Course Code	**AGF1**
Course Title	**Fundamentals of Agroforestry**
Credit Hours	2 (1+1)
Full Marks	50
Theory (Marks)	25
Practical (Marks)	25

Objective(s) of the Course

Upon the completion of this course, the student will have basic knowledge on principles and practices of agro forestry systems.

Course Breakdown (Theory)

S.N.	Topics	LH
1	Concept of agro-forestry: Definition, importance and scope.	1
2	**Tree selection and improvements:**	
2.1	Role of trees in fulfilling the basic requirements of people.	1
2.2	Characteristic of tree for Agroforestry development and tree improvement.	1
3	**Agroforestry system (AFS)**	
3.1	Classification and over-view of Agroforestry System (AFS)	1
3.2	Agroforestry system in Nepal and similar agro-eco-zoning in the world	1
4	**Nature of Tree- crop interaction:**	
4.1	Factors and types on nature of tree- crop interaction	1
4.2	Quantifying the agro-forestry product.	1
5	**Soil management under Agroforestry System:**	
5.1	Approaches of soil-water conservation	1
5.2	Soil fertility management under Agroforestry system	1
6	**Designing Agroforestry System:**	
6.1	Conceptual framework for designing AFS	1
6.2	Factors affecting Agroforestry system	1
7	**Project development:**	
7.1	ICFAF's diagnosis and design	1
7.2	Diagnostic methods and tools used in AFS	1
8	**Management of trees in AFS**	
8.1	Management of tree in Agriculture	1
8.2	Agricultural and Silvicultural management in relation to crop	1
	Total	15

Course Breakdown (Practical)		
S.N.	**Topics**	**LH**
1	**Tree selection and identification for AFS at different area:**	
1.1	High hills	1
1.2	Mid Hills	1
1.3	Terai	1
2	Practice in contour farming system.	1
3	Preparation 'A'-frames and determines contour lines.	1
4	Layout of soil-water conservation systems.	1
5	**Nursery establishment for AFS:**	
5.1	Collection and identification of seeds of Agroforestry trees	1
5.2	Preparation of nursery bed for agro forestry trees.	1
5.3	Seed sowing of Agroforestry trees	1
6	Tree-clinic for AFS	1
7	Training and pruning for Agroforestry trees	1
8	Height and canopy measurement for selected Agroforestry trees	1
9	Different AFS development (SALT and Home garden)	1
10	Design and Establishment of Agroforestry farm at Far western University (FWU)	1
11	A visit to success story of Agroforestry projects at local level	1
	Total	15

Note: LH = Lecture Hours

Lecture 1 Concept of Agroforestry: Definition, Importance & Scope

Concept of Agroforestry

Agroforestry is an age old practice, indeed very old. The scientific principles of agroforestry are Farmers of the warmer parts especially have long tradition of growing food crops, trees and animals together for producing multiple range of products. Trees and forests in fact an integral part of the Indian culture.

More recently, however, the forest area has receded and resources have shrunk considerably. The people are no longer able to meet their requirements of firewood, fodder, timber, bamboo, etc. from the forest. Due to shortage of wood the prices of these commodities have, therefore, increased manifold. Many forest based industries have been facing problems in supply of raw material. Many farmers quite recently started planting trees on their farm lands to meet these shortages along with agriculture crop; thus from the concept of agroforestry it emerged out:

- Agroforestry is a collective name for land use systems involving trees combined with crops and/or animals on the same unit of land. Further it,
- combines production of multiple outputs with protection of production base
- places emphasis on the use of multiple indigenous trees and shrubs
- is particularly suitable for low-input conditions and fragile environments
- involves the interplay of sociocultural values more than in most other land-use systems
- is structurally and functionally more complex than monoculture

Definition

Agroforestry is any sustainable land-use system that maintainsor increases total yields by combining food crops (annuals)with tree crops (perennials) and/or livestock on the same unitof land, either alternately or at the same time, usingmanagement practices that suit the social and culturalcharacteristics of the local people and the economic andecological conditions of the area.

Agroforestry is relatively new name of for set of old land use practices. Many definitions have been proposed world-wide. However it has now become an accepted land use system. Some of the definitions given by different workers are as follows:

- ICRAF's current definition is a collective name for land-use systems and practices in which woody perennials are deliberately integrated with crops and/or animals on the same land-management unit.

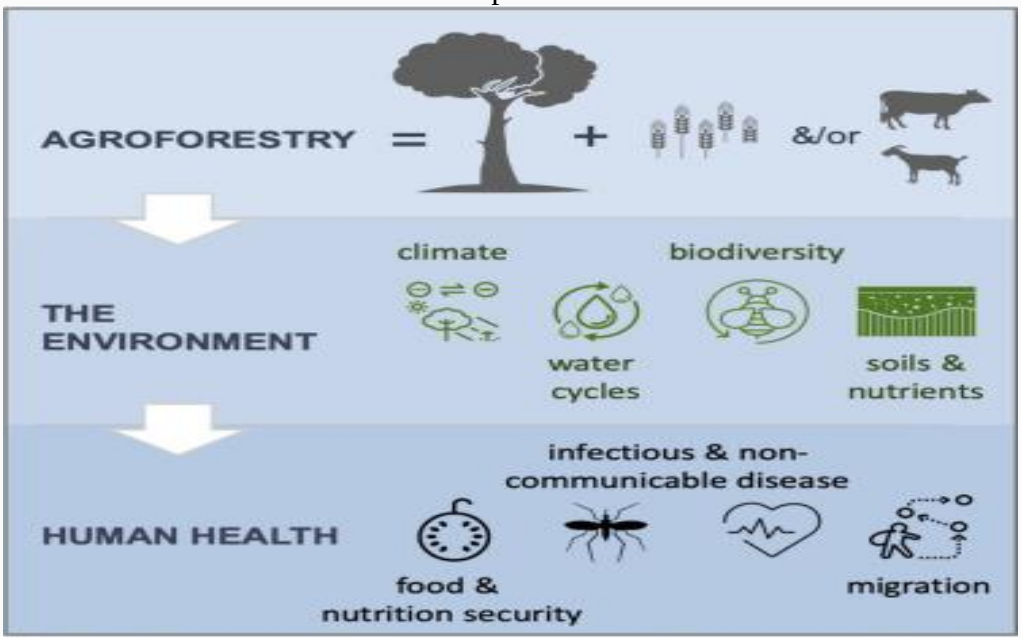
- Agroforestry is a collective name for land use systems involving trees combined with crops and/or animals on the same unit of land. Further it, combines production of multiple outputs with protection of production base. Places emphasis on the use of multiple indigenous trees and shrubs.

- Bene et al. (1977) defined agroforestry as a sustainable management system for land that increases overall production, combines agriculture crops, forest plants and tree crop and/or animals simultaneously or sequentially and applies management practices that are compatible with the cultural patterns of a local population.

- King and Chandler (1978): "Agroforestry is a sustainable land management system which increases the overall yield of the land, combines the production of crops (including tree crops) and forest plants and/or animals simultaneously or sequentially, on the same unit of land and applies management practices that are compatible with the cultural practices of the local population.

- Nair (1979) defines agroforestry as a land use system that integrates trees, crops and animals in a way that is scientifically sound, ecologically desirable, practically feasible and socially acceptable to the farmers.

- According to Lundgren and Raintree (1982), agroforestry is a collective name for land use systems and technologies, where woody perennials (trees, shrubs, palm bamboos, etc.) are deliberately used in the same piece of land management units as agriculture crops and/or animals in some form of spatial arrangement or temporal sequence. In agroforestry systems, there are both ecological and economical interactions between the different components.



Agroforestry was formally outlined in the early 20th century by American economic geographer **J. Russell Smith** in his book Tree Crops: A Permanent Agriculture (1929). Smith viewed tree-based "permanent agriculture" as a solution to the destructive erosion that often followed the cultivation of sloping lands.

There are three main types of agroforestry systems:
1 Agrisilvicultural systems are a combination ~~of crops and trees,~~ such as alley cropping or homegardens.
2 Silvopastoral systems combine forestry and grazing of domesticated animals on pastures, rangelands or on-farm.
3 Agrosylvopastoral The three elements, namely trees, animals and crops, can be integrated in what are called **agrosylvopastoral** systems and are illustrated by homegardens involving animals as well as scattered trees on croplands used for grazing after harvests.

Scope of Agroforestry

Agroforestry has vast scope in meeting this requirement throughmultipurpose tree species as:

- Provides main source of energy (fuel).
- Provides raw material (food) for human consumption
- Provides forage fodder for animal.
- Provides raw material for the cottage industries.
- Provides raw material for the shelter.
- High demand
- This system permits the growing suitable tree species in the fieldwhere most annual crops are growing well.
- By growing trees and crops on Agricultural or forest land resourcesare utilized efficiently.
- Large area is available in the form of farm boundaries, bunds, waste lands where this system can be adopted.
- System has potential generate employment.
- Provides raw material for the cottage industries.
- Helps in maintaining ecological balance.
- Soil and water conservation, soil improvement
- Easily earn cash money.
- Provide fresh O2
- Maintain temperature
- Help to high agriculture productivity
- Help to urbanization & industrialization

Importance of Agroforestry

1. Improved nutrition and food security

Planting trees in agricultural lands can help increase food production and boost food security.Agroforestry helps in health and nutrition improvement due to increased diversity and quality of food outputs.

2. More benefits from Trees

Planting trees, as part of agroforestry practice, can be beneficial for the health and survival of humans, animals, and crops.Trees can block strong winds, protecting crops from damage.

Combining proper tree species and responsive crops can lead to improved yields.

3. Creation of resilient livelihoods

Growing trees together with crops and animals can help reduce the vulnerabilities associated with agricultural production and even improve the recovery after natural disasters, hazards, or socioeconomicdownturns.

4. Climate change mitigation and adaptation

Growing trees in agricultural systems can reduce the impact of climate change on agriculture.Sourcing tree products from trees grown on farms reduces the need to cut trees and hence reduce the rate of deforestation that is quickly getting rid of the planet's carbon sinks while releasing stored carbon into the environment. Agroforestry plays a critical role in improving climatic conditions and weather patterns by modifying microclimatic conditions such as temperature and water vapor content of air and wind speed, resulting in beneficial effects on crop growth and animal welfare.

5. Environmental benefits

Careful planning and integration of agroforestry can help protect the natural resources in the environment. For example, growing trees can help improve the quality of water and its quantity by filtering and capturing of water resources.Trees also support biodiversity by providing a suitable environment for insects, animals, and plants. If trees with nitrogen-fixation function are part of the system, agroforestry can help restore soil fertility.

6. Support local communities and cultures

Agroforestry is designed to help local communities and cultures thrive.

With the help of agroforestry specialists, indigenous people and local communities can continue with the local beliefs and culture while ensuring long term sustainability of the traditional systems.

7. Can reduce poverty in some areas if practiced sustainably

Trees and tree products have economic value that can get agro foresters a source of livelihood and potentially reduce their poverty levels, especially in developing or emerging economies. The value addition of newly-produced tree products can be a source of employment and income for individuals. It is also worth noting that growing trees can help reduce the production costs resulting in increased household income. In addition to increment in outputs of food, fodder, fuelwood, and timber, agroforestry systems also help in the reduction in incidences of total crop failure, which is common in monoculture and single cropping systems.

Benefits of agroforestry

A) Environmental benefits

i) Reduction of pressure on forest

(ii) More efficient recycling of nutrients by deep-rooted trees on the site

(iii) Better protection of ecological systems

iv) Reduction of surface run-off, nutrient leaching and soil erosion through impeding effect of tree roots and stems on these processes

v) Improvement of microclimate, such as lowering of soil surface temperature and reduction of reduction of evaporation of soil moisture through a combination of mulching and shading vi) Increment in soil nutrients through addition and decomposition of litter-fall.

(vii) Improvement of soil structure through the constant addition of organic matter from decomposed litter.

B) Economic benefits

(i) Increment in an outputs of food, fuel wood , fodder, fertilizer and timber;

ii) Reduction in incidence of total crop failure,which is common to single- cropping or monoculture systems

iii) Increase in levels of farm income due to improved and sustained productivity

C) Social benefits

(i) Improvement in rural living standards from sustained employment and higher income

ii) Improvement in nutrition and health due to increased quality and diversity of food outputs iii) Stabilization and improvement of communities through elimination of the need to shift sites of farm activities.

Benefits of Agroforestry

A Immediate Benefits

1 Protective benefit

2 Minimization of surface runoff
3 Minimization of nutrient loss
4 Minimization of evaporation

B Ameliorative Benefits
1 Improvement of Nutrient status
2 Improvement soil organic matter
3 Improvement soil pH
4 Improvement soil structure
5 Improvement pest & diseases control
6 Reduction of Soil temperature

C Long terms benefits
1 Increase crop productivity
2 Sustainable food production
3 Improve socioeconomic status
4 Improve duration of health
5 Stabilized land use policy
6 Conservation of Biodiversity

Principles of agroforestry

- Help eradicate hunger through basic systems of pro-poor food production in disadvantaged areas based on agroforestry methods of soil fertility replenishment and land regeneration
- Reduce rural poverty through market-driven, locally led tree cultivation systems that generate income and build assets
- Advance the health and nutrition of the rural poor through agroforestry systems
- Conserve biodiversity through integrated conservation and development solutions based on agroforestry technologies, innovative institutions and better policies
- Protect watershed services through agroforestry-based solutions that reward the poor for their provision
- Enable the rural poor to adapt to climate change and to benefit from emerging carbon markets, through tree cultivation
- Build human and institutional capacity in agroforestry research and development

Components of Agro-forestry
In modern agroforestry, the systems are classified based on the present components of its practice. For example, where trees are grown together with crops, the system is referred to as Silvoarable whereas silvopastoral is where trees are grown together with animals. Agro-silvopastoral is where plants, animals, and trees are kept together.

1. Agrisilvicultural systems
In this system, the components are agricultural crops and tree crops intercropped between the trees. The agricultural crops in this system can be grown for up to two years under protective irrigation and up to four years under refined farming.
2. Silvopastoral systems

In this system, the components are woody plants that are grown for pasture. The components can be trees or shrubs primarily grown to produce fodder for livestock or for fruit, timber, fuelwood or to improve the soil.

3. Protein Bank

In this category, the system components are multipurpose trees that are usually protein-rich trees planted in or around the farmlands for providing animal feeds. The common components in this system are Acacia nilotica, Azadirachtaindica, Albizialebbeck, Gliricidiasepium, Leucaenaleucocephala, and Sesbaniagrandiflora.

4. A live fence of fodder trees and hedges

In this category, hedges and fodder trees are planted as a live fence. The common components in this category are Erythrinasp, Sesbaniagrandiflora, Gliricidiasepium, and Acacia sp.

5. Trees and shrubs on pasture

In this category, various shrub and tree species are planted irregularly or in a systematic pattern to supplement forage production. Some of the common components in this category are Acacia leucopheloea, Acacia nilotica, Azadirachtaindica, and Tamarindusindica.

6. Agrosilvopastoral systems

In this system, woody perennials are combined with annuals and pastures. The systems can be classified into two categories that include home gardens and woody hedgerows for a browse, green manure, mulch, and soil conservation.

7. Home gardens

This system is more common in areas with high rainfall areas in South and Southeast Asia where coconut is the main crop. Many tree species can be used in this system as well as vegetables, bushes, and herbaceous plants are grown randomly or in special or temporal arrangements. The system also supports a variety of animal components.

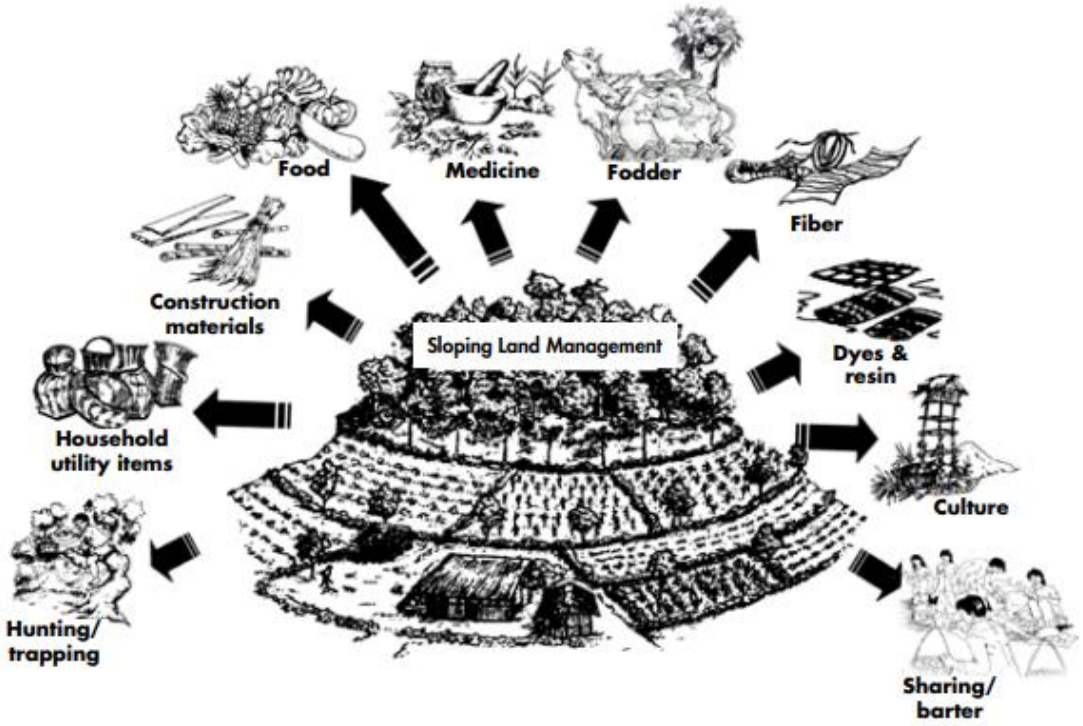
8. Woody hedgerows

In this system, woody hedges especially fast-growing, are preferred for the purpose of mulch, browse, soil conservation, and green manure. The common components include Leucaenaluecocephala, Erythrinasp, viz, and sesbaniaGrandiflora.

