

Chapter one

Introduction

History of Agroforestry

- ❑ Cultivating trees and agricultural crops in intimate combination with one another is an ancient practice by world farmer.
- ❑ For example it was a general custom to clear fell degraded forest, burn slush, cultivate crops for several years.
- ❑ Tracing the history of agroforestry states that in Europe, (King 1987)
- ❑ It has been in use for at least 1300 years ago according [Brookfield and Padoch, 1994],

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- ❑ In Africa where crops are grown under scattered trees and homegarden in ancient time .
- ❑ By end the nineteenth, the large plantation of forestry and agricultural crops had become rise .
- ❑ A typical example is forest plantation establishment by Taungya system.

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- ❑ in 1970s general agroforestry accepted as a system of land management in world.
- ❑ It is applicable to both farm and forest.

Factor that impose the world to accepted agroforestry in 1970 .

- ✓ A reawakening of scientific interest in both intercropping and farming systems
- ✓ The deterioration food situation in many areas of the developing world
- ✓ The increasing spread of tropical deforestation and ecological degradation

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- ✓ Energy crisis of the 70s
- ✓ The establishment of International Development Research Centre (IDRC) of Canada, initiator for development of agroforestry.
- ❑ From 1960s to 1970 Several agricultural research in initiating organized efforts in agroforestry were held.
- ❑ These organization are Consultative Group on International Agricultural Research (CGIAR) and several International Agricultural Research Centers (IARCs) were established in different parts of the world
- ❑ The objective of these research were enhancing the productivity of major agricultural crops (or animals) of the tropics.

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- Most of the IARCs and the national programs were focusing on individual crops. Eg wheat ,maize potato etc.
- However, farmer start to intercropping .
- intercropping may have several advantages over sole cropping.
- intercropping systems more effective use was made of the natural resources of sunlight, land, and water.
- Different research indicate intercropping also used in protected pest and disease (Papendick et al., 1976).

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- In particular, it was felt that there was a need for a more scientific approach to intercropping research.
- The system were needed with respect to crop physiology, agronomy, yield stability.
- Concurrently, the International Institute of Tropical Agriculture (IITA), an IARC in Ibadan, Nigeria, extended its work to include integration of trees and shrubs with crop production (Kang *et al.*, 1981)
- the most significant single initiative that contributed to the development of agroforestry came from the International Development Research Centre (IDRC) of Canada

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- research that was being conducted on Agroforestry was haphazard and unplanned.
- Therefore IDRC Project therefore, recommended the establishment of an international organization.
- In 1997 (ICRAF) International Council for Research in Agroforestry organization established
- These Organization support, plan, and coordinate, on a world-wide basis, research combining the land-management systems of agriculture and forestry.
- in 1991 renamed as The International Centre for Research in Agroforestry (ICRAF)
- ICRAF collecting information, conducting research, disseminating research results, pioneering new approaches and systems,

- Indeed, agroforestry is fast becoming recognized as a land use system which is capable of yielding both wood and food while at the same time conserving and rehabilitating ecosystems.

1.2 Definition and Concepts of Agroforestry

- ❑ AF is a collective name for all land use systems and practices where woody perennial plants are deliberately grown on the same land management unit as agricultural crops and/or animal.(Lundgren, 1987).
- ❑ AF is a dynamic ecologically based natural resources management system that through integration of trees on farms and in the agricultural landscape diversifies and sustains production for increased social, economic and environmental benefits (Leakey, 1996)

Attributes Of Agroforestry

- ❑ Agroforestry have three attributes;
- ❑ **Productivity** : agroforestry systems aim to increase production (of preferred commodities) as well as productivity (of the land).
- ❑ **Sustainability**: agroforestry conserving the production potential of the resource by woody
- ❑ **Adoptability**: agroforestry has already been accepted by the farming community

1.3 The role of Agro-forestry

- agroforestry are a system to optimize the use of land.
- **Agroforestry have different role these are;**
 - ✓ Consistent restoration of the fertility status of the soil.
 - ✓ A variety of products, firewood, poles, woodcraft, fodder, medicinal herbs and food for livestock and man respectively.
 - ✓ Prevention of wind and water erosion.
 - ✓ Improving the micro-climate effect.
 - ✓ Increased income opportunity
 - ✓ Reduce cost for establishing plantation
 - ✓ Increased ability to manage for sustained yield.

