



**PREPARED BY
TSEGU ERESO
DENBEL**

**BSC by Forest resource
Mgt**

**From HU in 2013 GC
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CHAPTER 1. 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.

Cont...

- ❑ 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

Cont...

- ✓ 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,

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- 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

Structure(Nature and Component Arrangement)		Function(Role/ output of component)	Ecological (Environment adaptability)	Socio economic and mgt level
Nature	Arrangement	Productivity	Lowland humid tropic.	Based on the technology use
Agrisiliviculture (Tree +crop)	In space (spatial) ▪Mixed dense (homegraden)	Food, Fodder, Fuelwood, etc	Highland humid tropic (> 1200 m, s a l)	▪Low input ▪Medium input ▪High input
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 + A	▪Boundary(tree on edge of field		Highland Sub humid tropic/in	

2.5 Agro-forestry system, practice, and technology

- The words "systems" and "practices" are often used synonymously in agroforestry.
- However, some distinction can be made between them.
- **An Agroforestry system** A system is group of physical components that is an assembly of object, connected or related in such an interdependent manner so as to form and/ or act as an entire unit.
- **An Agroforestry practice.** denotes a specific land management operation of AF nature on a farm or other management unit (field or plots). It includes an arrangement of component in space and time
- **Agroforestry technology** refers to an innovation or improvement, usually through scientific intervention, to either modify an existing system or practice,

