date**

In Rwanda, planting should be done during the short rainy season (October-November) and long rainy season (March –April-May). There is no restriction about the planting time during cloudy days but the best time is before noon on sunny days.

- ✓ **Soil characteristics:** The scientific study of soil is called Pedology. Soils are a composition of mineral particles 45% , organic matter 5% , air 25% , and water 25% . Brown earths are fertile and very suitable for agriculture. Their suitability for agriculture are due to their characteristics of good **texture**, dark colour, and ph value

- ✓ **Vegetations:**

Vegetation regions can be divided into five major types: forest, grassland, tundra, desert, and ice sheet. Climate, soil, the ability of soil to hold water, and the slope, or angle, of the land all determine what **types** of plants will grow in a particular region.

Topic 2. Establishment of base line format

A baseline format is a document that presents the baseline that will be used or considered for a particular project so that objective, organized, and well-detailed planning can be made. This can help the execution of work processes become properly guided. Through the identification of baselines and their relevance and correlation with the project management plan, it will be easier and more efficient to evaluate the outputs within each area of the project where the document will be used

LO 4.2 – Establish forest management plan logframe

Topic 1. Setting of monitoring and evaluation indicators.

Effective monitoring is essential for sustainable forest management . An important distinction exists between monitoring and auditing, which are complementary components of a monitoring system. Monitoring can be defined as the ongoing assessment of the technical, environmental and social performance and impacts of management.

The following may be helpful in keeping monitoring costs under control and achieving understandable results:

Keep monitoring focused on forest management – that is, on what you really need to know.

Whenever possible,

- ✓ use simple and cheap methods.
- ✓ Use resources already available in the company or organization.

Wherever appropriate, use easily applied indirect approaches. Criteria and indicators are tools for defining, guiding, monitoring and assessing progress towards forest managementin a given context. The overall aim of C&I is to promote forest management, taking into consideration the social, economic, environmental, cultural and spiritual needs of stakeholders. Criteria are categories of conditions or processes by which forest management can be assessed, and each criterion is characterized by a set of indicators that can be monitored to assess change over time.

Indicators are signs of progress – they are used to determine whether the program /intervention is on its way to achieving its objectives and goal

Types of Indicators

Indicators can be classified as follows:

1. Quantitative Indicators (Output Indicators)
2. Qualitative Indicators (Outcome / Performance Indicators

A. **Planned activities**: A forest management plan defines the planned forestry activities (e.g. inventory, yield calculation, harvesting, silviculture, protection and monitoring), specifying objectives, actions and control arrangements in a forest area.

B.Objectives: It aims at determining whether or not the intended project goals and objectives are being on the track. Forest management monitoring can also be defined as the ongoing process by which management gets regular feedback on the progress being made towards achieving the goals and objectives of the management plan.

C. The assumption: Assumption is "A factor in planning process that is considered to be true, real or certain often without any proof or demonstration". Another definition could be "The forest management Assumptions are events or circumstances that are expected to occur during the managementlife-cycle.Eg ,In Rwanda July and August is dry season reserved to the silvicultural operations in forest.

D. **Financial means**: Financial monitoring of the managements concerns comparing the actual costs to the planned costs in the management budget. Financial report reflects the actual activities carried out. In other words, it tells how much money was spent in the actual activities.

Topic 2.Scheduling monitoring and evaluation activities

Monitoring &Evaluation is a process of continual gathering of information and assessment of it in order to determine whether progress is being made towards pre-specified goals and objectives, and to highlight whether there are any unintended (positive or negative) effects from a forest management plan and its activities. It is an integral part of the project cycle and of good management practice.

A. Monitoring is the continuous collection of data on specified indicators to assess for a development intervention (project, programme or policy) its implementation in relation to activity schedules and expenditure of allocated funds, and its progress and achievements in relation to its objectives.

B. Evaluation is the periodic assessment of the design, implementation, outcomes and impact of a development intervention. It should assess the relevance and achievement of objectives, implementation performance in terms of effectiveness and efficiency, and the nature, distribution and sustainability of impacts.

Topic3. Elaboration of reporting and follow up forms of monitoring and evaluation.