1.4 Community, Farm, and Social Forestry

- **Social Forestry** is tree growing by the people, for the people.”
- Tree planting specifically to pursue social objectives usually betterment of the poor
- **Community Forestry**, a form of social forestry, refers to tree planting activities undertaken by a community on communal lands.
- **Farm Forestry** :tree planting on farms.
commonly used mainly in Asia

Chapter 2. Classification of Agroforestry

- 2.1 Structural basis;** refers to the composition of the components, including spatial and temporal arrangement of the different components.
- 2.2 Functional basis;** refers to the major function or role of the system, usually furnished by the woody components.
- 2.3 Socioeconomic basis:** refers to scale of management and commercial goals (subsistence, commercial, intermediate).
- 2.4 Ecological basis;** refers to the environmental condition and ecological suitability of systems

2.1. Structural classification of systems

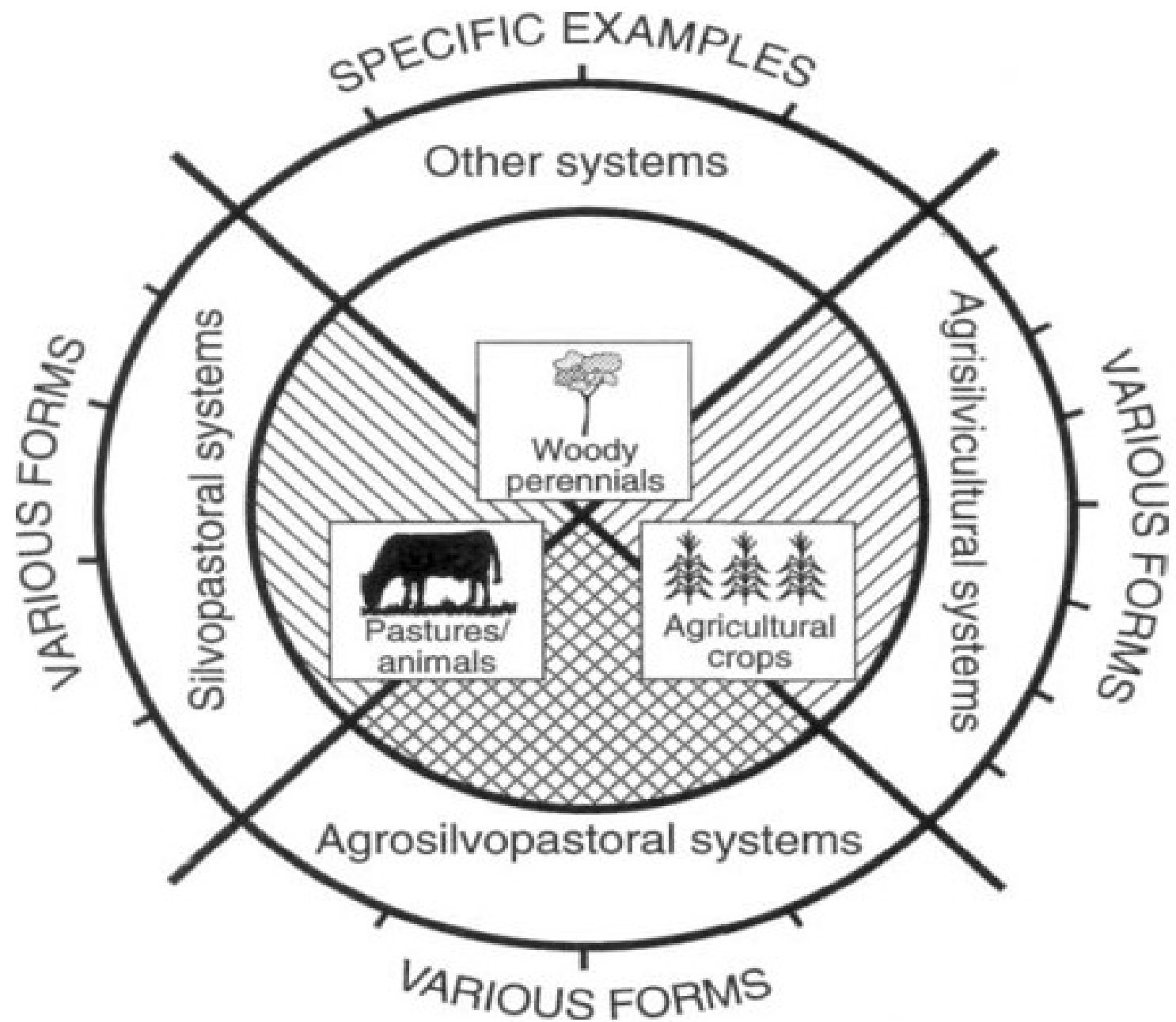
- The structure of the system can be defined in terms of its components arrangement.