9. Other systems:

Other systems such as *apiculture with trees*, *aquaforestry* and *mixed wood lots* also exist.

Why agroforestry?



Lecture 2 Role of trees in fulfilling the basic requirements of people.

1 Importance and Value of Trees

- Since the beginning, trees have furnished us with two of life's essentials, food and oxygen.
- As we evolved, they provided additional necessities such as shelter, medicine, and tools.
- Today, their value continues to increase and more benefits of trees are being discovered as their role expands to satisfy the needs created by our modern lifestyles.

2 Community & Social Value

- Trees are an important part of every community. Our streets, parks, playgrounds and backyards are lined with trees that create a peaceful, aesthetically pleasing environment.
- Trees increase our quality of life by bringing natural elements and wildlife habitats into urban settings.
- We gather under the cool shade they provide during outdoor activities with family and friends.
- Many neighborhoods are also the home of very old trees that serve as historic landmarks and a great source of town pride.
- Using trees in cities to deflect the sunlight reduces the heat island effect caused by pavement and commercial buildings

3 Ecological & Environmental Value

- Trees contribute to their environment by providing oxygen, improving air quality, climate amelioration, conserving water, preserving soil, and supporting wildlife.
- During the process of photosynthesis, trees take in carbon dioxide and produce the oxygen we breathe.

- According to the U.S. Department of Agriculture, "One acre of forest absorbs six tons of carbon dioxide and puts out four tons of oxygen.
- Trees, shrubs and turf also filter air by removing dust and absorbing other pollutants like carbon monoxide, sulfur dioxide and nitrogen dioxide. After trees intercept unhealthy particles, rain washes them to the ground.
- Trees control climate by moderating the effects of the sun, rain and wind.
- Leaves absorb and filter the sun's radiant energy, keeping things cool in summer.
- In addition to influencing wind speed and direction
- Trees also lower the air temperature and reduce the heat intensity of the greenhouse effect by maintaining low levels of carbon dioxide.
- Both above and below ground, trees are essential to the eco-systems in which they reside.
- Far reaching roots hold soil in place and fight erosion. Trees absorb and store rainwater which reduce runoff and sediment deposit .
- This helps the ground water supply recharge, prevents the transport of chemicals into streams and prevents flooding.
- Fallen leaves make excellent compost that enriches soil.

4 Practical & Commercial Value

- They have a wide variety of practical and commercial uses. Wood was the very first fuel, and is still used for cooking and heating by about half of the world's population.
- Trees provide timber for building construction, furniture manufacture, tools, sporting equipment, and thousands of household items. Wood pulp is used to make paper.
- But did you know the bark of some trees can be made into cork and is a source of chemicals and medicines?
- Quinine and aspirin are both made from bark extracts.
- The inner bark of some trees contains latex, the main ingredient of rubber. How many more uses can you name?

5 Property Value & Economic Value

- Individual trees and shrubs have value and contribute to savings, but it is the collective influence of a well-maintained landscape that makes a real economic impact and has the greatest effect on property value.
- Direct economic benefits come from a savings in energy costs.
- Cooling costs are reduced in a tree-shaded home, and heating costs lowered when a tree serves as a windbreak.
- Property values of homes with well-maintained landscapes are up to 20% higher than others.
- Homes with "excellent" landscaping can expect a sale price 6-7% higher than equivalent houses with "good" landscaping. Improving "average" to "good"

Agroforestry system support the production of wide range product listed below

- Food (Arable crop, vegetable, honey, pollen, animal product fruit etc.
- Fuel (Charcoal, fuel wood)
- Fodder and forage
- Fiber
- Timber
- Rubber
- Gardening materials (fencing, pole

- Medicinal products
- Recreation (Sports, hunting
- Ecological service

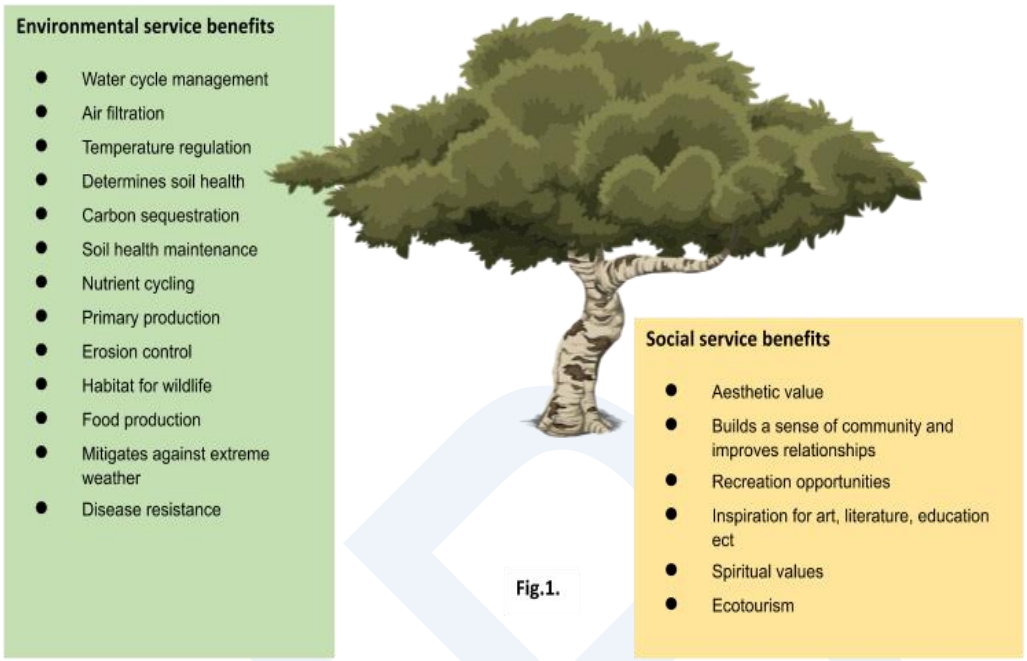


Fig.1.

Lecture 3 Characteristic of tree for Agroforestry development and tree improvement.

1. **Tree species selected should not interfere with soil moisture**

   In general, the species chosen for an agroforestry system should properties are below:

   - Tree species selected for agroforestry should have very less water requirement
   - Should not compete with main agricultural crops for water.
   - Tree species should be deep tap rooted so that they can draw water from deep strata of the soil.

2. **Tree species should not compete for plant nutrients**
   - Tree species should not utilize more plant nutrients
   - They should help in building soil fertility,
   - Leguminous tree species which fix atmospheric nitrogen in their roots should be prfer.
   - The root system and root growth characteristics should ideally result in to exploration of soil layers that are different to those being trapped by agricultural crop

3. **Tree species should not compete for sunlight**
   - Tree species should not interrupt sunlight falling on the crops.
   - Tree species should be light branching in their habit.
   - Trees permit the penetration of light into the ground and promote better crop, pasture growth and yield.
   - Tree species can withstand pruning operation if it possess dense canopy.

4. Tree species should have high survival rate and easy establishment

- Trees species should have high survival percentage,
- Leave little or no gaps after transplanting.
- Hardy tree species are easy to establish.

- They have less mortality percentage because they can tolerate transplanting shocks easily.
- Trees should have the ability to regenerate lateral roots within a short period of time after transplanting.

4. **Tree species should have fast growing habit and easy management**
   - Tree species for agroforestry system should be essentially fast growing,
   - Rapid growth, especially in the early years,
   - Tree should have short rotation (the period between planting and final harvesting)
   - Fast growing species such as Poplar, Casuriana, Leucaenaleucocephala etc. are important species which provide lot of opportunities to be planted in AFS
5. **Tree species should have wider adaptability**
   - A tree species selected for agroforestry combinations must have a wider adaptability.
6. **Tree species should have high palatability as a fodder**
   - Most of the Indian farmers rear livestock separately and cut and carry method of fodder production is quite prevalent.
   - Therefore, in agroforestry, farmer must select those tree species which are palatable to livestock and had a high digestibility.
7. **Tree species should have shelter conferring and soil stabilization attributes**
   - Some tree species, because of their inherent growth habit and adaptability, are especially helpful in providing protection for soils, crops and livestock. Poplars (Populus spp.), Willows (Salix spp.), Casurinaequisetifolia, etc. for example, have been extensively used in soil erosion control because of their extensive root system and ability to grow in water-logged soils.
8. **Tree species should have capability to withstandmanagement practices**
   - Many agroforestry systems demand extensive pruning and lopping of the trees in order to maximize production. In such cases, the trees must be able to withstand such treatment without drastically restricting growth rate.
9. **Tree species should have nutrient cycling and nitrogen fixation attributes**
   - Within an agroforestry system, trees can play an important role in recycling nutrients, leached down through the soil profile and minerals released from weathering parent material such as rocks and sediments.
   - These nutrients are used in the growth and development of the tree, many returning to the top-soil in form of dead leaves, twigs, flowers and seeds which slowly decompose on the surface, or are eaten by animals.
   - Although all trees play some role in maintaining the nutrient status of the soil through recycling.
   - Another important factor is the ability of many tree species to convert atmospheric nitrogen into organic nitrogen for their own use through complex symbiotic relationship between Rhizobium bacteria and their fine roots.
   - The bacteria form nodules on the roots which can convert nitrogen gas, as it is in the atmosphere, into usable nitrogen for the plant.
   - Most leguminous trees and some non-leguminous ones, such as Acacia, Leucaena and Prosopis as well as Casuarina spp. fix the atmospheric nitrogen.
   - The litter of these nitrogen fixing trees is generally high in nitrogen, thus increasing the nitrogen status of the soil.

Table Nitrogen fixing tree species

1.	**Acacia albida**	**21.**	**Bauhinia variegata**
2.	**Acacia auriculiformis**	**22.**	**Buteamonosperma**
3.	**Acacia catechu**	**23.**	**Cassia fistula**
4.	**Acacia aneura**	**24.**	**Cassia siamea**
5.	**Acacia dealbata**	**25.**	**Casuarinaequisetifolia**
6.	**Acacia decurrens**	**26.**	**Dalbergialatifolia**
7.	**Acacia farnesiana**	**27.**	**Dalbergiasissoo**
8.	**Acacia implexa**	**28.**	**Delonixregia**
9.	**Acacia leucophloea**	**29.**	**Gliricidiasepium**
10.	**Acacia mearnsii**	**30.**	**Hardwickiabinata**
11.	**Acacia melanoxylon**	**31.**	**Leucaenaleucocephala**
12.	**Acacia mollissima**	**32.**	**Moringaoleifera**
13.	**Acacia nilotica**	**33.**	**Oogeiniaoojeinensis**
14.	**Acacia planifrons**	**34.**	**Parkinsoniaaculeata**
15.	**Acacia senegal**	**35.**	**Peltophorumferrugineum**
16.	**Albiziachinensis**	**36.**	**Pithecellobiumdulce**
17.	**Albizialebbek**	**37.**	**Prosopis alba**
18.	**Albiziaprocera**	**38.**	**Prosopischilensis**
19.	**Alnusnepalensis**	**39.**	**Prosopis cineraria**
20.	**Alnusnitida**	**40.**	**Robiniapseudoacacia**
41.	**Samaneasaman**	**44.**	**Sesbaniabispinosa**
42.	**Saracaindica**	**45.**	**Sesbaniagrandiflora**
43.	**Sesbaniaaegyptica**	**46.**	**Tamarindusindica**

10. Tree species should have thin bark

- Species selected for agroforestry combinations should not shed its bark regularly but it should retain for longer period as bark shedding creates unhygienic conditions for under-ground crop.**Tree species should be free from chemical exudations**
- The species selected for agroforestry combination must be free from allelo-chemicals as these allelo-chemicals affect the growth of under-ground crops.

11. Tree species should have easily decomposable leaves

- The suitable tree species for agroforestry will be that one in which fallen leaves decompose with fast rate.
- The leaves of most of the legume tree species are small in size, decompose quickly and easily, and add a large quantity of organic matter and nutrients to the soil.
- Tree species having broad leaves such as teak, mango and banyan should not be preferred for agroforestry system.

12. Tree species should have their multiple uses

- The selected tree species should have multiple uses.
- The tree should yield more than one of the main produce like fuel wood, leaf fodder, edible fruit, edible flower and fiber.

13. Tree species should have high yield potential

- High yield potential is the most important criterion of selection of tree species for agroforestry systems as the main aim is to obtain overall more output per unit area. Care should be taken before collection of seeds and seedlings that they are being procured from reliable source.

Characteristics of Agronomical Crops for Agro-Forestry

- Agricultural crops should be short duration and quick growing.
- They should be at least partially tolerant to shade.
- Most of them should belong to Leguminosae family.
- They should respond well to high density tree planting.
- They should bear some adverse conditions, like water stress and/or excess of watering
- Crops should return adequate organic matter to soil through their fallen leaves, root system, stumps, etc.
- Crops should appropriately be fitted in intensive or multiple cropping system.

Agro-Forestry tree species found in Mid-Hills of Nepal

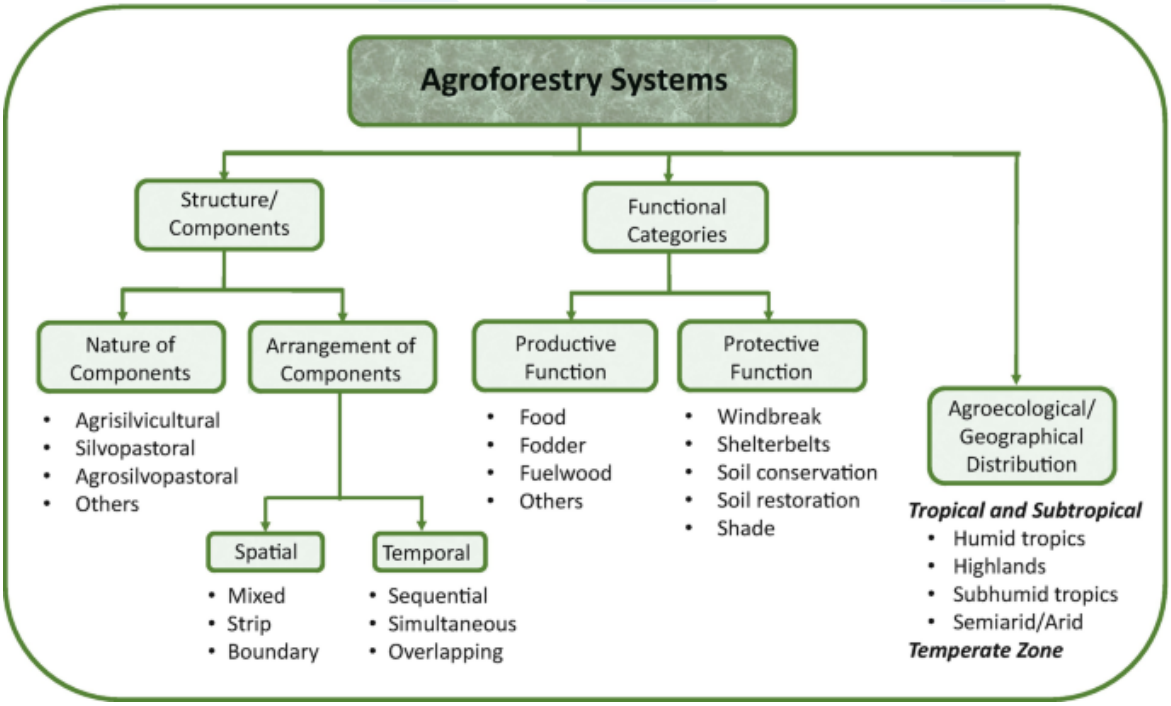
S.N.	Local name	Tree species	Family	Major Uses
1	Siris	Albizia species	Leguminoseae	Timber, Fuel, Tanning, fodder
2	Uttis	Alnusnepalensis	Betulaceae	Fodder, Timber
3	Champ	Micheliachampaca	Mangoliaceae	Fodder, firewood
4	Badahar	Artocarpuslakoocha	Moraceae	Fodder
5	RaiKhanyu	Ficussemicordatavarmontana	Moreceae	Fodder
6	Dudhilo	Ficusneriifolia	Moreceae	Fodder
7	Dabdabe	Garguapinnata	Burseraceae	Fodder
8	Tooni	Toona ciliate	Meliaceae	Fruit, Fodder
9	Chilaune	Schimawallichii	Theaceae	Timber, Fodder
10	Neem	Meliaazerdarach	Meliaceae	Timber, Fuel
11	Tanki/ koiralo	Bauhinia species	Moraceae	Fodder, vegetables
12	Kabro	Ficusinfectoria	Moraceae	Fodder, vegetables
13	KhasroKhanyu	Ficussemicordatavarsemicordata	Moraceae	Fodder , fiber
14	Kutmero	Litseamonopetela	Laurace	Fodder, Fuel
15	Bakaino	Meliaazaderach	Mileaceae	Fodder, Fuel
16	Rudrakshya	Elaeocarpus gantries	Elaeocarpaceae	Fodder, Fuel
17	Okhar	Juglansregia	Juglandeceae	Fruit, Fuel
18	Ipil-lpilFodderm	Leucaena spp.	Legumes	Fuel, Fruit
19	Kimbu	Morus alba	Moreceae	Fodder, silk worm
20	Laharepipal	Populusdeltoides	Salicaceae	Fodder, Green manure
21	Saaj	Terminaliaelliptica	Combretaceae	Wood,
22	Bans	Bambusa vulgaris	Gramineae	Fodder, construction

23	Amala	Embilicaofficinalis		Medicinal uses, fodder
24	Simal	Bombaxceiba	Bombaceae	Medicinal uses, Fodder
25	Alaichi	Elettariacardamomum	Zingiberaceae	Spices
26	Amriso	Thysanolanea maxima	Poaceae	Fodder
27	Timur	Xanthoxylumalatum	Rutaceae	Spices. medicinal value
28	Amba	Pisiumguajava	Myrtle	Fruits
29	Tejpat	Cinnamomumtamala	Lauraceae	Spices

Lecture 4 Classification and over-view of Agroforestry System (AFS)

Different types of Agroforestry systems exist in different parts of the world. These systems are highly diverse and complex in character and functions. To evaluate understand and seek to improve them requires their classification into different categories. Several criteria can be used in classifying them, but the most common include the system's structure, functions, and socio-economic scale of management and ecological spread.