The purpose of a monitoring visit (sometimes called a supervision visit or a field visit) is to make sure that project activities are implemented the way they are described in the plan. It normally involves meeting with the people running the project, meeting with the participants, and observing the activities.
At the end of a monitoring visit, it is important to prepare a report that describes what you found. These reports will document any discrepancies between the plan and actual implementation, as well as improvements made by the project team

- ✓ **Evaluation report :**An evaluation report, in the simplest sense, is a document which **reports** the results, findings, interpretations, conclusions, or recommendations derived through an evaluation. An evaluation report primarily gives an executive summary of the points covered by the evaluation

A. Introduction

The purpose of the forest management report is to evaluate the impact of silvicultural operations to the tree growth. He can explain what the program entails and that he will be evaluating it.

B. Background information

David will want to make sure that everyone who reads her report has all the background information necessary to understand it. Here, she might want to include information about tree species ,location ,soil nature and climate conditions.

C. Criteria

David will also want to make clear the way he's evaluating the program. Cost will certainly be a factor for her evaluation, but so will how is the size forest area to be managed during the program. Further, total clearing and systematic thinning will be used. These, two techniques might be criteria against which David evaluates the program.

He'll just explain each criterion that she will use to evaluate the program.

D. Evaluation

After explaining each criterion with which David is evaluating the program, she will want to explain how the program meets the criteria. In this section,He will want to include a subsection for each criterion and

how the program meets, or does not meet, that requirement. For example, in the subsection on clearing where total clearing and systematic thinning will be used, He can talk about total clearing and how operate systematic thinning and clearing.

E. Conclusions

In the conclusions section, Shondra will summarize how the program has lived up to its evaluation, or hasn't lived up to it. She might, for example, say that, even though the senior ride program costs the city a considerable amount of money, many seniors take advantage of it, which has led to a decrease in traffic accidents caused by older drivers and an increase in senior participation in town events.

Shondra might choose to create a summary table in this section with each criterion and how the program did for that criterion. That makes a nice, visual way to present information about the evaluation.

F. Recommendation

By this point, Shondra's opinion of the program should be pretty clear. But this is the section where she recommends that the program continue or not. Before this, she's evaluated it, but now she applies that evaluation. Based on her evaluation, for example, she might recommend that the city keep the program, even though it costs money.

LO 4.3 – Elaborate forest management contingency plan

Topic 1.Identification of risks and assumption

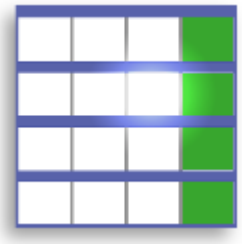
A. Identifying risks and assumptions

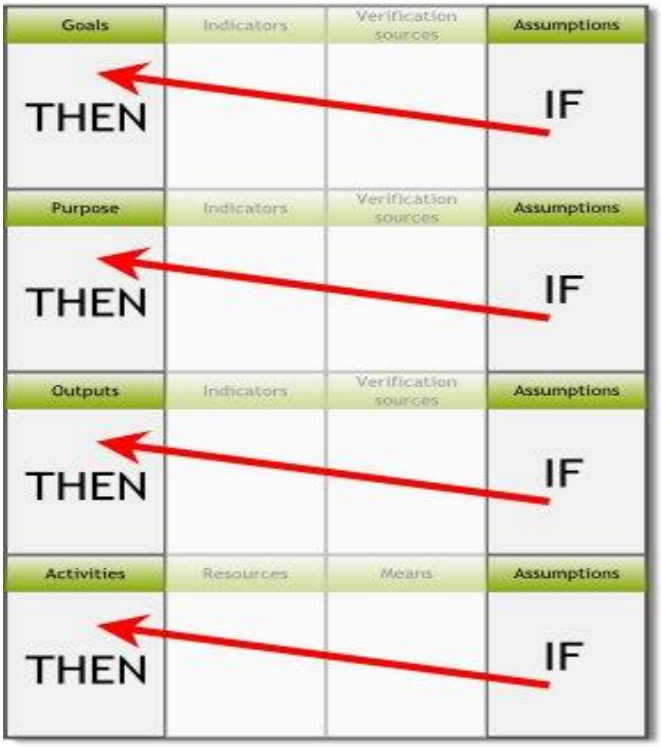
When you’re planning a project, you tend to be optimistic about its progress. You envisage what you have to do and to what beautiful results this will lead. You don’t want to think about all the nasty things that can happen.

But there are many things that can go wrong. The logframe helps you identify these risks and the assumptions that you make at each stage and level. This is the role of the fourth column.

The assumptions describe the situations, events, conditions or decisions which are necessary for the success of the project, but which are largely or completely beyond the control of the project's management.

The fourth column and the first column have an if… then… relation. If the assumptions in column four are met, or if the risks do not occur, then we'll achieve what we've set out to do in column one.