2.1.1. Based on the nature of components.

- In agroforestry systems there are three basic sets of elements or components that are managed by the land user, namely, the tree or woody perennial, the herb (agricultural crops including pasture species), and the animal
- in order for a land-use system to be designated as an agroforestry system, it must always have a woody perennial.
- In most agroforestry systems, the herbaceous species is also involved.
- the notable exceptions being apiculture and aquaculture with trees, and plantation-crop mixtures

Cont...

- Based on the component Agroforestry system classify in to three:
- **Agrisilviculture** - crops (including shrubs/vines) and trees.
- **Silvopastoral** - pasture/animals and trees
- **Agrosilvopastoral** - crops, pasture/animals and trees



2.1.2 Based on the arrangement of components

- The arrangement of components refers to the plant components of the system (especially if the system involves plant and animal components).
- Such plant arrangements in multispecies combinations can involve the dimensions of space(Spatial Arrangement) and time(Temporal).
- Spatial arrangements of plants in agroforestry mixtures vary from dense mixed stands (as in homegardens) to sparsely mixed stands (as in most silvopastoral systems).

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- Moreover, the species can be in zones or strips of varying widths.
- There can be several scales of such zones varying from microzonal arrangements (such as alternate rows) to macrozonal ones.
- A commonly mentioned example of the zonal pattern is hedgerow intercropping .
- An extreme form of zonal planting is the boundary planting of trees on edges of plots and fields for a variety of purposes and outputs (fruits, fodder, fuelwood, fencing and protection, soil conservation, windbreak, etc.).

Temporal arrangements

- Temporal arrangements of plants in agroforestry can also take various forms.
- An extreme example is the conventional shifting cultivation cycles involving 2 to 4 years of cropping.
- temporal arrangements of components in agroforestry have been described by terms such as **coincident**, **concomitant**, **overlapping** (of which the extreme case is relay cropping)

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- **COINCIDENT**; Coffee under shade trees; pasture under trees .
- **CONCOMITANT**; Taungya, Annual crops under coconut; ,
- **INTERMITTENT(Space dominant)**; Seasonal grazing of cattle in pastures under trees .
- **INTERPOLATED**; Homegarden.
- **OVERLAPPING**; Black pepper and rubber .
- **SEPARATE**; Improved "fallow" species in shifting cultivation

2.2 Classification based on function of systems

- Production and protection (which is the cornerstone of sustainability) are, theoretically, two fundamental attributes of all agroforestry systems .
- agroforestry systems have a productive function yielding one or more products that usually meet basic needs, as well as a service role (i.e., protecting and maintaining the production degree of commercialization, can systems).

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- Raintree (1984) argues that any land-use system, regardless of its be described and evaluated in terms of the output of relevant basic needs such as food, energy, shelter, raw materials, and cash.
- This is the logic which underlies the basic-needs approach within the methodology for agroforestry diagnosis and design, developed by ICRAF .
- Additionally, this approach recognizes the service roles of woody perennials as factors contributing to the production of one or more of these basic needs.

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- For example, soil conservation affected by appropriate agroforestry practices can be expressed in terms of its contribution to augmenting the sustainability of crop production.
- For example, soil conservation affected by appropriate agroforestry practices can be expressed in terms of its contribution to augmenting the sustainability of crop production.
- Although production is a very important consideration in agroforestry, it is the sustainability attribute that makes it different from other approaches to land use

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- Moreover, all agroforestry systems produce more than one basic-need output (largely because of the multipurpose nature of the associated woody perennial component).
- Therefore, all agroforestry systems have both productive and protective roles.
- Depending on the relative dominance of the particular role, the system can be termed productive or protective.