According to Nair (1987), Agro-forestry systems can be classified according to following sets of criteria.



A) **Structural Basis**

Consider the composition of the components; specially refer including spatial admixture of the woody component, vertical stratification or the component mix and temporal arrangement of different components.

B) **Functional basis**

This is based on the major function or role of the system; mainly of the woody components (This can be productive or protective).

C) **Socio-economic basis**

Consider the level of inputs or management (low input, high input) or intensity/scale or management and commercial goals.

D) **Ecological basis**

Take into account the environmental conditions on the assumption that certain types of systems can be more appropriate for certain ecological conditions.

E) **Physiognomic basis**
F) **Land Use Basis**
G) **Technology basis**

A) Structural classification is done on the basis of-

1 Based on Nature of Compositions

1. **Agri- silviculture:** The land is used to produce both forest trees and agriculture crops either simultaneously or alternatively.
2. **Silvi- pastoral system:** In this system tress are managed to produced wood and fodder grasses and for rearing of domestic animals.
3. **Agri – silvi- pastoral system**: In this system combines agri- silviculture and silvi-pasture.
4. **Multipurpose forestry production system**: forest is managed to yield multiple product in addition to wood. They are grown to yield fruits, fruits, leaves, honey, gum, and medicine. This system is best suited for hill tribal.

2 Based on Dominance of Components

On the basis of dominance of components, the systems is further classified into the following categories-

1. **Silvo- agriculture:** The trees are the major component of land use and the agriculture crops are integrated with then. E.g. shifting cultivation, taungya cultivation.
2. **Agro- silviculture**: Agricultural component is the major one and trees are the secondary e.g. Allay cropping.
3. **Silvo- pastoral system:** Trees is the major component and pasture is secondary to allow the animals for grazing.
4. **Pastoral silviculture:** pasture is the component and trees are secondary sometimes allowing over grazing of forest beyond its carrying capacity.
5. **Agro- silvi- pastoral system**: Combination of crops, trees and pastures, e.g. home gardens wherein trees, herbs, shrubs, climbers and grasses are grown on the same land.
6. **Silvo- agri- pasture**: Silviculture is the dominate component. Agriculture and pasture are secondary.

3 . Based on Arrangement of Components

Arrangement of component can involve the dimension of space and time. Based on the arrangement of components Agroforestry system can be classified as-

* In Space or spatial arrangement.
* In time or temporal sequence.
* Vertical stratification of components.

3.1 Classification on the basis of in space or spatial arrangement:

a. **Mixed dense:** Different components are arranged together with high density, e.g. Home garden.
b. **Mixed sparse:** Different components are arranged together with low density, e.g. Most systems of trees in pastures, Scattered trees on agricultural lands.
c. **Strip plantation**: Width of strip to be more than one tree. e.g. Alley cropping.

d. **Boundary plantation:** Trees on edges of plots/ fields.

3.2 Classification on the basis of in space or temporal sequence:
a. Coincident: It occurs when different crops occupy the land together, e.g. Tea / Coffee under shade tree, pastures under trees.

b. Concomitant: When different components stay together for certain period, e.g. Taungya system.
c. Intermittent: When annual crops are grown with perennial ones. e.g. Rice under coconut trees or other MPTs, Seasonal grazing of cattle pastures under trees.

d. Interpolated: When different components occupy the space during different times, e.g. Home garden.

e. Overlapping: e.g. Black pepper in rubber.

f. Separate: When components occupy space at different times, e.g. Improved 'fallow' **Improved fallows** are the deliberate planting of fast-growing species — usually legumes — for rapid replenishment of soil fertility. Species in shifting cultivation.

3.3 Classification on the basis of in space or vertical stratification:
a) Single layered
b) Double layered
c) Multilayered
d) Dense
e) Scattered
f) Mixed intercropping

B) Classification of Agro-Forestry System on Functional Basis
This classification based on the major function or role of the system. Mainly on the woody component, this can be as productive or protective.
a) Productive Functions:
i) Supply of Food:
The tree species in agroforestry mainly fruits and nuts can supply food to the increasing population. The fruit trees like Mango, Ber, Jackfruit, Jamun, Tamrind, Wood apple, Bael, Caronda can supply the food.
ii) Supply of Fodder:
For 41 cores cattle to feed sufficient quantity of fodder is required which is supplemented by trees like Subabhul, Vilayti chinch, Hadga, Shevari, Neem etc.
iii) Supply of Fuel Wood:
The species like Subabhul, Khair, Sissoo, Casurina etc. can supply the fuel wood required for cooking. Thus diverting the cow dung to agriculture.
iv) Supply of Timber:
The agro-forestry can produce the timber wood in addition to the food grains by planting the trees like Teak wood, Eucalyptus, Silver oak, Sal, Arjun, Mohagoni. The timber wood is required for doors, windows, railway sleeper, furniture, poles and post for construction of bridges and for centring.
v) Other Products:

A number of minor forest products like flower medicinal plants, fibre, floss.gum, lac, tannin, resin etc. are obtained and thus, flourish the small cottage industry there by increasing employment.

b) Protective Function:

Protecting and mentioning production systems

1) Wind break
2) Shelter belt
3) Soil conservation
4) Moisture Conservation
5) Soil improvement
6) Shade (from crop animal and man)

C) Classification of Agro-forestry System on Socio-economic Basis

1 Commercial Agro-Forestry Systems:

The term commercial is used whenever the sale of the production of the output (usually a single commodity) is the major aim of the system the scale of operations is often moderate to large and land ownership may be government, corporate or private. Commercial production of shade-tolerating plantation crops such as coffee, tea and cocoa under over storey shade trees; rotational timber/food crops systems in which a short phase of food-crop production is used as a silvicultural method to ensure establishment of the timber species (various forms of taungya); commercial grazing and ranching under large-scale timber and pulp plantations etc. e.g. Tea, Coffee under shade tree.

2 Intermediate Agro-Forestry Systems:

Intermediate Agro-Forestry systems are those between commercial and subsistence scales of production and management, production of perennial cash crops and subsistence crops undertaken on medium to small size farms wherein the cash crops cater for the cash needs and the food crops meet the family's food needs.

3 Subsistence Agro-Forestry System:

Subsistence Agro-Forestry systems are those wherein the use of land is directed towards satisfying basic needs and is managed mostly by the owner/occupant and his family. Cash crops, including sale of surplus production of commodities, and all forms of traditional shifting cultivation are the most widespread examplesShifting cultivation, scattered trees in the farms, Homestead Agroforestry.

D) Classification based on Technology

i) Low technology system:

The technology used in this system is primitive as in shifting cultivation.

ii) High technology system:

This system depends on the modem technology for production of forest and agricultural crops, e.g. Tissue culture, Biotechnology,Genetic engineering etc.

iii) Intermediate technology system:

This system is an intermediate between low and high technology systems. Most of Agroforestry systems belong to this category.

E) Classification based on Utilization of Land-

On the basis of Utilization of land, the Agroforestry production systems are sometimes classified into the following categories-

1 Homestead Agroforestry:

Production of fruit trees, selected MPTs having less canopy and decorative trees/ shrubs along with vegetables, spices and many shade loving crops.

2 Forest land Agroforestry:

Production of crops in the vacant spaces of the forest.

3 Crop farm forestry:

Production of crops and trees in the crop land.

4 Fish farm forestry:

Production of fishes and trees in the fish farm.

5 Animal farm forestry: Classified as-

Poultry farm forestry: Farming of poultry birds and trees.

Dairy farm forestry: Farming of milk cattle and trees.

Beef cattle farm forestry: Farming of beef cattle and trees.

Goat farm forestry: Farming of goats and trees.

Integrated farm forestry: Production of crops, animals, fishes along with trees.

Road side Agroforestry: Production of deep rooted tall trees with narrow canopies and soil building grasses or crops along the sides of roads, highways, railways and embankment.

F) ClassificationBased onEcological

The Agroforestry system is related to various ecological factors. It can be classified on the basis of important ecological parameters (Climate, edaphic and physiographic ones). On the basis of Ecological parameters, it can be classified as-

1. Tropical:

Vegetation in extreme climate, such as high temperature, low humidity and scarcity of water etc. e.g. Tropical Silvopasture.

2 Sub-tropical:

Vegetation in suitable climatic condition, e.g. Agroforestry practices in the sub-tropical regions including Bangladesh.

3 Temperate:

Vegetation in low temperature, e.g. Silvopasture or pastoral silviculture in temperate region.

4 Sub-alpine:

Vegetation in low and medium mountainous regions, e.g. Natural or artificial forest vegetation in low or medium mountains.

5 Alpine:

Vegetation in high mountainous regions, e.g. Natural forest vegetation in high altitude.

G) Physiognomic basis

1) Hydromorphic Agroforestry

-Water logged area. E.g. Aqua forestry, Rice with fish farming.

2) Xeromorphic agroforestry

-Dry land area. E.g. Agro-forestry Africa.

3) Mesomorphic Agroforestry

-Water is available is optimum level.

Agroforestry System and Agroforestry Practices

1 . Agroforestry system is a specific local example of a practices, characterized by environment, plant species and their arrangement and socioeconomic functioning.

An Agroforestry practices denotes a distinctive arrangement of component in space and time.

2. Agrisilvicultural System

Improved fallow

* Taungya

♦ Alley cropping

♦ Multilayer tree gardens

♦ Multipurpose trees on crop land

♦ Plantation crop combinations

♦ Home gardens

♦ Trees in soil conservation and reclamation

* Shelter belts and Windbreaks live hedges

♦ Fuel wood production

3. Silvopastoral system

* Trees on range land and pastures

♦ Protein banks

♦ Plantations crops with pastures and animals

4. Agrosilvopastoral system

♦ Home gardens involving animals

4* Aquaforestry

4* Multipurpose wood lots

Property values of homes with well-maintained landscapes are up to 20% higher than others.

Homes with "excellent" landscaping can expect a sale price 6-7% higher than equivalent houses with "good" landscaping. Improving "average" to "good"

1. Conserve trees and forests in your area.

Forests and trees—especially big trees and mature forests—have many benefits.

They provide habitat for a multitude of species, store carbon, maintain water quality, stabilize the climate, and provide places for people to recreate and connect with nature.

2. Plant trees—the more the better

Reforestation is a critical part of the solution to climate change, and restoring previously degraded ecosystems provides essential habitat for threatened species.

3. Visit forests often.

Spend time in forests and green spaces; You will have a greater appreciation for and connection with the natural world, as well as positive effects on your health and well-being.

As the world urbanizes and people spend more time online, society is growing increasingly disconnected and separated from nature. So get outside! Go hiking or camping, have a picnic, or try to spot some birds.

Lecture 5 Agroforestry system in Nepal and similar agro-eco-zoning in the world

- Agroforestry farming system is a combination of agriculture and forest crops including livestock managed in spatial and temporal arrangements to satisfy mostly the household needs/ objectives and other priorities, subject to the given biophysical and socioeconomic condition.

- A farming system can be described both structurally and functionally.
- Structurally, in a given farming system, each component could be observed in relation with the existing settings. For example, boundary, buildings, crops, animals located in a farm.
- However, the structure of a farm may not be permanent.
- It changes with respect to the agricultural crops grown and other components employed.
- The study of any farming systems within a larger system is known as an eco-zone system.
- Eco-zone system is based on the biophysical characteristics such as altitude, climate, topography, soil type, or vegetation.
- It can also be described based on specific farming and/or production systems which reflect to a large extent what is feasible in terms of the above agro-ecological determinants.
- Ecozone study provides a logical basis for classifying farming systems for example, a general definition (e.g., systems with maize and cattle), will encompass a greater number of farms, while a more specific definition (e.g., systems with specific management and yield levels of maize) will contain a lesser number of farms.
- A farming system comprises different activities over the natural resources. The activities are: cropping systems and practices, livestock keeping, farm management, agro-based enterprises, rural livelihoods etc.
- The classification of the farming systems of developing countries like Nepal is based on the natural resource base: biodiversity (forest resources, plant resources, agrobiodiversity, and animal resources), water resources, rangeland/ grazing areas, physiographic zones, altitude, landscape, biophysical condition, climate, farm size, land tenure, organization. Likewise, the other criteria are: patterns of farm activities and household livelihoods, field crops, livestock, trees, aquaculture, apiculture, processing, marketing, off-farm activities, account of the main technologies used, which determine the intensity of production, and integration of crops, socio-economy of farmers etc.
- Nepalese farming systems include and represent the major farming systems of South Asia and East Asia.
- The broad farming systems identified in the region are lowland rice, upland rice, tree crop mixed, root-tuber crop, upland intensive mixed, highland extensive mixed, temperate mixed, pastoral, sparse (forest), urban farming system.
- The altitudinal variation has detrimental role in creating diversities in flora, fauna, climate, soil, ecosystems and hence in farming systems, farm animals, cropping systems, cropping patterns, among others.
- Farming system depends on the type of land and its optimum utilization.
- In the Nepalese context, However, farmers have been looking only to fulfill the household needs at subsistence level. There is hardly any computation on the intensity of use, and the management level each household are putting on it.
- This is mainly because in most of hill farming system, marketing the product is a problem. There are two reasons for it. One is the lack of inputs, mainly in terms of labour and prevailing marketing rules for forest products. Farmers distinguish various types of land as per their use.
- In the low land Terai, where paddy is widely grown, they are known as khet.
- The second category is the bari land where mainly maize and mustard are grown.

- Similarly, in the hills, farmers call pakhobari, meaning land without facility of irrigation where maize and millet are mainly grown.
- Kharbari is the land where thatch grass and fodder trees are normally planted. The categories of land use from Terai to the Mountain, in general, in all the physiographic zone of the country is provided in Figure.