Types of AF systems

- ❑ **Agrisilviculture systems:**

trees + crops

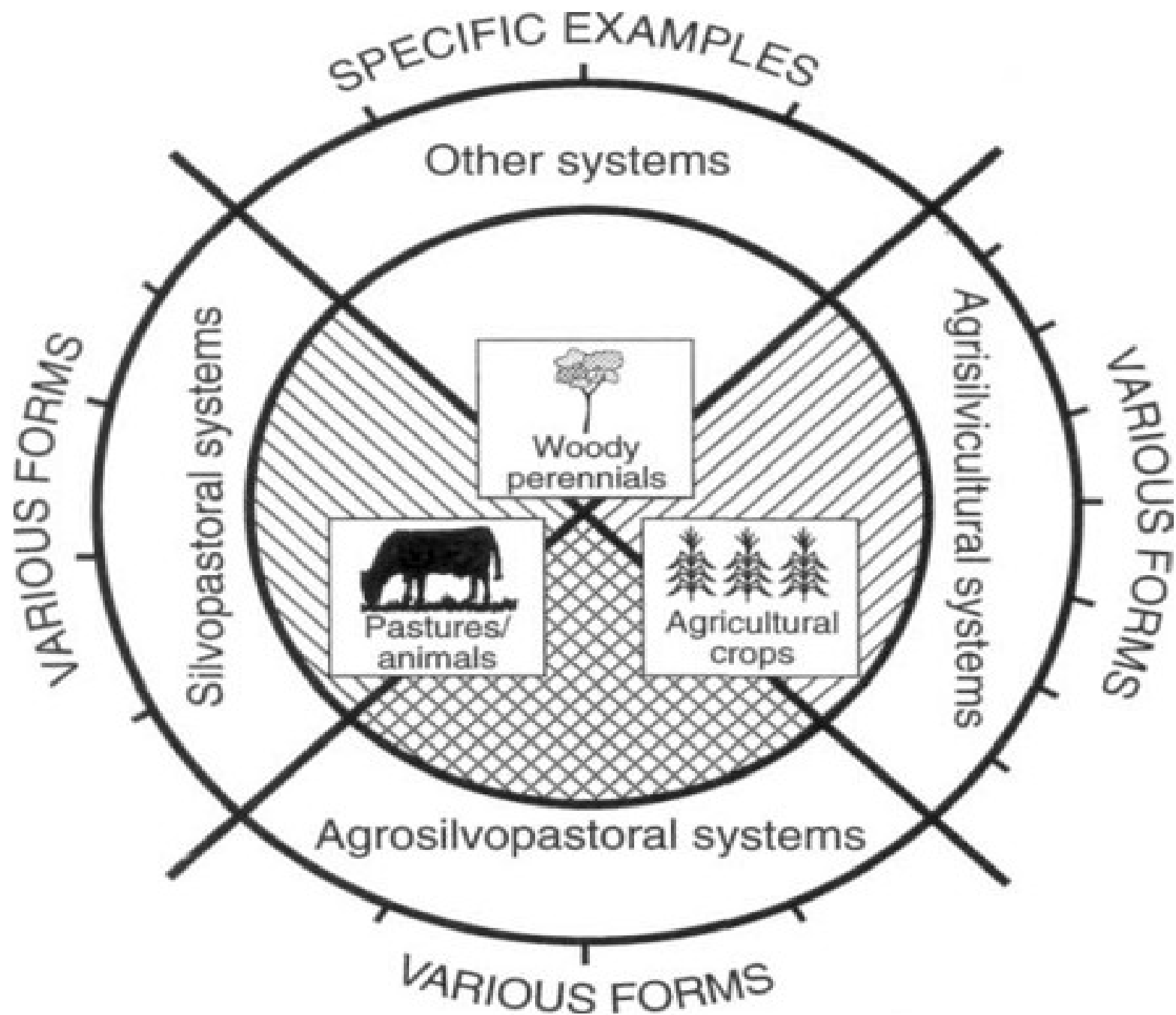
- ❑ **Silvopastoral systems:**

Trees + animals

- ❑ **Agrosilvopastoral systems**

tree + crop + animals

**These can be expressed as
simultaneous and sequential
systems**



Chapter 3. Agro-forestry Systems in the Tropics

3.1 Tropical environment

- “Tropics” part of the world located between 23.5 degrees north and south of the Equator.
- tropics in a general sense, they includes the subtropical developing countries
- Majority of the people work and depend on the land for their livelihood.
- yet agricultural production per unit area is very low.
- Most nations and people in the tropics are poor; gross domestic product per person is low (about \$ 100-150 per year)

3.2 Ecological spread of major Agro-forestry systems

- ecological factors determine the major type of agroforestry system in a given area.
- Socioeconomic factors, such as human population pressure, availability of labor and proximity to markets, are also important determinants.
- Agroecological factors have a considerable bearing on the functional emphasis of agroforestry practices.
- Eg agroforestry practices in sloping lands is erosion control and soil conservation; in wind-prone areas the emphasis is on

Major Types Of Agroforestry System in Tropics

☐ ***Humid Lowlands***

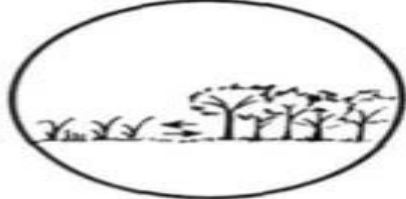
- ✓ Shifting cultivation ,Plantation-crop combinations, Taungya, Multilayer tree gardens ,Intercropping systems

☐ ***Semiarid Lowlands***

- ✓ Silvopastoral systems, Windbreaks and shelterbelts, Multipurpose trees for fuel and fodder ,Multipurpose trees on farmlands

☐ ***Highlands***

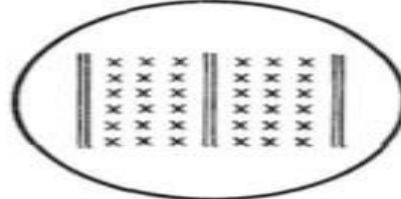
- ✓ Soil conservation hedges, Silvopastoral combinations Plantation-crop combinations



a
Improved
fallows in
shifting
cultivation.