2.3 Ecological classification

- Most of these agroforestry system characterizations pertain to specific ecological conditions of different geographical regions.
- It is thus easy to find several descriptions of agroforestry systems in, say, the highland, subhumid tropics (or the tropical highlands, as they are popularly known):
- for example, the Chagga system on Mount Kilimanjaro in Tanzania (Fernandes et al., 1984), hill farming in western Nepal (Fonzen and Oberholzer, 1984)

- agroforestry technologies have also been suggested for specific agroecological regions, for example, the hilly regions of Rwanda (Nair, 1983a).
- and for areas with common physical features such as sloping lands (Young, 1984) or soil constraints such as acidity (Benites, 1990).

2.4 Classification based on socioeconomic

- Socioeconomic criteria such as scale of production and level of technology input and management.
- Based on socio-economic AF systems classify into commercial, intermediate and subsistence systems.
- The term commercial is used when the major aim of the system is production of the output (usually a single commodity) for sale.

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- Examples include commercial production of agricultural plantation crops such as rubber, oil palm, and coconut, with permanent understories of food crops etc.
- commercial production of shade-tolerant plantation crops like coffee, tea, and cacao under overstory shade trees.
- "Intermediate" agroforestry systems are those that are intermediate between commercial and subsistence scales of production and management,

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- production of perennial cash crops and subsistence crops undertaken on medium-to-small-sized farms where the cash crops satisfy cash needs.
- food crops meet the family's food needs.
- The main features distinguishing the intermediate system from the commercial system at one end and from the subsistence system on the other are holding size and level of economic prosperity
- Several agroforestry systems in many parts of the world can be grouped as intermediate systems.
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- subsistence define as a farmers as those who produce most of what they consume.
- Subsistence agroforestry systems are those where the use of land is directed toward satisfying basic needs and is managed by the owner or occupant and his/her family.
- Cash crops, including the sale of surplus commodities, may well be part of these systems, but are only supplementary.

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- Most of the agroforestry systems practiced in various parts of the developing countries come under the subsistence category.
- Forms of traditional shifting cultivation found throughout the tropics are the most widespread example.

Silvopastoral (Tree +Animal)	▪Mixed Sparse(tree in pasture) ▪Strip(Width of Stripe more than one)	Protective ▪ Wind break, ▪ Shelterbelt, ▪ Shade, ▪ Soil conservation etc	Lowland sub humid tropic (eg savanna in africa	Based on the cost/benefit ▪Commercial ▪Intermediate ▪Subsistance
Agrosilvopastoral (Tree+Crop+Animal)	▪Boundary(tree on edge of field		Highland Sub humid tropic (in Ethiopia and Keniya	
Others (multipurpose tree lots, apiculture with trees etc)	Time(temporal) ▪Concident(coffee under tree ▪Concmitent(Toungy) ▪ Overlapping,(Black pepper and rubber ▪Sequential,Time domint (shifting cultivation) ▪Interpolated;Ti			

Chapter three

Silviculture of multipurpose trees

- ❑ Agroforestry species" usually refers to woody species, and they have come to be known as "multipurpose trees" (MPTs) or "multipurpose trees and shrubs" (MPTS).
- ❑ In Agroforestry MTs those trees or shrubs which are deliberately kept and managed for more than one preferred use, product, and/or service.
- ❑ Important woody perennial groups in agroforestry include fruit trees, fodder trees, and fuelwood species.
- ❑ the term MPTs encompasses all these, especially the fodder and fuelwood trees
- ❑ MPT the most distinctive component in agroforestry

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- It is incorrect, however, to assume that agroforestry species consist only of MPTs;
- the herbaceous species are equally important in agroforestry.