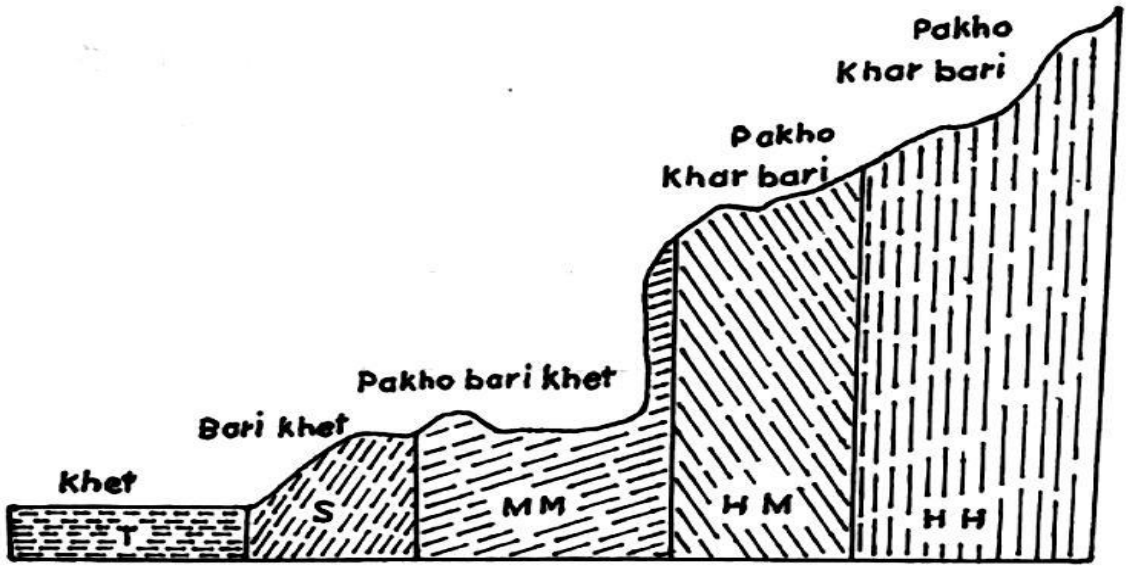


Fig: AGROFORESTRY SYSTEMS AND PRACTICES IN NEPAL

Table 2: Land use of Nepal

Categories	Area (Million hectares)	Percent
Forest*	5.96	40.36
Other Wooded Land *	0.64	4.38
Grass land **	1.77	12.0
Agriculture land **	3.09	21.0
Non-cultivated inclusions**	1.03	7.0
Water, streams, and river beds**	0.38	2.6
Urban and industrial areas**	2.62	17.8
Total	15.49	105.14

*Source: DFRS, 2016. ** Source: GoN/MoFSC, 2014.

Forest, range land, wetland, and agro-ecosystem are the major ecosystem groups of Nepal. A total of 118 ecosystems are found in Nepal. Of the five physiographic zones of the country, Middle Mountain has the maximum number of ecosystems (Table 3).

Table 3: Number of ecosystems in Nepal

Physiographic Zone	Ecosystems	
	Number	%
Terai	12	10.2
Siwalik	14	11.9
Middle Mountains	53	44.9
High Mountains	38	32.2
Other	1	0.8
Total	118	100

Source: GoN/MoFSC, 2014

Over view of AFS and Practices in Nepal (Important land use system in Agroforestry)

- Based on a survey of agroforestry systems and practice in Eastern, Central and Far-western Nepal, 35 agroforestry practices within seven agroforestry systems are documented.
- An agroforestry practice is defined by the combination of agroforestry components particularly species having unique biological and economics relationships requiring similar management strategies and techniques.
- An example of agroforestry practice is Utis– Cardamom agroforestry (Alnus-*Amomumsabulatum*) in Eastern and Central Nepal.
- A group ofagroforestry practices for which major components are closely related economically, environmentally and socially are referred to as agroforestry system.
- The seven agroforestry systems in Nepal are

(1) agrisilviculture,
(2) silvopastoral,
(3) agrosilvipastoral,
(4) silvofishery,
(5) Home gardens,
(6) Woodlots and
(7) Shifting cultivation.

Agrisilviculture

- Agrisilviculture system practiced widely in Nepal is generally defined by deliberate intercropping of trees and crops in a variety of spatial arrangement.
- The species of woody perennials and cash crops (both annual and perennial) vary between geographic location, i.eTerai and hills as well as East and Western Nepal. For example, in Eastern Nepal, Tea (*Cameliaspp*) is most common in larger estates, while cardamom, vegetable and cereal crops are common in smallholdings except a few exceptions.
- The tree species in this agroforestry system also vary in altitudinal zones – e.g. Siris (*Albizia*) and Sisau (*Dalbergiasissoo*) as common woody crops in the Terai while Utis (*Alnusnepalensis*) and Loth Sallo (*Taxuswallichiana*) are common in higher elevation.
- The major product from the woody components in the Eastern and Central Nepal are timber and firewood.
- Trees is the widely planted in spatial arrangements of agrisilviculture systems while windbreaks and trees on terrace risers were also practiced.
- In Far western Nepal, Rittha (*Sapindusmukorossi*) and Chiuri (*Diploknemabutyracea*) trees are common agroforestry species where interest for massive agroforestry planting of this species is emerging among landholders.

Agro-silvo-pastoral (crops, pasture/animals)

- Under this system tree crops, pasture/ livestock are raised.
- This system is more prevalent in hill as compared in the low land and prevalent in those areas where there is a need or opportunity for intensive and efficient management.
- This system is practiced at subsistence level. This system promotes both agriculture and livestock in one space and time. Specially, goats are raised along with agricultural crops. The preference however is given for goat rearing meaning establishment of new fodder trees and protection of old ones. Farmers prefer

Badahar (*Artocarpuslakoocha*), Ipil-Ipil (*Leucaenalatisiliqua*), Bakaino (*Meliaazadarach*), Kabro (*Ficuslacor*), Saj (*Terminaliaalata*), Koiralo(*Bauhinia variegate*), Tanki (*B. purpurea*), Katus (*Castanopisusindica*), Khanyuspp (*Ficussemicordata*var.*semicordata*andF. *semicordata* var. *montana*), Pakhuri (F*icusglaberrima*) as agroforestry/ fodder trees for their livestock specially goat.

Silvo-pastoral (pasture/animals and trees)

- This system is characterised with intensive cultivation of fodder trees and grasses for animal use primarily goat and dairy buffalo and cattle.
- Fodder grasses and fodder trees in combination with timber trees occupying the upper stratum. Livestock are allowed to openly graze and some are tethered but generally, most animals are under 'cut-and-carry' system with enclosures and houses.
- This system is widely practiced in the mid-hills from Eastern to Far-western Nepal. Pasture productivity was studied by Devkota et al in 2008 in New Zealand by pruning Italian gray alder (*Alnuscordata*) planted to control soil erosion on hills, the study showed that the pruning of alder has the potential to improve the productivity of the under-storey pasture and its acceptability to sheep.

Homegarden

- While home gardens may be classified under agrisilvicultural systems, it is classified as a system in its own right in Nepalese context as it has a distinct system components and relationships relative to other systems.
- Conversely, while many agroforestry practices in Nepal have homesteads nearby like that found in agrisilviculture and agrosilvipastoral systems.
- Home gardens are found across Terai and Midhills of Nepal characterised by a homestead with intensive cultivation of annual (cereals, vegetable and species, vegetables and spices), perennial crops (timber, poles, firewood, fodder and fruit trees), grasses and animals.
- The annual crops grown in home garden are the same across Nepal however the tree species vary with ecological zones. For example, Ficus and Citrus trees on terrace rises are common in Eastern Nepal, Ficus and Banana in Central Nepal, and Fusro (*Greviaoptiva*), fodder tree in Western midhills of Nepal. There are many species compositions in home garden systems. One single or two species do not represent the entire country.

Woodlots

- Small-scale woodlot is practiced in Eastern and Central Nepal to meet timber demand in rapidly growing urban and metropolitan areas.
- The famous species are Sallo (Pine), Chilaune (*Schimawallichii*), Utis (*Alnusnepalensis*), Sisau (*Dalbergiasissoo*), Teak(*Tectonagrandis*), Kadam (*Neolanarckiacadamba*), Bakaino (*Meliaazedarach*), Eucalyptus spp and Siris (*Albiziaspp*) which are relatively faster growing species. Many farmers have started harvesting their trees giving them substantial returns.

Shifting cultivation

- In Nepal, shifting cultivation is practiced in the middle and high mountain physiographic zones of the country, often on very steep slopes.
- People tend to use forest land for crop production mainly maize, buck wheat,, potato and millet.

- They first clear the land and burn the area completely and take the advantage of pre-monsoon rain in sowing the crop.
- Rotation cycles vary depending on land location and population pressure but generally it is between three to five years in many places.
- Although this system provides a livelihood for a substantial number of people, it is wasteful and inefficient one.
- This practice also prevents regeneration of many valuable plant species and results in site deterioration. At present clearing and burning is restricted in the government land. Shifting cultivation was common in Terai part of the country as well before 3-4 decades, particularly by the ethnic groups in Chitwan and some western districts of the country.

Taungya System

History

Taungya system was started for the first time by British in Burma in 1856.
Then it was introduced into Bangladesh (Chittagong Sylhet) in 1870.

Introduction

Terminology: Taungya (taung=hill, ya=cultivation) is a Burmesh word coined in Burma.

Definition:

Taungya system is the process of forest management system in which land is cleared & planted initially to food crops .Then seedlings of desirable tree species are planted on the same plot of land , either in combination with food crops or following several years of cultivation. After 3-4 years ,the tree canopy closes, preventin any further agricultural use & the land is used solely for the timber crops until the cycle is repeated following harvest of the timber.

This is the modified term of shifting cultivation in which labor is permitted to raise a crop in an area but only side by side with the forest species planted by them.

In Nepal, Taungya system of AFS initiated in 1972 at Tamagadhi area of Bara district reduced the cases against villagers for encroaching forest reserve. After the settlement of conflict between agriculturist and forester, agro-forestry has become an established technology.

Types of Taungya System

1.Departmental Taungya

- Raising agricultural crops & the plantation keeps the land free of unwanted vegetation.
- Under this, agricultural crops and plantations are raised by the forest department by employing daily paid labores.

2.Leased Taungya

The forest land is given on lease to the person whom affects the highest money for raising Agril.

3Village Taungya

- This is the most successful of all the three Taungya system.
- Usually each family has about 0.8-1.7 ha of land raising trees & cultivating crops for 3-5 years.

Advantages of Taungya System

1. Artificially, regeneration of the forest is done at cheaper rate.
2. Problem of unemployment is solved to some extent.
3. Maximum utilization of land.
4. Weed, climber growth is eliminated.

Disadvantages of Taungya System

1. Creates some legal issues.
2. Loss of soil fertility due to exposure of soil.
3. It is the form of exploitation of human labour.
4. Susceptibility of land to accelerated erosion increases.

Silvopasture

- Silvopasture is a form of agroforestry that combines trees with forage and livestock production.
- The trees in a silvopasture system are typically managed for high- value sawlogs and, at the same time, provide shade and shelter for livestock and forage.
- The partial shade throughout a silvopasture can reduce stress on the animal, and in some cases, it can increase forage production and quality. In plantations of conifers or hardwoods for timber or Christmas trees, managed grazing provides additional annual income from hay or livestock production.
- Silvopasture is a particularly popular agroforestry system in the Southeast, but it is becoming more popular in other areas across the country where coniferous trees exist.
- Some nut (e.g. walnut and pecan) and fruit orchards may also be managed as a silvopasture.
- Silvopasture is successful when the tree, forage, and livestock components are all compatible.

Alley Cropping

Classification of Alley Cropping

According to the purpose for which the alleys are raised, alley cropping may be grouped into

1. Forage alley cropping.
2. Green manure- cum – mulch alley cropping.
3. Forage – cum- mulch- alley cropping.
4. Forage- cum- green manure alley cropping.

Forest Farming

- Forest farming is a specific form of agroforestry that involves the cultivation of high-value non-timber crops under the protection of a forest canopy that has been modified to provide the shade level appropriate for a specific crop.
- Ginseng, shiitake mushrooms, and decorative ferns are all crops that are typically cultivated under forest cover and are sold for medicinal, culinary, and ornamental uses.
- Forest farming provides annual income while high-quality trees are being grown on a longer rotation for wood products.

- Additionally, forest farming can promote biodiversity by reestablishing previously exploited, naturally occurring plants. The diversity created with forest farming can also attract a variety of wildlife species.

Riparian Forest Buffers

- Riparian forest buffers are a form of agroforestry that involves the natural or re-established streamside forests made up of trees, shrubs, and grasses.
- They intercept and reduce the impact of non-point source pollution associated with agricultural operations on land adjacent to waterways.
- Riparian forest buffers also reduce bank erosion, protect aquatic environments from excess nutrients and sedimentation, enhance wildlife, and increase biodiversity.

Windbreaks/Shelterbelt

- Windbreaks are linear plantings of trees and shrubs designed to enhance crop production and protect people, livestock, soil, and water.
- There are several types of windbreaks. Field windbreaks protect a variety of wind-sensitive crops, control wind erosion, and increase bee pollination and pesticide effectiveness.
- They can also spread snow evenly across a field, increasing spring soil moisture. Livestock windbreaks help reduce animal stress and mortality, reduce feed consumption, and help reduce visual impacts and odors. Living snowfences keep roads clear of drifting snow and increase driving safety.
- All properly designed windbreaks provide protection for wildlife from harsh winds. Over 50 bird species are known to use windbreaks during the breeding season.

Agroforestry System

Agroforestry System or Practice		Description and arrangement of components	Agroecological zones
A. Agrisilviculture (crops and trees including shrubs)			
1.	Siris (Albizia) – tea (Camellia sinensis)	Tea under Siris (Albizia) trees in random mix pattern	Terai in Eastern Nepal
2.	Sisau (Dalbergiasisso) – tea	Tea under Sisau (Dalbergiasisso) trees in random mix pattern	Terai in Eastern Nepal
3.	Utis (Alnusnepalensis) –tea	Tea under Utis (Alnusnepalensis) in random mix pattern	Midhills in Eastern Nepal
4.	Betel nut (Areca catechu) – cardamom (mix)	Cardamom (Elettariacardamomum) under Betel nuts (Areca catechu) planted in regular spacing of 3m x 4m	Terai in Eastern Nepal
5.	Betel nut (Areca catechu)Bakaino (Meliaazedarach), Siris (Albizia) Sisau (Dalbergiasisso) – crops	Betel nut and maize, rice, vegetable intercropping, Trees on borders	Terai in Eastern Nepal
6.	Tea Utis (Alnusnepalesnis) -	Tea under Utis (Alnusnepalesnis) and Loth Sallo (Taxuswallichiana)	Midhills in Eastern Terai

	Loth salla (Taxuswallichiana) – Tea	in random mix patters	
7.	Utis (Alnusnepalensis)-Cardamom (Elettariacardamomum	Cardamom (Elettariacardamomum) under Utis in mix random planting	Midhills in Eastern and Central Nepal
8.	Utis (Alnusnepalensis)-Amriso	Amriso (Thysanolaenalatifolia) under Utis at wider spacing (4m x 5m) or Utis in farm border for narrow lots	Midhills in Eastern and Central Nepal
9.	Bhanj (Quercusspp) – cereal crops, lentils, vegetables	Cereal crops (maize, wheat, millet), lentils and vegetable grown on terraced bari under widely spaced naturally growing Quercus	Midhills in Farwestern Nepal
10	Chiuri – cereal, lentils and vegetable	Cereal crops (maize, wheat, millet), lentils and vegetable grown on terraced bari under Naturally growing and widely spaced Chiuri trees	Midhills in Farwestern Nepal
11	Utis-chilaune-fodder trees – maize	Maize as alley crop; naturally growing Utis (Alnusnepalensis), Chilaune (Schimawallichii) and fodder on terrace risers	Midhills in Eastern and Central Nepal
	Utis-chilaune-fodder trees– tea	Tea as alley crop; naturally growing Utis (Alnusnepalensis),Chilaune (Schimawallichii) and fodder on terrace risers	Midhills in Eastern Nepal
12	Utis-chilaune-fodder trees – cardamom	Cardamom as alley crop; naturally growing Utis (Alnusnepalensis), Chilaune (Schimawallichii) and fodder on terrace risers	Midhills in Eastern Nepal
13	Utis-chilaune-fodder trees – amriso	Amriso (Thysanolaenalatifolia) as alley crop; naturally growing Utis (Alnusnepalensis), Chilaune (Schimawallichii) and fodder on terrace risers	Midhills in Eastern and Central Nepal
14	Utis-chilaune-fodder trees –ginger	Amriso (Thysanolaenalatifolia) as alley crop; naturally growingUtis (Alnusnepalensis), Chilaune (Schimawallichii) and fodder on terrace risers	Midhills in Eastern and Central Nepal
B	Multi-purpose trees on terrace risers – cereal crops – fodder grasses – animal (cut and carry)	Alley cropping of cereals on terraces, multipurpose trees and forage grasses on terrace risers, and cut-carry system for animals (goat, cow, buffalo)	Nepal
15			
16	Multi-purposetrees–	Amriso (Thysanolaenalatifolia)	Midhills Central

	fodder grasses	for grass and broom), fodder grasses and multipurpose trees in mix random plantings	Nepal
17	Fodder trees– banana – animal (goat – cut and carry)	Banana on terraces; fodder trees on terrace risers and goat (cut-and-carry system)	Midhills Central Nepal
18	Foddertrees–banana-ginger -animal (goat – cut and carry)	Banana and ginger on terraces; fodder trees on terrace risers and goat (cut-and-carry system)	
C.	**Silvopastoral (pasture/animals and trees)**		
19	Foddertrees–ginger-animal (goat – cut and carry)	Ginger on terraces; fodder trees on terrace risers and goat (cut-and-carry system)	Midhills Central Nepal
20	Foddertrees–amriso-animal (goat – cut and carry)	Amriso (Thysanolaenalatifolia) on terraces; fodder trees on terrace risers and goat (cut-and- carry system)	Midhills Central Nepal
21	Fosro(Grevia) trees - cereals (maize, rice, wheat, millet), lentil and vegetables), goat and cattle (cut and carry system)	Cereal crops (maize, wheat, millet), lentils and vegetable grown on terraced bari under naturally growing and widely spaced Fosro trees; goat, cattle and buffalo in cut and carry System	MidhillsFarwestern Nepal
22	Betel nut – goat grazing	Tethered goats grazing under mature Betel nuts (Areca catechu)	Terai Eastern Nepal
	Timber trees – bamboo- forage grasses	Tethered and free-range goats grazing under multi-storey systems: Upper storey – timber trees-Haldu (Adina cardifolia), Bakaino (Meliaazedarach), Gutel, (Trewianudiflora), Siris (Albizia); middle storey - bamboo; ground cover–forage Grasses	Terai Eastern Nepal
23	Fodder trees –fodder grasses- animals (goat)	Tethered and free-range goatsgrazingopen grazing and cut and carry system	All Midhills
24	Trees – apiculture	Bees kept in homestead feeding on farm trees and community forest	Midhill Central Nepal
25	Small woodlots – grasses – animals (tethered and cut- and-carry system)	Naturally grown fodder grasses under woodlots; animals are tethered and cut-and-carry system	Midhills Far- western Nepal
D.	**Silvofishery (trees with fish on ponds or mangroves)**		
26	Multi-purpose trees-fish, Central Nepal	Multipurpose (fodder and firewood) planted on border or dikes of fish ponds (mainly tilapia)	Midhill Central Nepal