So starting at the bottom:

- If the basic assumptions (row 4) hold true ⇒ then we can do the activities as planned
- If we can do the activities and the assumptions of row 3hold true ⇒ then we will get the output (results) that we expected
- If we get all these results (outputs) and the assumptions of row 2hold true ⇒ then we will realise the project's purpose
- If the purpose is achieved and the assumptions of row 1hold true ⇒ then we will contribute to the goals.

Identifying the risks and assumptions may seem easy, but there is more to it than meets the eye.
The Results Based Management approach puts a lot of attention to this aspect, so check it out if you want more information.

When you've identified the possible risks, you have to assess what the probability is that each risk occurs:

- If the risk is very likely to occur and the impact on the project is grave (it is doubtful you can achieve the project), then you have to redesign your project to eliminate or significantly reduce this risk. If this is not possible you should really think again about doing the project.
- If the risk is likely to occur and the impact is important, but not life threatening, you should include it in the log frame and monitor the risk. If possible, you should try to influence the risk.
- If the impact of the risk is low, you shouldn't include it into the log frame.

Like indicators, assumptions have to be verifiable. Don't invent problems in your head.

a**) Natural risks**: Natural hazards are naturally occurring physical phenomena caused either by rapid or slow onset events which can be geophysical (earthquakes, landslides, tsunamis and volcanic activity), hydrological (avalanches and floods), climatological (extreme temperatures, drought and wildfires), meteorological (cyclones and storms/wave surges) or biological (disease epidemics and insect/animal plagues).
b)**Technological or man-made hazards** (complex emergencies/conflicts, famine, displaced populations, industrial accidents and transport accidents) are events that are caused by humans and occur in or close to human settlements. This can include environmental degradation, pollution and accidents.Technological or man-made hazards (complex emergencies/conflicts, famine, displaced populations, industrial accidents and transport accidents)
There are a range of challenges, such as climate change, unplanned-urbanization, under-development/poverty as well as the threat of pandemics, that will shape humanitarian assistance in the future. These aggravating factors will result in increased frequency, complexity and severity of disasters.

Topic 2. Assumption analysis

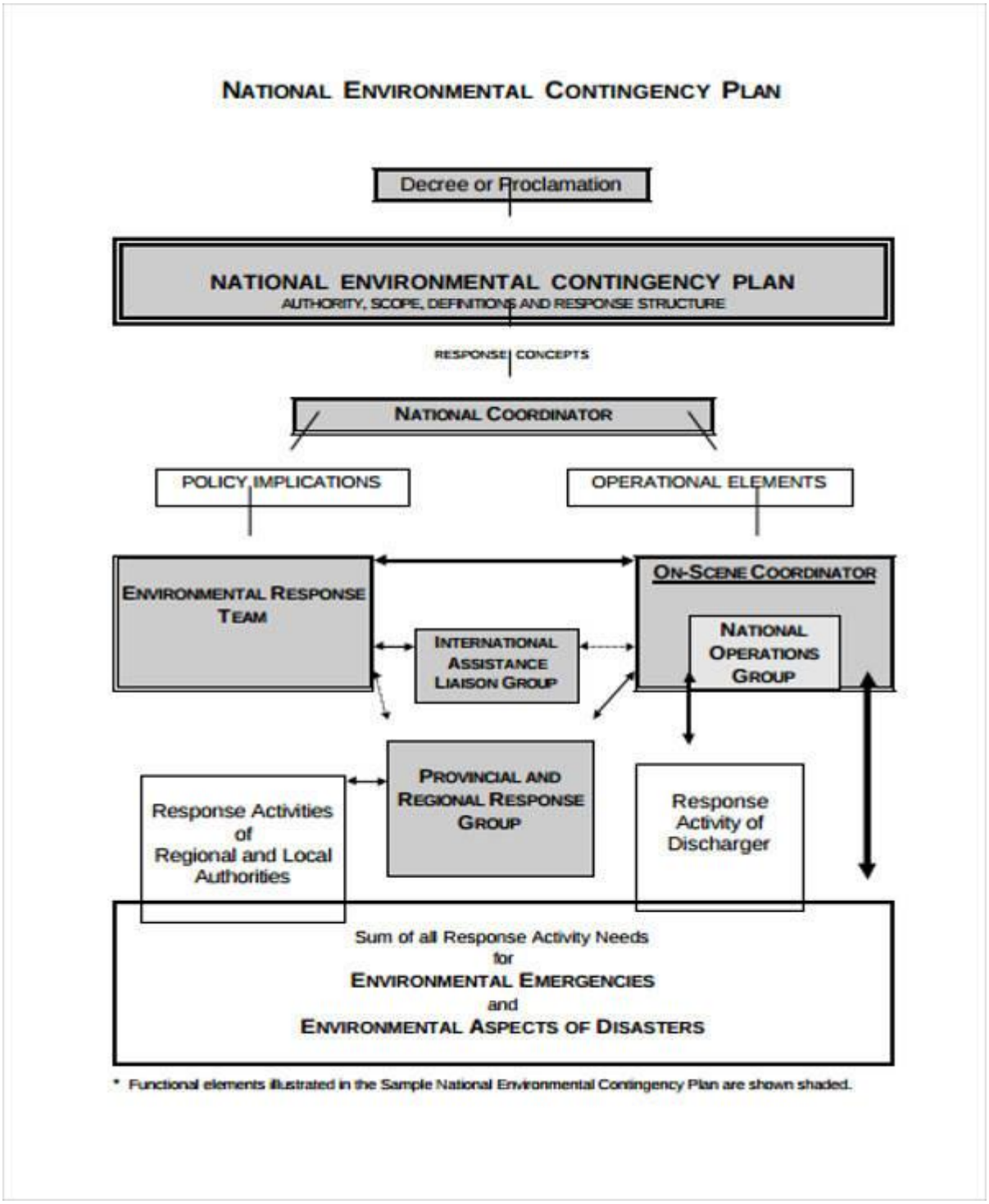
Definition. Assumptions analysis refers to a specific technique that is used by project team members to minimize risks involved in making assumptions during the process of planning a particular project. The process in which this analysis takes place is fairly straightforward, yet is essential to minimizing risk.