3.2 Tree selection and concept of ideotype

❖ **Characteristics of the species** needed vary according to the purposes

a. Fuel wood (firewood & charcoal)

❖ **Species characteristics for fuel wood are:**

- **Fast growing and short rotation (less than 10 years rotation)**
- **Coppicing ability**
- **Easy to chip**
- **High caloric value**
- **Burn without excessive smoke and ashes**
- **Absence of sparks**

E.g. Eucalyptus species, Acacia species, Azadirachta indica, Casuarina species, are among the best choices for firewood plantations.

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b. Timber

❖ **Species characteristics for timber or saw log are:**

- **Moderate to fast growth (20-25 years)**
- **Able to grow to large size, as wide diameter is important**
- **Diameter greater than 30cm at the age of rotation**
- **Straight and circular bole**
- **Strong and resistant**
- **Good seasoning and preservation abilities**
- **Easy to work and attractive appearance**

E.g. Cordia, aningeria, etc.

Cont...

c. Poles

❖ **Species characteristics for poles are:**

- **The stems should be straight, round and of adequate strength.**
- **The trees should be fast growing and able to coppice.**

E.g. Eucalyptus.

d. Pulp and paper

❖ **Species characteristics for pulp and paper are:**

- **Thick and long fibres**
- **Colour should not dark**
- **Low lignin content**

3.3 Diagnosis and design method

- ❑ D & D is a methodology for the diagnosis of land-management problems and the design of agroforestry solutions.
- ❑ It was developed by ICRAF to assist agroforestry researchers and development fieldworkers to plan and implement effective research.
- ❑ the ability to solve a problem begins with the ability to define what the problem is
- ❑ A clear statement of the problem is often all that is needed to suggest a solution.

Cont...

- o A clear statement of the problem is often all that is needed to suggest a solution
- o D & D is simply a systematic approach to the application of this principle in agroforestry
- ❑ The basic procedures of D & D consist of five stages..[Desktop\D and D.docx](#)
- ❑ The nature of data and information to be gathered, as well as the types of questions to be asked or inquiries to be conducted at each stage

Key features of D & D

- As we have seen, D & D is a methodology that has been developed specifically for agroforestry applications
- with emphasis on a comprehensive diagnosis of the problems, followed by design and implementation of appropriate interventions to solve the diagnosed problems

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Its prominent features are;

- a) **flexibility**; D & D is a discovery procedure which can be adapted to fit the needs and resources of a wide variety of land users.
- b) **speed** ; D & D has been designed to allow for a "rapid appraisal" application at the planning stage of a project with in-depth analysis occurring during project implementation.
- c) **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.

- D & D is based on the premise that, by incorporating farmers into research and extension activities
- subsequent recommendations and interventions will be more readily adopted.
- During the prediagnostic and diagnostic stages, multidisciplinary team of researchers interacts with farmers and other landusers either individually or in groups.
- These group exercises are used to characterize current agroforestry practices, identify economic, agronomic, social, and other forms of constraints to production, and discuss alternate production and management strategies

- These activities are needed to identify or elicit farmer perceptions of land-use constraints.
- Special efforts are also made to involve women in the diagnostic interviews.
- Farmer interviews are also useful in initiating linkages and developing trust between farmers and researchers, which is necessary for

- This framework is applicable to both research and extension activities.
- If the agroforestry technologies that are envisaged in the design already exist, the D & D methodology can be used directly as a guide for agroforestry interventions by extension workers.
- If, on the other hand, the desired technologies do not exist or are not fully developed, the designs can provide a basis for identifying the kind of research that needs to be undertaken.

Attribute of MPT

Tree Attribute	R/ship to performance in AF sytem
1,Heigt	Easy to harvest leaf, fruit, seed
2,Steam form	Suitable for timber, pole and shade effect
3,Physical and chemical composition of leaves , pods and Thorniness Wood quality	Fodder and mulch quality; soil nutritional aspects
4, Crown size, shape and density	Quantity of leaf, mulch and fruit production
5,Rooting pattern (deep or shallow, spreading or geotropic	Competitiveness with other components
6, Site adaptability and ecological range	Suitability for extreme sites .
7,Response to pruning and cutting	Use in alley farming, or for lopping or coppicing

Chapter Four

Agroforestry Component Interaction

- ❑ **Component interaction** refers to the influence of one component of a system on the performance of the other components as well as the system as a whole.
- ❑ **Exploitation of interactions** between woody and nonwoody (herbaceous or annual crop) components is the key to the success of all agroforestry (AF) systems.
- ❑ Therefore, a better understanding of the interactions provides a strong for improvement of traditional, as well as evolving systems.