27	Timber trees – banana on borders of banana of fish pond	Fishpond with multi-storeysystem on dike and borders: Teak (Tectonagrandis) and Sisau (Dalbergiasisoo) trees in upper storey, Banana in themiddlestorey and grasses as ground cover	TeraiFarwesternNepal
E	**Home garden**		
28	Homestead – multistoreysystem – cereal, vegetables, spices, and animals	A homestead with small compartment of multistory system: ¢ Upper stratum: betel nut with betel leaf, pepper species), coconut, Bakainon (MPTS) ¢ Mid stratrum: banana fruits (banana, guava, citrus), eskos, black pepper ¢ Lower stratum: grasses, vegetables (mustard, colocassia, corn, turmeric ginger) ¢ Animal shed for cow, goat or buffalo	Terai Eastern Nepal
29	Multipurpose trees, fodder trees and fruit trees on terrace risers-crops (maize, vegetables, and vines) on alleys-homestead (house and animal shed)	A homestead with intensive cultivation of cereal (maize, wheat, rice or millet), vegetables, spices on terraces or alleys, and multu- purpose trees (timber, fruits, fodder, firewood) and grasses on terrace risers, and animals in cut-and-carry system	All Terai and Midhills
30	Teak, Sisau - fruit trees-vegetables, homestead and animals (cut and carry system)	Homestead with teak, Sisau, fruit trees (mango, guava, papaya); vegetable patch and animals on cut-and carry System	TeraiFarwesternNepal
F.	**Woodlots**		
	Small-scale woodlot	Eastern Nepal: Kadam (Neolamarckiacadamba) Teak (Tectonagrnadis), Sisau (Dalbergiasissoo), Molato (Plantagomalato, Utis (Alnusnepalensis), Sallo (Pine), Siris (Albizia), Central Nepal: Sallo (Pine), Utis (Alnusnepalensis) Chilaune (Schimawallichii), Sal (Shorearobusta-Castanopsis spp.), Siris (Albizia).	Eastern and Central Nepal (midhills and Terai)
G.	**Shifting cultivation**		
35.	Shifting cultivation	Clearing and burning of fallowed lands and or public forests then planting of cereals (maize and millet) and vegetables in 3-5 years cultivation	Eastern Nepal and central Nepal

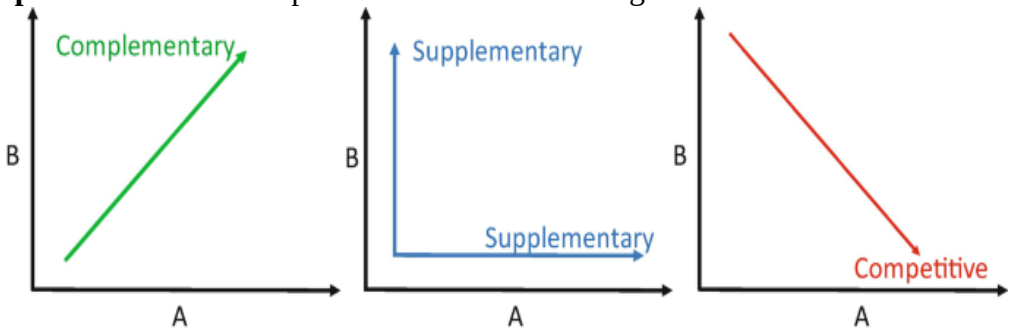
Lecture 6 Factors and types on nature of tree- crop interaction

- Agroforestry is an ecologically sustainable land use system that maintains increase total yield by combining food crops (annuals) with tree crops (perennials) and/or livestock on the same unit of land.

Types of interactions

Interactions usually termed as complementary, supplementary and competitive.

- **Complementary:** When the interaction is positive, there is complementarity between the components.
- **Supplementary**: Complementary force = Competitive force
- **Competitive:** there is competition if interaction is negative



Interactions based on components

Woody perennials (trees) are important of all agroloreslry systems. Based on components, interactions types are as:

A. Tree-Crop interactions or Treer Crop interface (TCl)

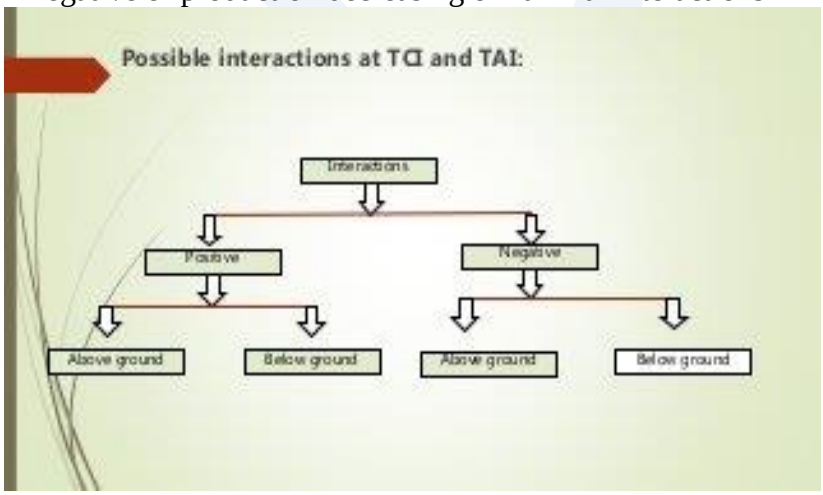
B. Tree- Animal interactions or Tree» Animal interface (TAI).

Interactions at Tree- Crop Interface (TCI)

- Positive or production enhancing or beneficial interactions.
- Negative or production decreasing or harmful interactions.

Interactions at Tree-Animal Interface (TAI)

- Positive or production enhancing or beneficial interactions.
- Negative or production decreasing or harmful interactions



Interactions at Tree- Crop Interface (TCI)

Positive (Production enhancing) interactions

- Shading trees (Stress reduction)
- Efficiently Use oflight (PAH) or reduce waste of light resources

- **Biomass contribution**-Biomass can add by pruning materials, leaf liners, and rum residues etc, which add nitrogen, organic matter. improve soil condition and thereby increase 1he productiviiy.
- Microclimate amelioration
  Change of microclimate which is favorable ior agroforestry components (tree, crop, animal etc.) e.g. - Increasing soil moisture
  - Reducing soil temperature
  - Augment organic matter and nutrients through litter and root decomposition
  - Trapping and reoyciing of nutrients from deeper zone eto.
- Balanced utilization of nutrient
  - Crop utilized nutrient from upper 6 inch which is continuously enriched by litter tall and pruning materials and root residues decomposition.
  - Bringing up nutrients released by weathering in lower soil horizons.
  - Trapping and recycling of nutrients that would otherwise have been lost by leaching.
- Efficient utilization ofaerial space
  Tree crop association ensures optimal utilization of aerial space both horizontally and genetically. e.g., Mixed dense, Mixed sparse, Homestead agroforestry etcl
- Water conservation
  Reducing 1ranspiration, pumping watr from the deep soil which makes the surface soil moistened.
- Weed suppression
  Effect of shade is more severe for Iighl demanding weeds. e.g. in alley cropping system Cassia siamea reduce weed infestation.
- i. Soil conservation: Trees alone do not normally protect soil against erosion. Closely planted shrub hedges can do so. In agroforestry systems appropriate tree crop association control soil erosion efficiently, e.g. SALT models, Hedge row barrier (alley cropping).Wind-breaks directly serve lo control wind erosion‘

Negative (production reducing) interactions

- Light competition
- Nutrient competition
- Water competition
- Weedgrowih increasing
- Allelopathy-The phenomenon of one plant having detrimental effect on another through the production and exertion of toxic chemical compounds is called allelopathy. Allelopathy is the indirect harmful effect through exertion of chemical substances. Allelopathic substance was first detected by Davis (1928) in black walnut tree (Jug/ansni‘gra) whose foliar leachate containing Juglone was found to damage germination and seedling growth of crops beneath the tree.Several phytotoxic substances termed as allelochemicals are generally present in plants (leaves, stems, roots, rhizomes, fruits, seeds etc.) and released in environment and rhizosphere under appropriate conditions to affect neighboring plants. These chemicals interfere With metabolic pathways of plants growing in the vicinity causing suppression of growth.

Factors affecting tree crop interaction

A) Interference effects: In an agroforestry system, trees being the dominant partners,will compete with the herbaceous substratum for resource pools of light, water and nutrients.

When the immediate supply of a single necessary factor falls below the combined demands of the plant, then the competition begins.

1 **Effect of species:** Proper choosing of compatible tree- crop combinations.

2 **Effect of sun light:** Light crown tree, either selection of shade tolerant crops or management of tree crop for reducing shade on agricultural crops.Compared to open field, the total and net radiation beneath the tree canopy were only 24% and 16% respectively.

3 **Effect of density:** Numbers of trees/ha, planting of tree at optimum numbers of tree in a given area for reducing competition among crop and tree.

4 **Effect of age**: At early stage of tree crop, competition is minimal.

5 **Effect of site factors:** Relates about the carrying capacity of the site, site quality.

6 **Effect of management**: Level of management for tree crop for benefits of agricultural crops or improving the total productivity of the system.

7 **Effect of nutrients in the top soil:**Below ground root competition for moisture, nutrients and space is relatively more important in agroforestry systems than above ground competition. Since light is more relatively more abundantly available than moisture and nutrients.A higher concentration of the fine tree roots in the soil layer upto 50cm suggests that trees also obtain most of the nutrient requirements from the soil layer upto 50cm. The lower concentration of the fine roots below 50cm soil depth suggests that the nutrient absorption from deeper soil layers may be small.

8 **Competition for moisture :** One of the primary promises of agroforestry , especially of mixed systems rests on the assumption that trees being deep rooted abstract water from the deeper regions and therefore do not compete in the upper stratum to which the herbaceous component is restricted. The increased yield of arable crops and range grasses under Prosopisjuliflora was due to the deep taproot of the tree. The predominant occurrence of lateral roots in the top 30cm soil has also been reported in Eucalyptus and it extracted moisture mostly from the upper soil layer. Thus trees do compete with arables in the top 30cm soil profile. In intercropping experiment, depletion of soil moisture was considerable in bamboo.

9 **Allelopathy:**The phenomenon of one plant having detrimental effect on another through the production and exertion of toxic chemical compounds is called 'allelopathy'**.** Allelopathy substance was first detected by Davis in black walnut (*Juglansregia*) whose foliar leachate containing Juglone was found to damage germination and seedling growth of crops beneath the tree.Allelopathy is one of the widely considered limitations for promotions and adoption of agroforestry at the field scale.

10 **Environmental aspects**

(i) Possible competition of trees with food crops for space, sunlight, moisture and nutrients which may reduce food crop yields

(ii) Damage to food crops during tree harvest operations

(iii) Potential of trees to serve as hosts to insect pests that are harmful to food crops

(iv) Allelopathic effect of trees on agricultural crops

11 Socioeconomic aspects

(i) Requirement for more labour inputs, which may cause scarcity at times in other farm activities (ii) Competition between food and tree crops, which could cause aggregate yields to be lower than those of a single crop

(iii) Longer period required for trees to grow to maturity and acquirean economic value

(iv) Resistance by farmers to displace food crops with trees especially where land is scarce

12 Damage due to Birds

It is generally believed that planting of trees in the farm will attract the birds and thereby enhance the risk of damage for agricultural crops.

Lecture 7 Quantifying the Agroforestry Product

How do you measure a standing tree?

The stick is held pointing straight up, at 90 degrees to your outstretched, straight arm. Carefully walk backwards until the top of the tree lines up with the top of your stick. Mark where your feet are. The distance between your feet and the tree is roughly equivalent to the height of the tree.

Principle of Similar Triangles:

Two triangles are said to be similar when the corresponding angles are equal and the corresponding sides are proportional. ADE and ABC are similar triangles.

Thus, BC: DE = AC: AE

Tree Height (BC) = DE x (AC/AE)

Where, DE and AE are known and AC can be measured in ground

Height sticks are used to measure the height of small trees. Hypsometers, altimeters and clinometers are used to measure height of tall trees (CCC 2009).

i. Hypsometers:

Used for determining the height of standing tree from observations taken at some distance from the tree.

ii. Altimeters:

Generally altitude measuring instruments, which can be devised to determine heights of tree.

iii. Clinometers:

It measures angle of slope. Any instrument which measures angles of slope can be used for height of tree by trigonometrical methods.

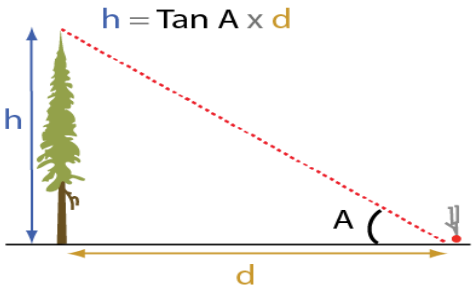
iv. Laser Dendrometers:

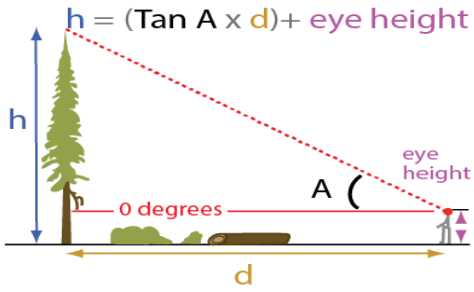
They basically rely on the same geometric principles as the hypsometers.

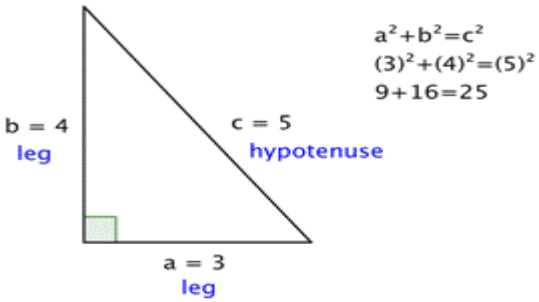
1 How to measure height

Height is the hardest measurement to take accurately, especially for larger trees. Measurements become more reliable the greater the distance you are from the tree (the distance you are away from the tree must be greater than the total tree height). In dense forests it can be challenging to get a clear view of the tree top. The slope of the ground can also make measurement difficult. Trees that are leaning significantly should be measured with the lean to the right or left, not with the lean toward or away from you.

In challenging forest situations we recommend making more than one attempt to measure height. If possible try and remeasure from a different view point, and always double check your measurements.







2 Density

It refers to the number of individual per plot or per hector and is expressed as Density= 1000 per ha, Where 1000 is the number of stems per hectors.

3 Canopy Cover

It is simply measure the of canopy expansions. This can be measured by the expanding the measurement tape on ground level throughout the canopy length.

$$\text{Canopy Cover} = \frac{W_1 \text{ X } W_2}{4\ л}\ M^2$$

4 Volume measurement

$$\text{Volume } (V = \frac{(g)^2}{(4)^2} \text{ X L Cuf}$$

$$\text{Volume } (V = \frac{\text{LX gh+g m +gt}}{3}\ Cm^3$$

G= 0.0000785 d^2

Volume Calculation of Firewood/Stacked Wood:

Volume may be estimated for stacks of logs or processed products by measuring dimensions. In these cases, local knowledge is often needed for appropriate estimation of volume.

Firewood is stacked in the form of rectangular parallel piles and the volume of the stacked firewood is calculated by:

Volume = Length (L) x Height (H) x Breadth (B) of the stack expressed in cubic meter or cubic feet.