Assumptions Activity Introduction: As we begin the process of understanding the concepts of valuing and managing diversity, we must spend time exploring our own biases and stereotypes that we carry as individuals. When we spend time thinking about how quickly we determine whether or not we will allow

ourselves to have a working relationship with another person, we realize that we make up our minds very quickly.

- ✓ **Assumption activity:** As we begin the process of understanding the concepts of valuing and managing diversity, we must spend time exploring our own biases and stereotypes that we carry as individuals. When we spend time thinking about how quickly we determine whether or not we will allow ourselves to have a working relationship with another person, we realize that we make up our minds very quickly. This exercise demonstrates just how quickly we make a decision about another person and what that person represents

Topic3.Elaborate of contingency format



2.7.19. Contingency Planning, For Immediate Action, Matrix

CONTINGENCY PLANNING:

4. For immediate action

Region..... District.....

ISSUE	... in the Current Situation		FOR IMMEDIATE ACTION	
	Immediate	Resources	at Regional level	at National level
Population And Society				
Environment				
Production & Economy				
Infrastructure & Services				

2.7.19. Contingency Planning, For Immediate Action, Matrix

CONTINGENCY PLANNING:

4. For immediate action

Region..... District.....

ISSUE	... in the Current Situation		FOR IMMEDIATE ACTION	
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Reference(s):

- Sri. K. Jagatheesu (2005), Intermediate vocational course

- Evans J& J Turbull(2004),Plantation Forestry in the Tropics (3rdedn.)

- Jacovelli.PA.(2014),The future of plantation in Africa. International Forestry

Review vol.16(2);pp100-160)

- NAFA.(2011),EssenceLignese . Recommandees dans les plantation forestiere et agroforetiere au Rwanda

- F.Cailliez.(1992),Centre technique forestiertropical.vol1;pp(6-30).

- MINIRENA/RNRA.(2015),Tree plantation establishment and management

- Timor- Leste**(**2005),National Forestry policy.

- Ismailia(2012), Sustainable Forest management plan

- MURERÉREHE Sabin (2010),*Plan d'amenagement forestier du District de Gicumbi (PAFD)*

- DISTRICT DE GICUMBI(2007),*Plan de Développement du District de Gicumbi, Juillet 2007*

- PAREF/MINERENA(2009),*Termes de références pour l'Elaboration du Plan d'Aménagement Forestier du District de Gicumbi, Juillet 2009.*

- Pardé et Bouchon (1988),*Dendromètre*, *ENGREF, Nancy 1988.*

http://books.google.rw/books?id=d8edvVlgDDAC&pg=PA77&hl=fr&source=gbs_toc_r&cad=4#v=onepage&q&f=false