Cont...

- agroforestry researchers, have used the terms "below-ground" and "above-ground" as adjectives to describe interactions.
- Below ground interaction rise between the components for growth factors absorbed through roots (nutrients and water).
- Above ground interaction those absorbed/intercepted light through

Cont...

- All Species interaction involved in agriculture intercropping as either " Competitive " or " Facilitative "
- These approaches have been applied to species mixture in AF.
- Competitive interaction among plants in monoculture are intense b/c all plants are similar , having similar root and crown structure , phenology and resource requirement .
- The key to designing mixture is to find combination of species with niche difference that reduce the intensity of competitive interaction .

Cont...

- One approach to identify compatible species for AF is to combine species of different life form (canopy tree, Subcanopy tree, Shrub, perennial herbs, annual herb)
- B/C life form is an indicator of the different fundamental roles plant species play in ecosystem.
- The key to reducing Competitive interaction in AF system appears is to combine a small number of carefully chosen species that different life form
- In Other important functional characteristic such as NF, Phenology and Canopy density may vary as much within as among life form.

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- The objective of designing facilitative interaction in plantation in practical economic terms is to achieve high level of productivity without incurring the cost of fertilizers and pesticide
- The use of NF species has received the most attention use in AF system.
- Combination of species may be chosen entirely to achieved high productivity through complementarily .
- The main goal AF system is to add tree to an existing food crop system to achieve greater long term sustainability .

Cont...

- However , facilitation cannot be achieved without the potential for some degree of competition b/n tree and crop
- Thus a balancing act is often required in designing species combination . in which tree must be selected to carry out the facilitative function without negating the benefit to the main crop through interspecific competition

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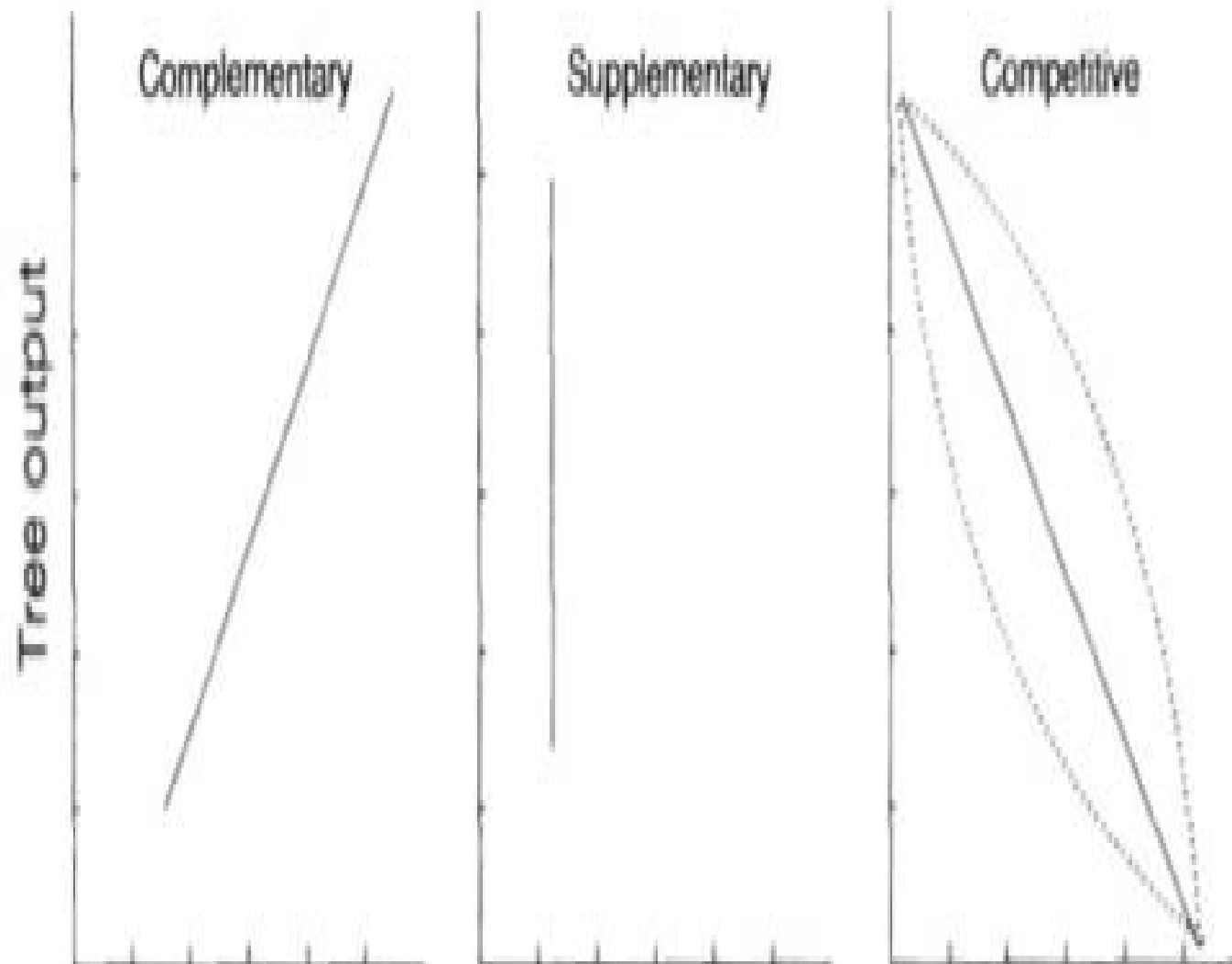
The positive or negative effects of interaction in AF can be :