1 Calculate the volume of a 12 fit long log whose girth at the midpoint was measured 4 fit.

Here length= 12 fit
Midpoint= 4
Volume = ?
Formula

Volume $(V = \frac{(g)^2}{(4)^2} \times L$ Cuf

Volume $(V = (4/4)^2 * 10$
=12 cuft

2 Calculate the volume of a 10m long log whose girth at the midpoint was measured 60 cm.
Here length= 10m
Midpoint= 60cm =0.6m
Volume = ?
Formula

Volume $(V = \frac{LX\ gh+g\ m\ +gt}{3}$ Cm^3

Volume (V = 10*3.14*3.14*0.6*0.6/4*4
=2.22Cum

3 Calculate the canopy height of a tree 30m and clean bole is 5 m.
Here height= 30m
Clean bole= 5m
Volume = ?
Formula
Canopy Cover = Hight-Clean bole

Canopy Cover =30-5
= 25m

Taken length (L) = 12m
Angle (Q)= 80^0
Height of person (d)= 1.43m
Height tree (H)= ?
Here
$H = \frac{L}{\text{Tan X}} + D$

$$H = \frac{12}{80^0} + 1.43$$

$$H = \frac{12}{5.67} + 1.43$$

H= 3.04 m

Lecture 8 Soil management under agroforestry
Soil water conservation
Introduction

- Soil is one of the most important natural resources to suffers a result of deforestation widespread deforestation and increasingly intensive use of land to sustain a growing population has increased soil erosion, lowered soil fertility , and reduced agricultural productivity in the hills of Nepal.

- This has raised concern over sustainability of the hill farming system.

- Therefore, protection of soil is very important with understanding of how this resource is influenced in any agroforestry system.

Approaches for soil water conservation

AF technologies that have potential applicability to maintain the soil fertility and to improve its productivity. These are:

- Improved fallow
- Alley cropping
- Multispecies tree garden.
- Home garden
- Trees in soil conservation and land reclamation.
- Shelter – belts and wind breaks.
- Multipurpose trees on range land.
- Boundary planting of trees and woody hedges.
- Wood lots for green manure, woody mulch or fodder

Approaches for soil water management

- Deforestation should stopped and reforestation should get priority.
- Overgrazing of rangelands should be stopped.
- Sloppy land technology in hills should be launched.
- Preventive and rehabilitative soil conservation works must be undertaken.
- The people should be educated about the seriousness of the problem and encourage to participate actively on soil conservation program.
- Should develop and lunches appropriate agroforestry systems for the particular agroecozones.

Soil and water conservation refers to the practices that are carried out to prevent loss of the two resources. These practices maintain the soil fertility.

Contour farming

- Contour farming involves ploughing, planting and weeding along the contour, i.e., across the slope rather than up and down.
- Contour lines are lines that run across a (hill) slope such that the line stays at the same height and does not run uphill or downhill. As contour lines travel across a hillside, they will be close together on the steeper parts of the hill and further apart on the gentle parts of the slope.
- Experiments show that contour farming alone can reduce soil erosion by as much as 50% on moderate slopes. However, for slopes steeper than 10%, other measures should be combined with contour farming to enhance its effectiveness.

A-frame.

- Materials.
- Three poles-of 2.5m length
- Handful of nails
- 1m – 2m strong string
- A piece of rock (stone)
- Two pegs

Procedure.

- Use the poles and nails to make a frame in the shape of an "A" (Picture 1)

▪ Tie one end of the string to the top of the "A“

- Tie the stone to the other end of the string, so it hangs down just below the horizontal crossbar of the "A"

Calibrating the A-frame

- Stand the A-frame upright on reasonably level ground. Mark on the ground where the two legs stand.
- Hold the A-frame still, and use the pencil to mark lightly on the crossbar where the string crosses it (Picture 2).
- Turn the A-frame round, so that each leg stands exactly where the other had stood.
- Make a second light mark on the crossbar where the string crosses it.
- The two marks on the crossbar should be fairly close together. Halfway between them shows where the string would cross if the A-frame were standing on exactly level ground. Make a heavy pencil mark or notch the bar with a knife at this point (Picture 3).

Locate the contour lines using the A-Frame

1. Choose a place on the slope to begin. Stand the A-frame up and mark where the first leg stands with a peg or large stone.

2 Keeping the A-frame upright, and without moving the first leg, swing the second leg up or down the slope until the string crosses the crossbar exactly at the heavy pencil mark (Picture 4)

3 Mark where the second leg stands with another peg or stone.

4 Keeping the second leg in the same place, lift the first leg up and pivot it around. Move it up and down the slope until you find the place where the string crosses the crossbar at the heavy pencil mark.

5. Mark where the first leg is now standing with another peg or stone.

6 Continue in this manner to the end of the field.

7 The line of pegs or stones will mark a contour line: they will all be at the same height on the slope. The pegs are usually not in a straight line. If necessary, make a smooth curve by moving them a little up or down.

8 To mark another contour line, move up or down the slope a certain distance - usually about 20 m (20 paces) on a gentle slope, or a drop of 1.5 m on steeper slopes. Repeat the process from Step 9 above onwards.

Introduction to SALT

SALT is a package technology of soil conservation and food production, integrating differing soil conservation measures in just one setting. Basically, SALT is a method of growing field and permanent crops in 3-5 m wide bands between contoured rows of nitrogen fixing trees. The nitrogen fixing trees are thickly planted in double rows to make hedgerows. When a hedge is 1.5-2 m tall, it is cut down to about 75 cm and the cuttings (tops) are placed in the alleyways to serve as organic fertilizer.

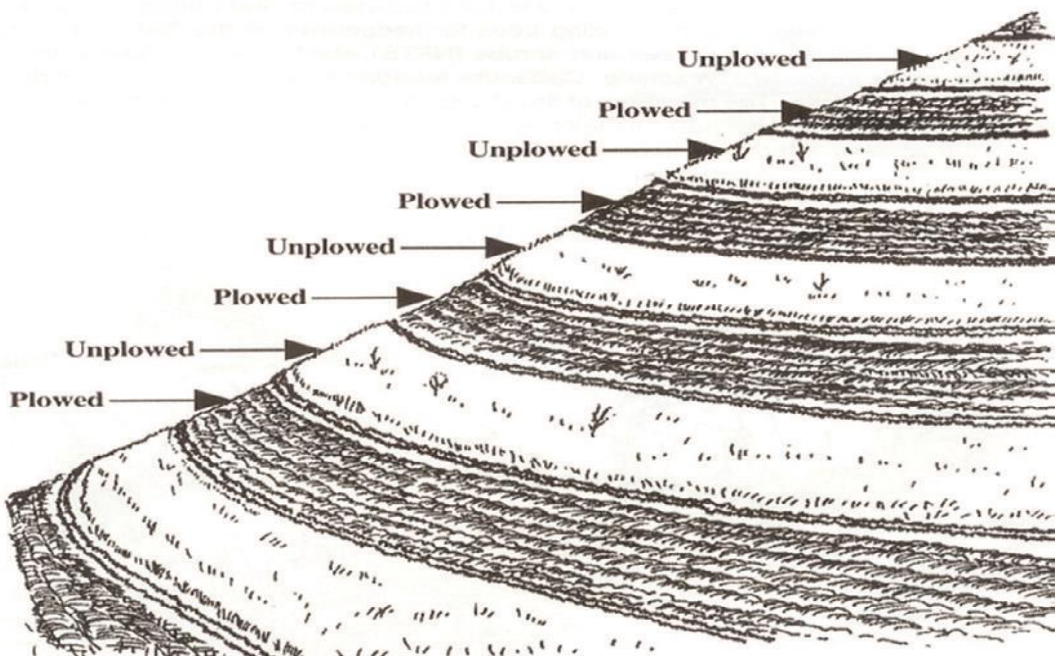
History of SALT:

The Mindanao Baptist Rural Life Center (MBRLC) developed SALT on a marginal site in Kinuskusan, Bansalan, Davao del Sur. Dialogues with local farmers acquainted the MBRLC staff with farm problems and needs which gave them the impetus to work out a relevant and appropriate farming system. From testing different intercropping schemes and observing ipil-ipil (Leucaenaleucocephala) based farming systems in Hawaii, SALT was

finalized, verified and set up as an initial model in 1978. While it was still in the developing stage, the following guidelines were considered essential.

The system must:
• adequately control erosion
• help restore soil structure and fertility
• be efficient in food crop production
• be applicable to at least 50% of hillside farms
• be easily duplicated by upland farmers
• be culturally acceptable
• have the small farmer as the focus and food production top priority
• be workable in a relatively short amount of time
• require minimum labor
• be economically feasible

Advantages of SALT farming
• The SALT system protects the soil from erosion.
• SALT helps restore soil fertility and structure.
• SALT is efficient in food crop production.
• SALT is applicable to at least 50% of hillside farm.
• SALT is easily replicated by hillside farmers.
• SALT is culturally acceptable because the farming techniques are in harmony with Asian beliefs and traditional practices.
• SALT has the small family as its focus, and food production as the top priority–fruit trees, forest and other crops are secondary priority.
• SALT is workable in a relatively short time.
• SALT is economically feasible.
• SALT is ecologically sound.
• The SALT farm can easily revert back to forestland if left unfarmed.



Lecture 9 Soil fertility management

Soil fertility is the ability of a soil to supply the nutrient elements in the amounts, forms and proportions needed for the growth of specified plants when temperature and other factors are favorable.

Soil productivity refers to the capacity of a soil to produce a given yield of crops under a specified system of management.

Main factors contributing towards soil fertility

- Soil depth.
- Drainage.
- Good aeration.
- High water holding capacity.
- High levels of nutrients.
- Freedom from pests and diseases.
- High levels of micro-organisms.
- Optimum Ph.
- Organic matter.
- Soil texture and structure play a vital role in determining the ability of the soil to produce high crops through their influence on some of these factors e.g. moisture holding capacity and drainage.
- Organic matter is another component which influences most of the factors that contribute to soil fertility.

Soil fertility may be lost through:

- Soil erosion - wind or water.
- Leaching.
- Weeds.
- Monocropping.
- Loss of nutrients through sale of farm produces off the land.
- Change of soil pH.
- Compaction- hardpan impeding infiltration of water and root penetration.
- Rainfall amount and intensity.
- Sun / heat.
- Fires.
- Wind.
- Mining

Methods of maintaining and /or improving soil fertility

- Improving soil moisture characteristics.
- Good cropping system.
- Minimum soil disturbance.
- Soil pH control.
- Addition of organic matter.
- Erosion control.

Factors influencing water erosion

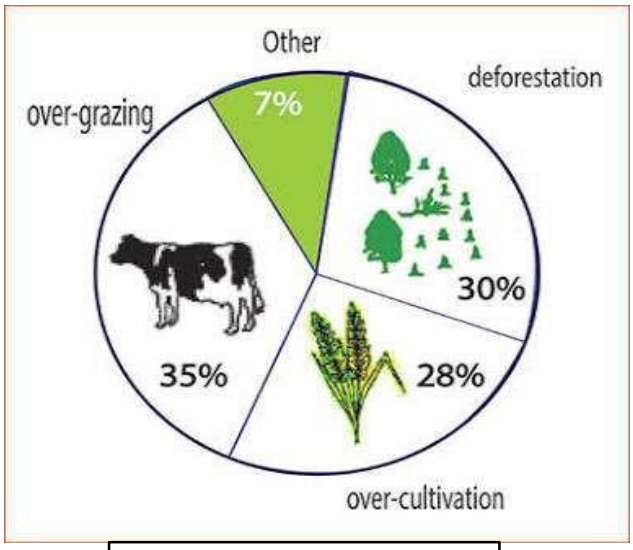
- Rainfall intensity and runoff
- Soil erodibility
- Slope gradient and length
- Vegetation
- Land use

What is Land Degradation?

- The loss in the capacity of a land to support the growth of useful plants on a sustained basis.
- According to UNEP (1999), land degradation is the temporary or permanent lowering of the productive capacity of land.
- Land degradation posing a major threat to livelihood and environment security of the country.

Causes of Land Degradation

- Overgrazing
- Deforestation
- Inappropriate
- Agriculture practices.
- Other includes
- careless Forest management,
- increasing biotic pressure,



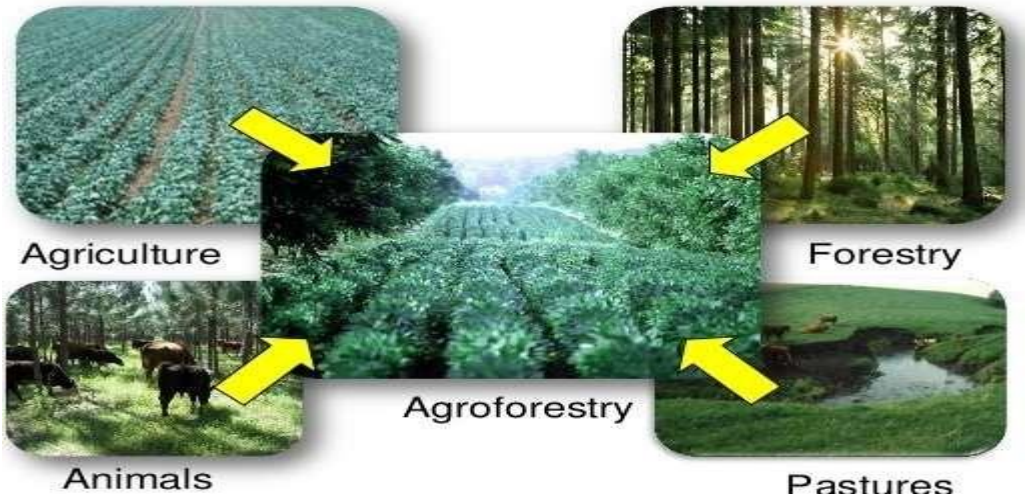
- surface mining,
- urban planning and
- commercial/industrialdevelopment & etc.

Land Degradation- A Global problem

Continent	Total Area (million Km^2)	AreaDegraded (million Km^2)	Percent^{Degraded} (million Km^2)
Africa	14.326	10.458	73
Asia	18.814	13.417	71
Australia and Pacific	7.012	3.759	54
Europe	1.456	0.943	65
North America	5.782	4.286	74
South America	4.207	3.058	73
Total	51.597	35.922 Bekele, (1992)	70

Agroforestry

- Agroforestry- An old practice, but a new science.
- A specialized way of farming crops and trees in various combination on the landscape.

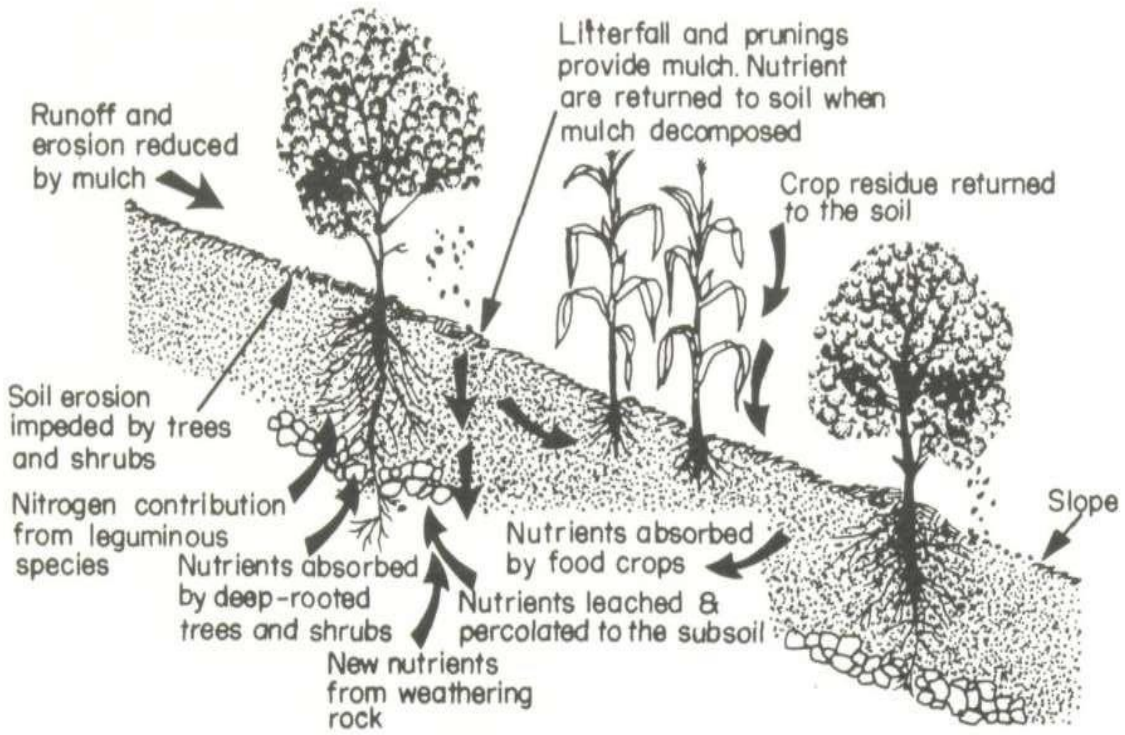


Soil fertility improvement using Agroforestry Practices

- Agroforestry promotes a more efficient cycling of nutrient because tree roots extend into portions of the soil profile (B and C horizons) and extract nutrient that may not be accessible to annual crop root systems

- Leguminous tree species have potential for soil fertility improvement and soil water conservation since soil fertility improvement can be achieved through biomass transfer, long/short term fallows, nitrogen fixation

Soil fertility improvement using Agroforestry Practices



Waterlogged soil amelioration using Agroforestry Practices

- Tree act as a bio-drainage.
- Root systems of tree intercept saturation zone water table to control shallow water table.
- Plantations act like groundwater pumps, pumping water at the rate of.

Mechanisms of soil improvement in AF

- Plantation of compatible and desirable species of woody perennials on farm land improves the organic matter of the soli , increase activity of favorable microorganism in the root zones.
- Inclusion of trees in AFS result in improvements in physical conditions of the soil thereby enhancing the permeability, water holding capacity , aggregate stability and soil temperature regimes.
- Inclusions of trees in farm land reduces the risk of soil erosion (reduction in rate of siltation of downstream aquatic ecosystem , dams and reservoirs.
- Presence of trees on farm land improves the hydrological characteristics of catchment area.
- Improves the physical properties of soil (Structure and texture).
- Maximum utilization of soil nutrients.
- Improves nutrient cycling.
- Dinitrogen fixation by trees(legume trees).

- Shelter and wind break.
- Enhances ecosystem stability.

Soil erosion a major reason for declining crop productivity

- A major cause of soil erosion is deforestation. The huge gap between deforestation and tree plantation in the topics is the most acute problem.
- The world resources Institute has estimated that 160 millions ha of upland watershed in the Himalayas and Andean range, and in the central American , Ethiopian and Chinese highlands, have been seriously degraded due to human interference.
- Cheerapunjee, once the westest area in the world and covered by dense tropical forest, is now practically devoid of vegetation.
- Overcutting for fuel wood and overgrazing trends to accelerated desertification .
- Extensive deforestation results in raised river beds, which reduces their water – carrying capacity and consequently their irrigation potential.

Some of the reasons for this rapid rate of deforestation are:

- Overcutting for timber and fuel wood.
- Overgrazing in arid and semi arid region.
- Commercial greed and careless technology.

Consequences of deforestation.

- Rise in sea level.
- Flooding/Inundation of coastal area.
- Acceleration of erosion at the seashore.
- Creation of salinity.
- Shifting of population.
- Reduction of water table.

Lecture 10 Conceptual framework for designing AFS

The Agroforestry Design Tool is based upon positioning plant species that occupy different forest layers in orientation to each other in time and space (short-, medium-, and long-term crops). Agroforestry is a collective name for land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land-management units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence.

Produce for Designing agroforestry project

1 Information collection

2 Feasibility study

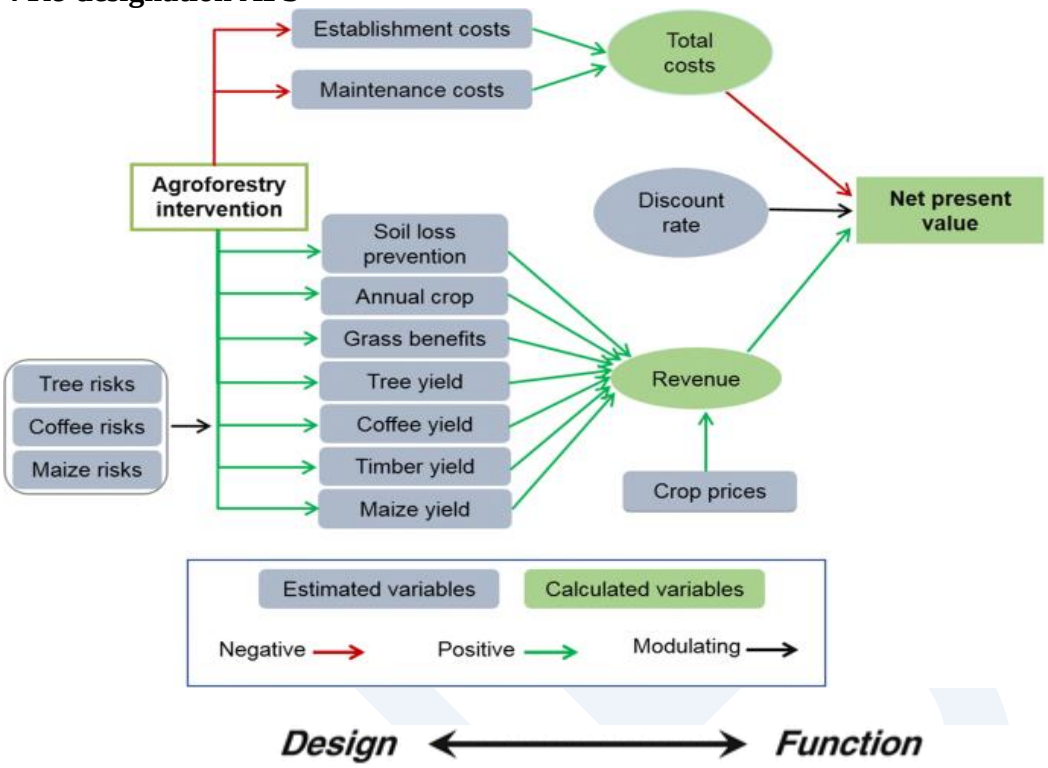
- Site selection criteria
- Prioritization of AFS
- Strategy

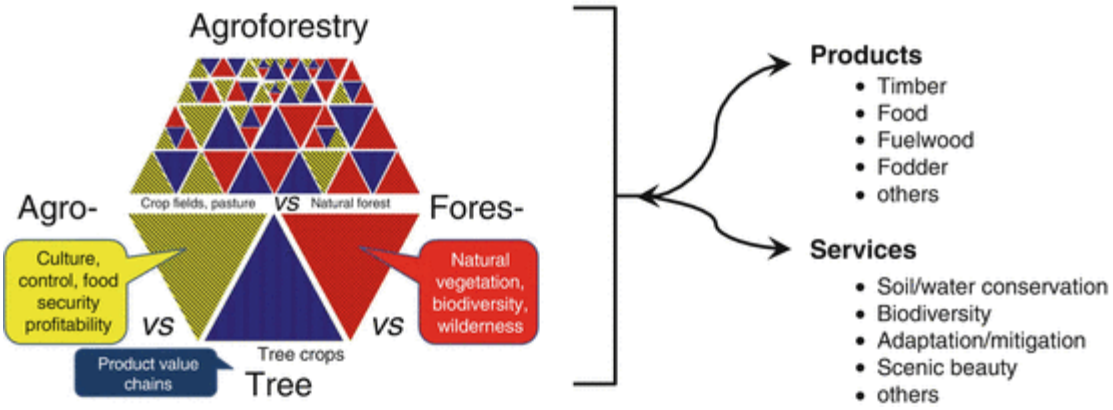
3 Technical Design

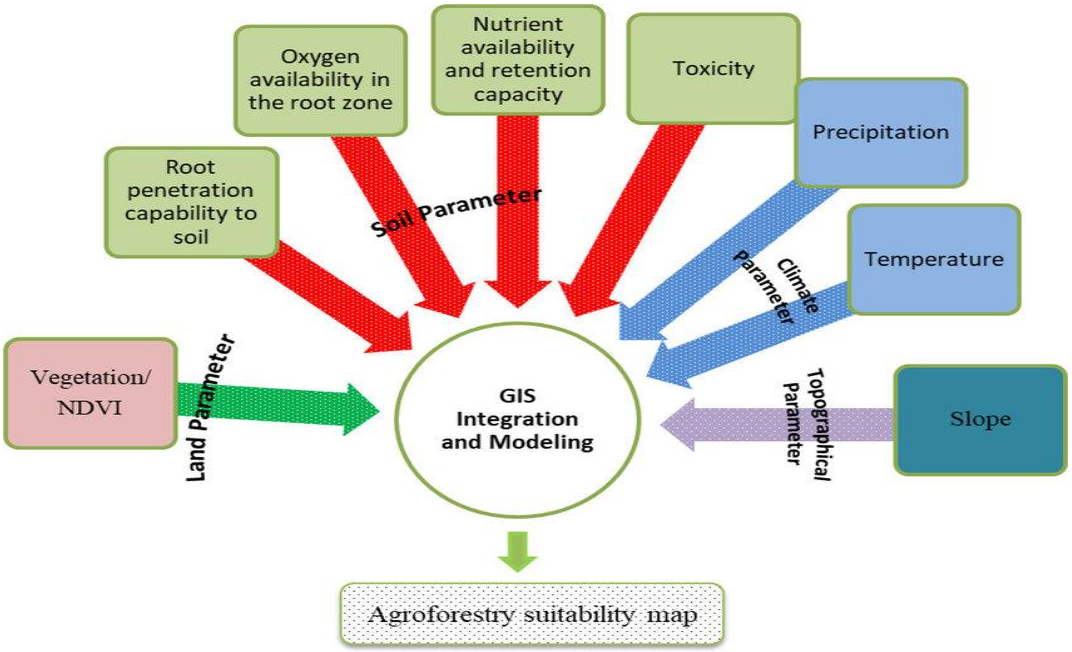
- Vertical space arrangement
- Horizontal deposition
- Temporal structure

- Technical structure
- Resigned model

4 Re-designation AFS







Lecture 11 Factors Affection Agroforestry Systems

1. Climatic factors

More than any other factors, climatic factors affects significantly the agriculture and Agroforestry practices in any region.

- Rainfall, solar radiation ,temperature and Humidity are important factors that directly affect the crops planted in the Agroforestry systems.
- Rainfall also affect the rates of Soil erosion , sediment yields and surface runoff.

2. Biophysical factor

- Site factor such as soil characteristics, slope and terrain as well as plant communities play an important roles in the development of Agroforestry practices.
- It is generally assumed that tropical soil are much older and infertile than temperate soils.
- Much of the fertility of the tropical soils are tie-up with biomass or organic matter of green plants.
- In slash and burn agriculture , removal of the plant biomass also decrease the fertility levels of the soil.
- The increased soil erosion rate due to the removal of the ground cover leads to faster degradation of uplands soils.

3 **Socioeconomic factor**

- Most of the farmers in the upland hills and mountain are resource poor farmers and occupy the lowest economic strata of society.
- The farming is basically subsistence type. Food insecurity becomes a matter of great concern for most of these farmers. Besides , they need some cash to buy essential goods from the markets.

- Therefore , the agricultural or the agroforestry production systems must take into account not only the subsistence needs of the families in term of food, fuel wood, fodder but also some cash incomes to meet their growing needs.
- Therefore, the development of appropriate models of Agroforestry system in a given area is basically an interaction function of climatic , biophysical and socioeconomic factors prevalent in the area.
- A detailed and careful study of these factors constitute the most important step in the design of Agroforestry system.

4 Natural Resource Base

1. **Water resource**

- To a large extent water is influenced by climatic factors specifically the amount of the rainfall and the occurrence of seasonal phenomenon such as monsoon.
- In the upland , the type of vegetation , soil properties, Management practices and land use policies paly important roles in maintain this important resources.

5 Land and Forest resources.

- Most of the land subjected to slash and burn agriculture is forest land . Population pressure and poverty are two important reasons that drive lowlanders to the uplands.
- Mismanagement of these fragile resources not only affects erosion rates, surface runoff, landslides and nutrient losses in the uplands but also may cause destructive floods, siltation of rivers, dams and the agricultural fields in the lowlands during rainy season and possibly destructive of riverine ecosystem down streams.
- In essence ,the removal of forest resource in the uplands may create a chain of harmful consequences in the lowlands affecting a greater number of people.

Human Resource

- Human resource in the uplands are important components of the natural resource base.
- Human Adaptation and the evolution of agricultural farming systems in the fragile ecology of the uplands hills and mountain must be taken into account while developing appropriate Agroforestry systems in the uplands.

6 Finance

7 Marketing

Lecture 12 ICFAFs diagnostic and design

International Center for Research in Agroforestry / ICRAF

The International Centre for Research in Agroforestry, ICRAF, has an ultimate purpose guiding its research. It is to work towards mitigating tropical deforestation, land depletion and rural poverty through improved agroforestry systems. Its goal is to initiate and assist in the generation and dissemination of appropriate agroforestry technologies for resource-poor farmers and other land users.

Headquarters - Nairobi, Kenya

The International Council for Research in Agroforestry (ICRAF) was created in response to a visionary study in the mid-1970s led by forester John Bene of Canada's International Development Research Centre (IDRC). The study coined the term "agroforestry" and called for global recognition of the key role trees play on farms. This led to the establishment of ICRAF in 1978 to promote agroforestry research in developing countries.

Definition Agroforestry D & D is a family of procedures for the diagnosis of land management problems and potentials and the design of agroforestry solutions. The ICRAF has developed an approach to assist agroforestry researchers and development fieldworkers to plan and implement effective research and development projects.

Key Features of D & D

i) Flexibility: D & D is a flexible discovery of procedure, which can be adopted to fit the needs and resources of different users

ii) Speed: D & D has been designed with the option of a 'rapid appraisal' application at the planning stage of a project with In-depth follow-up during project Implementation.

iii) Repetition: D & D is an open-ended learning process. Since initial designs can almost always be improved.The D & D process need not end until further Improvements are no longer necessary.

WHAT IS D&D? DIAGNOSIS AND DESIGN

D&D is a methodology for the diagnosis of land management problems and design of agroforestry solutions. It was developed by ICRAF to assist agroforestry researchers and development fieldworkers to plan and implement effective research and development projects.

THE KEY FEATURES OF THE D&D:

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3. REPETITION

D&D is an open-ended learning process. Since initial designs can almost always be improved, the D&D process need not end until further improvements are no longer necessary.

Criteria of Good Agroforestry Design

A good agroforestry design should fulfill the following criteria:

i) Productivity:

There are many different ways to improve productivity with agroforestry viz., increased output of tree products, improved yields of associated crops, reduction of cropping system inputs, increased labour efficiency, diversification of production, satisfaction of basic needs and other measures of economic efficiency or achievement of biological potential.

ii) Sustainability:
By seeking improvements in the sustainability of production systems, agroforestry can achieve its conservation goals while appealing directly to the motivation of low income farmers, who may not always be interested in conservation for its own sake

iii) Adoptability:
No matter how technically elegant or environmentally sound an agroforestry design may be, nothing practical is achieved unless it is adopted by its intended users. This means that the technology has to fit the social as well as environmental characteristics of the land-use system for which it is designed

Procedures of AF Diagnosis and Design The procedures of AF D & D are usually done of two types:
1) 'Macro' D & D and
2) 'Micro D & D '

i) MACRO D & D

- An agroforestry research programme normally begins with a macro D & D exercise covering an entire large ecological zone with I n a country.
- This consists of a rapid appraisal
- Secondary information complemented by a few selected surveys in the field. by a few selected surveys in the field. .
- Macro D & D includes on assessment of existing land use system constraints, agricultural policies and institutional arrangement, current agroforestry practices and the potential for improving productivity and sustainability through agroforestry interventions.
- The study zone is a broad region chosen for its importance at the national level.
- Macro D & D is usually followed up by a national or regional workshop to analyze the common problems and potentials of land-use systems in the zone to identify agro-forestry technologies with potential relevance for the zone as a whole, to identify specific land-use systems as the focus for future research and development efforts and to establish preliminary research requirements.

Its selection is usually based on the following factors.
- Contribution to food production and the national economy;
- Population area
- Urgency of problems or importance of unexploited potential
- Level of agricultural development and land use intensification

ii) MICROD & D

- Land-use systems within the chosen small ecological zone
- Leading to the selection of target systems for more detailed analysis by micro D & D.
- A land-use system is defined as a distinctive combination of crops, livestock, trees and other production components.
- The primary focus of analysis is the management unit that makes decisions and shares resources, objectives, labour and products.

- Analysis of a land-use system comprises all the characteristics that affect its management and performance.
- An important aspect of micro D & D is an analysis of the needs, objectives, and constraints of land-users.
- This step is based on interviews and field surveys.
- One major aspect of micro D & D is the analysis of existing knowledge and agroforestry practices.
- Any performance gap can be evaluated by comparing present resources and outputs (what the farmers are actually producing) with biophysical potentials (for instance the yields obtained from on-station or on farm experiments).

These characteristics include the following:
- Location: Administrative and political divisions
- Environmental characteristics
- Socio-economic characteristics
- Land-use
- Resources/supporting service
-Development activities and policies.

These two levels
In making the analysis, it is helpful to distinguish between constraints and potentials of existing land use systems and those that pertain to the appropriateness of potential agroforestry technologies. These two levels of evaluation (dealing with constraints and potentials of different types) are part of a sequence of analyses outlined below:

Diagnostic Phase
1. Characterize the essential features of structure and function in the existing land use system and identify the output subsystems.
2. Evaluate the performance of the subsystems (that is, identify problems).
3. Determine what constraints limit the performance of the subsystems.
4. Identify general potentials for performance-improving (constraint-removing) interventions of an agroforestry nature (candidate technologies).