a. Direct effects

result from the physical presence of the woody component in the system, which causes microclimate amelioration or nutrient additions via litter fall and root decay.

b. Indirect effects

It may result from management practices connected with or necessitated by the presence of woody perennials, e.g weeding, pruning, irrigation, or fertilization.



Nature of common types of biological interactions in agroforestry systems

4.2 Basic Interaction In Agroforestry

- woody perennials (trees) are important components of all agroforestry systems.
- Practically in AF there is two interaction ; tree-crop interactions and tree-animal interactions.
- Tree-crop interaction know as Tree crop interface (TCI)
- Tree-animal interaction known as Tree animal Interface (TAI)

	At the TCI	At the TAI
	shading trees (stress reduction	- shading
Positive	biomass contributions	manure deposition
	water conservation	
	soil conservation	
Negative	light competition	phytotoxins
	nutrient competition	browsing damage
	water competition	trampling
	Allelopathy	disease / pest

Positive (production-enhancing) interactions

- The beneficial effects of one component on another.
- The positive interaction also manipulation of negative effects to minimize their influence on the productivity of the overall system.
- The major types of positive or complementary interactions at the tree-crop interface (TCI) are those relating to microclimate amelioration and nutrient balance.
- In agroforestry systems, microclimate amelioration involves as results primarily from the use of trees for shade, or as live supports, live fences, or windbreaks and shelterbelts

Cont...

- The positive interactions at the TAI can affect overall system productivity in various ways.
- ✓ some part of the autotrophic production that is of no direct use to the farmer (such as weeds or tree fodder) can be transformed into animal biomass with high nutritional and monetary value.
- ✓ the productivity of the individual system components can be increased e.g., through the transfer of manure as a fertilizer source

Negative (production-decreasing) interactions

- Negative interaction raise as result all plant community utilize the same resource (such as light, nutrients, water, and CO₂) for growth.
- negative interactions, often through competition, are likely to occur in every plant association
- The major yield decreasing effects at the TCI arise from competition for light, water, and nutrients, as well as from interactions via allelopathy

4.3 Interaction management

- ❑ The magnitude of interactive effects between trees and other components of agroforestry systems depends on the characteristics of the species, their planting density, and spatial arrangement and management of the trees.
- ❑ Manipulating densities and arrangements is probably the most powerful method for capitalizing on beneficial effects of trees while reducing negative ones.
- ❑ tree crowns and roots can be manipulated through management operations, mainly by pruning and thinning.

5. Major agroforestry technologies/practices