Design Phase
5. Determine constraints that condition the appropriateness of candidate agroforestry technologies (components and practices).
6. Identify remaining potentials for specific agroforestry technologies (existing or to be developed).
The following section discusses details of the logic of agroforestry diagnosis and design and considers what is needed at each of the above steps.

Lecture 13 Diagnostic methods and tools used in AFS
1 Farming system research (FSR)
2 Agro ecosystem analysis (AEA)
3 Rapid rural appraisal (RRA)
4 Participatory rural appraisal (PRA)
5 Diagnoses & design (D&D)

1 Farming system research

- The whole farm is viewed as a system.
- Research is conducted with a recognition and emphasis on the choice of priorities that reflect the whole farm.
- Research on a farm sub-system is legitimate FSR, provided the connections with other sub-systems are recognized and taken into account.
- Evaluation of research results explicitly takes into account linkages between sub-systems.
- As long as the concept of the whole farm and its environment is preserved, not all the factors determining the farming system need to be considered as variables -- some may be treated as parameters or constants.

Farming Systems Research (FSR) may be defined as a diagnostic process, providing acollection of methods for researchers to understand farm households and their decision-making.

Some of the major characteristics of FSR are as follows:

- *Farmer Centre Stage***.**
- *Work with Representative Farmers***.**
- *Involves an lnterdisciplinary Approach.*
- *Dynamic and Iterative Approach***.**
- *Complementary to Station-based Research***.**

Four research categories usually fall under this system. They are:

- Basic (On-station, generate new understanding of biological process)
- Strategic (On-station, solve specific research problem)
- Adaptive (On-farm, adjust technology to representative environment)
- Applied (On-farm, create new technology

Farrington et al. (1988) suggest various methodological techniques for the conduct of FSR. These techniques include:

- Analysis of secondary data and exploratory surveys
- Formal surveys and farmer monitoring
- Laboratory tests
- Direct observation in farmers' fields
- On-farm trials

2 Agro ecosystem analysis

This system was developed by Gordon Conway and researchers working in KhonKhaen University in Thailand in the early 1980s. AEA is often used in the diagnostic or planning stage of program development. This actually employs rapid rural appraisal methodology in planning research activities.

Agro-ecosystem analysis is a thorough analysis of an agricultural environment which considers aspects from ecology, sociology, economics, and politics with equal weight. There are many aspects to consider; however, it is literally impossible to account for all of them.

Agro-ecosystem Properties Both Conway (1985) and Molnar (1989) have outlined the following four key agro-ecosystem properties. They are:-

- **Productivity:** "the net increment in valued product per unit of resources, commonly measured as yield. or net income per hectare".
- **Stability:** "the degree to which productivity remains constant despite fluctuations in environmental variables such as climate or economic conditions such as market"
- **Sustainability**: "the ability of a system to maintain its productivity when subject to stress or disturbance, often diffi cult to measure".
- **Equity:** "measure of how evenly productivity of the agroecosystem is distributed among its human beneficiaries".

Tools for AEA Analysis
AEA uses semi-structured informal interviews as mechanisms for eliciting information from key informants in the village. The following tools are generally used

1 System definition
System boundaries and hierarchies are usually delineated by biophysical features such as watersheds, administrative boundaries and economic boundaries.

2 Spatial analysis
Spatial patterns are usually determined using simple sketch maps, and agro ecosystem transects indicating functional relationships with physical features (soils, elevation).

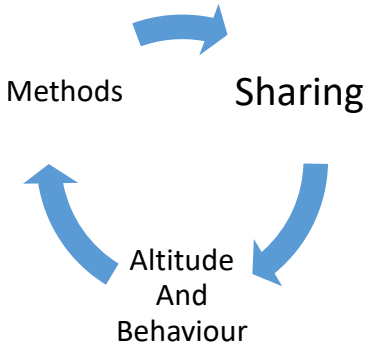
3 Time analysis
Temporal patterns are best analyzed through graphs and charts showing trends such as seasonal change, longer term changes such as prices, and changes in landscape over time. Patterns of stability, productivity are revealed in such diagrams.

4 Flow analysis
Flow diagrams help indicate the patterns of flow and transformation of commodities such as money, agricultural produce, information these can be represented as decision trees, or spheres of influence (vertu diagrams).

5 Key questions
These arise throughout the whole procedure of systems definition and are continually revised throughout the process. At the end of the exercise these questions form researchable hypotheses which should fi t into a conventional research or development programme.

3 Rapid rural appraisal
This technique was developed in the early 1980s to create a new investigate tool to improve data gathering in natural resources management programmes. International Institute of Environment and Development (IIED) in London, and the Universities of KhonKaen in Thailand and Sussex in the UK, and other several international institutes working on agricultural research have developed RRA appraisal methodology during the 1980s (Townsley, 1996)

Rapid Rural Appraisal (RRA) is an approach used for identifying quickly, inexpensively, and reliably groups and individuals most in need of primary health care. The method has been used primarily in agricultural research.



According to Chambers (1992) the techniques used in RRA include:

- Mapping and modelling to make thematic maps of resource use
- Analysis of aerial photographs
- Transect walks
- Time lines, chronology of events
- Trend analysis
- Seasonal diagrams of climate, labour, food, prices
- Livelihood analysis
- Ranking exercises
- Case studies
- Check-list, simple questionnaires
- Analysis and report writing

The RRA is a powerful data collection tool in a relatively short span of time.

4 Participatory rural appraisal

This approach emerged in the late 1980s and is based on further refinement and modification of AEA and RRA techniques. Participatory Rural Appraisal is a tool that helps target group or community through exercises in the field itself.

"Participatory Rural Appraisal (PRA) recently renamed Participatory Learning for Action (PLA), is a methodological approach that is used to enable farmers to analyses their own situation and to develop a common perspective on natural resource management and agriculture at village level.

Key features of PRA methodology

- **Building on villagers' knowledge and capabilities:** PRA builds on villagers' knowledge through techniques such as participatory maps and models using simple materials often constructed on the ground. The strength of this tool lies in 'handing over the pencil or stick' to the villager, and thus enabling villagers to express their capabilities.
- **Relaxed rapport:** The PRA process tries to develop a relaxed rapport between outsiders and villagers early in the process, to increase participation. This helps build the team spirit between the outsiders and the villagers, and sustains the participatory process.
- **Diagramming and visual sharing:** Using diagrams, models, maps on the ground with local materials (sticks, stones, seeds) helps share the information being collected with a group of people; this allows cross-checking by the group and greater participation in the analysis.

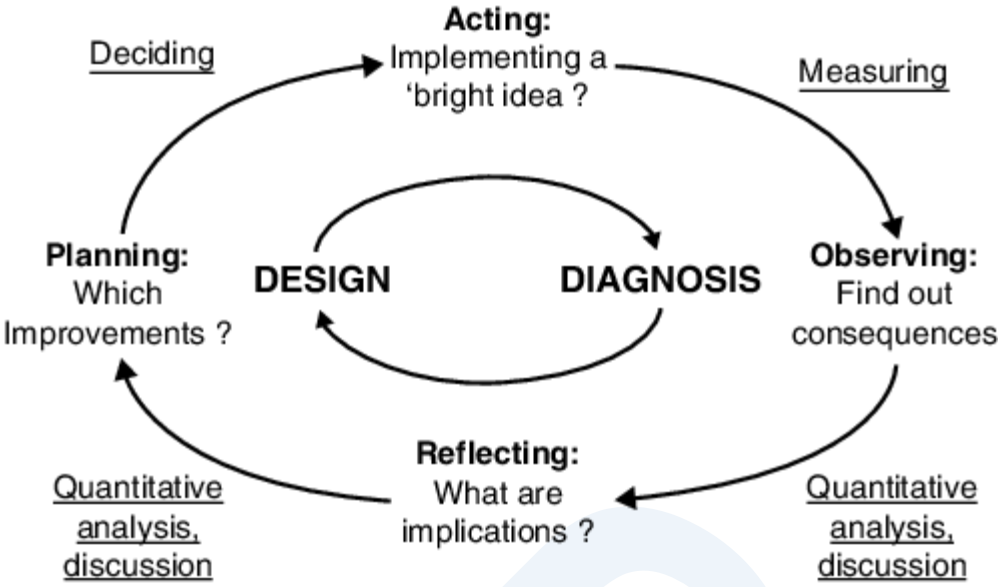
- **Sequences:** Going through a series of PRA tools, such as maps, transects, and matrix ranking, allows local people to see the interaction between different sub-systems in the village, increases their interest in the activity and allows for greater learning and analysis. Villagers are able to use their own Criteria in generating a local agenda and assessing priorities.
- **Training and reorientation for outsiders:** PTA training is simple and can have a profound effect on researchers, in terms of their behaviourial outlook towards villagers and learning from local people.

PRA has been used in four major types of processes:

- Participatory appraisal and planning;
- Participatory implementation, monitoring and evaluation of programs;
- Topic investigations (such as natural resources management, food security, health, etc.);
- Training and orientation of outsiders and villagers.

5 Diagnoses & design

DIAGNOSIS AND DESIGN D&D is a methodology for the diagnosis of land management problems and design of agroforestry solutions. It was developed by ICRAF to assist agroforestry researchers and development fieldworkers to plan and implement effective research and development projects.



The Diagnosis & Design process It follows fi ve stages:

Basic logic of AF Diagnosis and Design

Basic question	**Key factors to consider**
1 Prediagnostic stage	
Which land-use system?	Distinctive combinations of resource technology and land-user objectives.
How does the system work?	Production objectives and strategy subsystems and components.
2 Diagnostic stage	
How well does the system work?	Problems in meeting objectives, causal factors, constraints, and intervention points.
3 Design and evaluation stage	
How can the system be improved?	Specifications for problem-solving or performance-enhancing interventions.
4 Planning stage	
How can the Improved technology be developed and disseminated?	D & D needs, extension needs
5 Implementation stage	
How can the plan of action be adjusted to new information?	Feedback from research trials, independent farmer innovations etc.

Lecture 14 Management of Trees in Agroforestry

- A Silvicultural management of regime strategy is a prescribed method of manipulating the growth of trees so as to satisfy the objectives of the growers. Regimes can be varied by changing the initial tree space , time and type of thinning , degree and time of pruning , use of fertilizers plus age and method of harvesting.
- Silviculture regimes must be developed on the basis of a clear objectives appropriate to the conditions of site , topography , markets and multiple use.
- The management objectives should demand significant agriculture production.
- Therefore , the main objective of the tree management is to maximize the values of tree production without greatly reducing the agricultural potential of the site.

- The tree should be managed in such a way that it will facilitate adequate levels of light , nutrients, moisture for significant agricultural production.

TENDING OPERATIONS

Tending operations are very important especially in agroforestry as it involves both forest and agriculture crops in the same space and in time. These operations include weeding, cleaning, thinning, and climber cutting.

1 Type and timing of pruning

1.Fixed lift pruning

- It is the complete pruning of all branches below a prescribed point on the stem.
- The lift is specifies as height from the ground level and the choice of height which based on the shape of development attained by the stand.

2. Variable lift pruning

- It is a complete pruning of all branches below a prescribed variable point on the stem. This point be specified either as a proportion of height or as a diameter limit.
- The specification is often directed towards achieving green matters from the trees regardless of size.

3. Selective Pruning

- It is the removal of some of the branches on the stem at various levels above the ground according to a particular prescription.
- It is used to correct early / incipient faults in the crown or remove branches which may be difficult in Subsequent pruning.

4. Tip pruning .

- Tip pruning is the removal of branch at a point other than at its junction with the stem.
- It is used to retard the development of branch.

Basal branch pruning and selective branch pruning are the most common practices adopted in agroforestry. However , 4 other methods of pruning are often useful as illustrated below.

1. Operations which spreads the tree laterally.
2. Operation which lops off the main stem and encourage branching.
3. Operation which limits branching but leaves the main stem intact
4. Root pruning.

2 Weeding

Weeding is an important tending operation. Especially in plantations, weeding has to be carried out at least twice a year: once immediately after plantations and next in winter period. Results have shown that weeding has a remarkable effect on the height and diameter growth especially in case of Eucalyptus species.

3 Pollarding

Pollarding is normally carried out at some height above the ground so that it produces a crown of new shoots from buds below the cut. A special advantage is that the new shoots are out of reach of cattle. Pollarding is done at 1 m. to 1.2 m. height. The following species have good pollarding ability

4 Thinning

In agroforestry thinning is known as partial cuttings of planted trees. They are designed to improve future growth by regulating. Thinning grades are differentiated on the basis of the crown classes removed. In a low-grade thinning, removals are confined to over topped trees or those dead or nearly dead. The timing of each thinning of tree species varies depending on its growth and underneath crops.

5 Looping

Lopping is distinguished from pruning in that branches are not cut from the base. Also lopping is not always done starting from the lower part of the tree but can be more haphazard. If any selection of branches is made, the main criterion is often a good green leafy biomass since the lopping is usually done to obtain branches for fodder.

6 Root pruning

Farmers' tend to harvest trees as and when necessary. Harvesting age of trees varies depending on the objectives of plantation. In Terai belts of the country people in general harvest trees especially for firewood. The minimum harvestable age of some agroforestry trees (both indigenous and exotic) is provided in Table 17.

Table 17. Harvesting age of some agroforestry trees

Local name	Scientific name	Exotic	Indigenous	Minimum harvesting age (years)
Gliricidia	*Gliricidia sepium*	*		2
Ipil-Ipil	*Leucaena latisiliqua,*	*		2
Acacia	*Acacia auriculiformis,*	*		3
Cassia	*Cassia siamea,*	*		2
Masala	*Eucalyptus camaldulensis*	*		4
Masala	*Eucalyptusteriticornis*	*		4
Masala	*Eucalyptus alba*	*		5
Gamari	*Gmelina arborea*		*	3
Sisau	*Dalbergia sissoo*		*	14

6 SELECTION OF AGROFORESTRY SPECIES

Attributes of tree	Relationship of attribute with performance in agroforestry system
Height	Ease of harvesting
Stem form	Suitability for timber, posts, poles shading effects
Crown size, and density	Quality of leaf, mulch and fruit production, shading/wind effects
Rooting pattern	Competitiveness with other components
Physical and chemical composition of leaves	Fodder and mulch quality, soil nutritional aspect
Thorniness	Suitability for barrier or alley planting
Wood quality	Acceptability for fuel and various other wood products
Phenology	Timing and labour demand for fruit, fodder, seed harvest, season of fodder availability
Di/monociousness	Sexual composition of individual species; important for seed production and pollen flow
Pest and disease resistance	Important regardless of function
Vigour	Biomass productivity, early establishment
Site adoptability	Suitability for extreme sites.
Response to pruning and cutting management	Use in alley farming or lopping or coppicing

Lecture 15 Agricultural and Silvicultural management in relation to crop

- Agriculture production within an AFS may take many form such as pasture for grazing , horticultural crops, apiculture, fish poultry, agricultural crops, cash crop, forage crops, for harvesting or any combination of these. Agricultural management is highly varied due to the changing nature of the systems. Agricultural management systems is divided into the following stages on the basis of tree growth and management
- 1. Pre –planting Phase
- 2. Establishment phase (From planting to the time of first pruning/ Thinning)
- 3. Silvicultural management phase (during which all the thinning and pruning is done)
- 4. Maturing Phase (during which the trees are left virtually unattended until they reach maturity)
- 5. Harvesting phase.

1.Pre- planting Phase

This phase consists of adequate site preparation , improvement of soil fertility and weed control. In this phase the site is prepared and fertility of the site is increased by growing

one or two agricultural crops before planting trees. Emphasis for N- fixation trees will improve more soil structure and fertility

2. Establishment Phase

In this phase of management , young trees are carefully tended until they are large enough to fend for themselves.

. The crop should not grow close to the base of the trees as this will encourage competition which may affect the tree growth during its establishment phase.

3. Cropping between young trees

Appropriately managed tree planting allow considerable agro crop production in between tree rows.

4. Silvicultural management Phase

During this phase of tree development it is important to consider to do the thinning and pruning in such a way as to minimize the effects on agricultural production . Light is the most limiting factor to affect agro crops.

5. Maturing Phase

In this of management , different practices are involved beneath the maturing trees such as grazing , maintenance of soil moisture and fertility and weed control which improve the aesthetic value of the stand.

Some of the suitable trees to Integrated in land use systems of Nepal.

1. Khair*(Acacia catechu)*
2. Babul *(Acacia nilotica)*
3. Bael*(Aegelemarmelos)*
4. Siris*(Albizialebbeck)*
5. Uttish*(Alnusnepalensis)*
6. Cashew*(Anacardiumoccidentallis)*
7. Neem*(Azadiractaindica)*

ROLE OF TREES IN FULFILLING THE BASIC REQUIREMENT OF PEOPLE

Tree

- A **tree** is a tall plant with a trunk and branches made of wood. **Trees** can live for many years. ... The four main parts of a **tree** are the roots, the trunk, the branches, and the leaves. The roots of a **tree** are usually under the ground.

- Main source of food, shelter and fuel.