B
Improvement
to taungya



C
Alley
cropping



D
Multilayer
tree
gardens



e
Multipurpose
trees on
croplands



F
Plantation
crop
combinations



g
Homegardens



H
Tree hedges
for soil
conservation



i
Trees on
pastures/
rangelands



J
Trees in
pisciculture



K
MPT woodlots
for



L
Windbreaks/
sheiterbelts

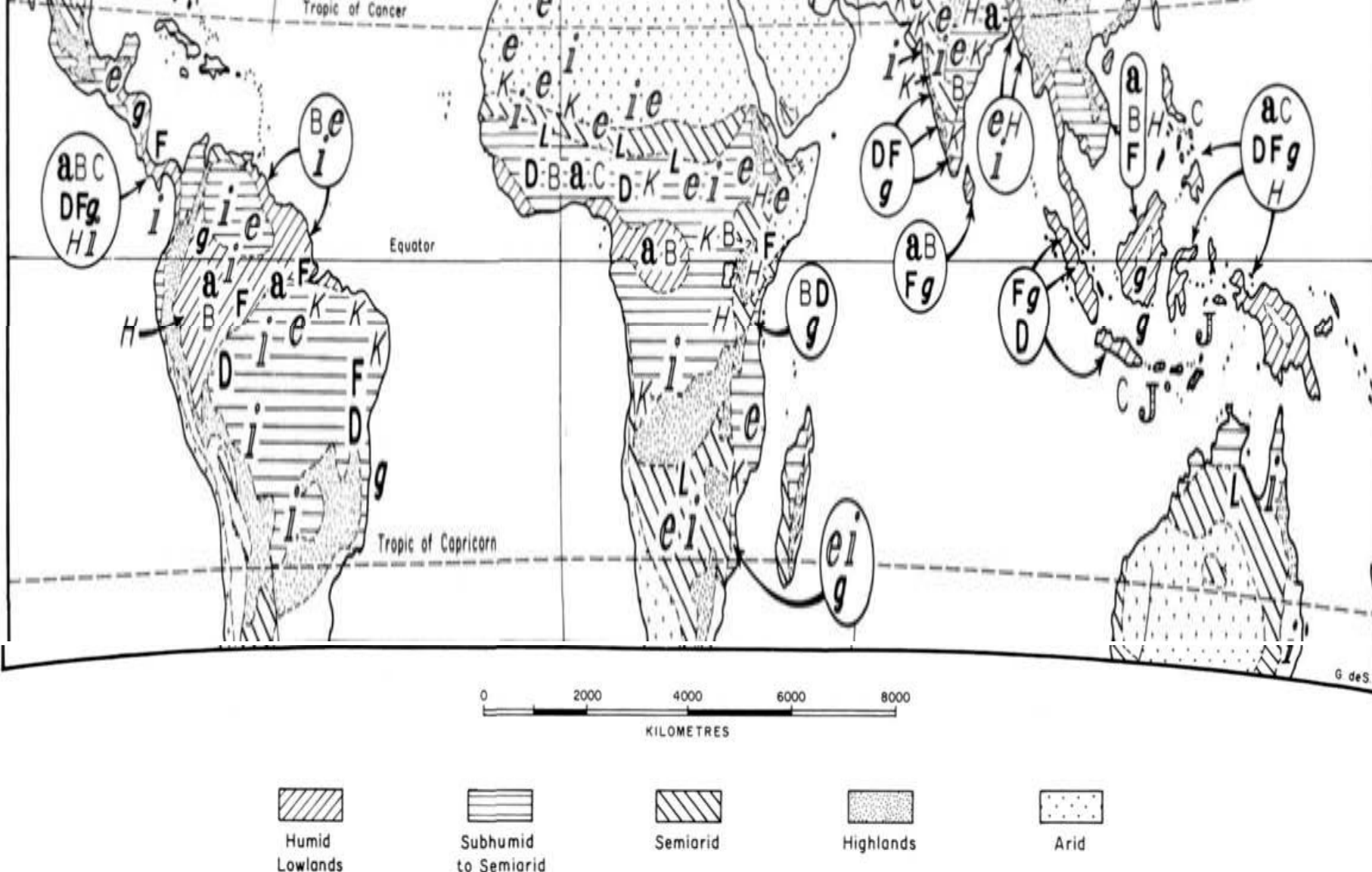


Figure 4.1. Major agroforestry systems in different ecological regions of the tropics and subtropics (see legend for systems on page 51).
Source: Nair (1989).

Chapter 4. Soil and Agro-forestry

4.1 Effects of trees on soils

☐ Trees maintain or improve soils by;

A) Processes which increase additions to the soil:

- ✓ increase of soil organic matter through carbon fixation in photosynthesis and its transfer via litter and root decay.
- ✓ nitrogen fixation by some leguminous and a few non-leguminous trees.
- ✓ nutrient uptake
- ✓ Atmospheric inputs: the provision by trees of favorable conditions for inputs by rain and dust

B)Processes which reduce losses from the soil:

- Protection from erosion and losses of organic matter and nutrients
- Reduction in the rate of organic matter decomposition, by shading and mulching
- Reduction of water loss from evapotranspiration, by shade and litter
- Increased water storage capacity, through better soil physical conditions

C) Processes, which affect soil physical conditions

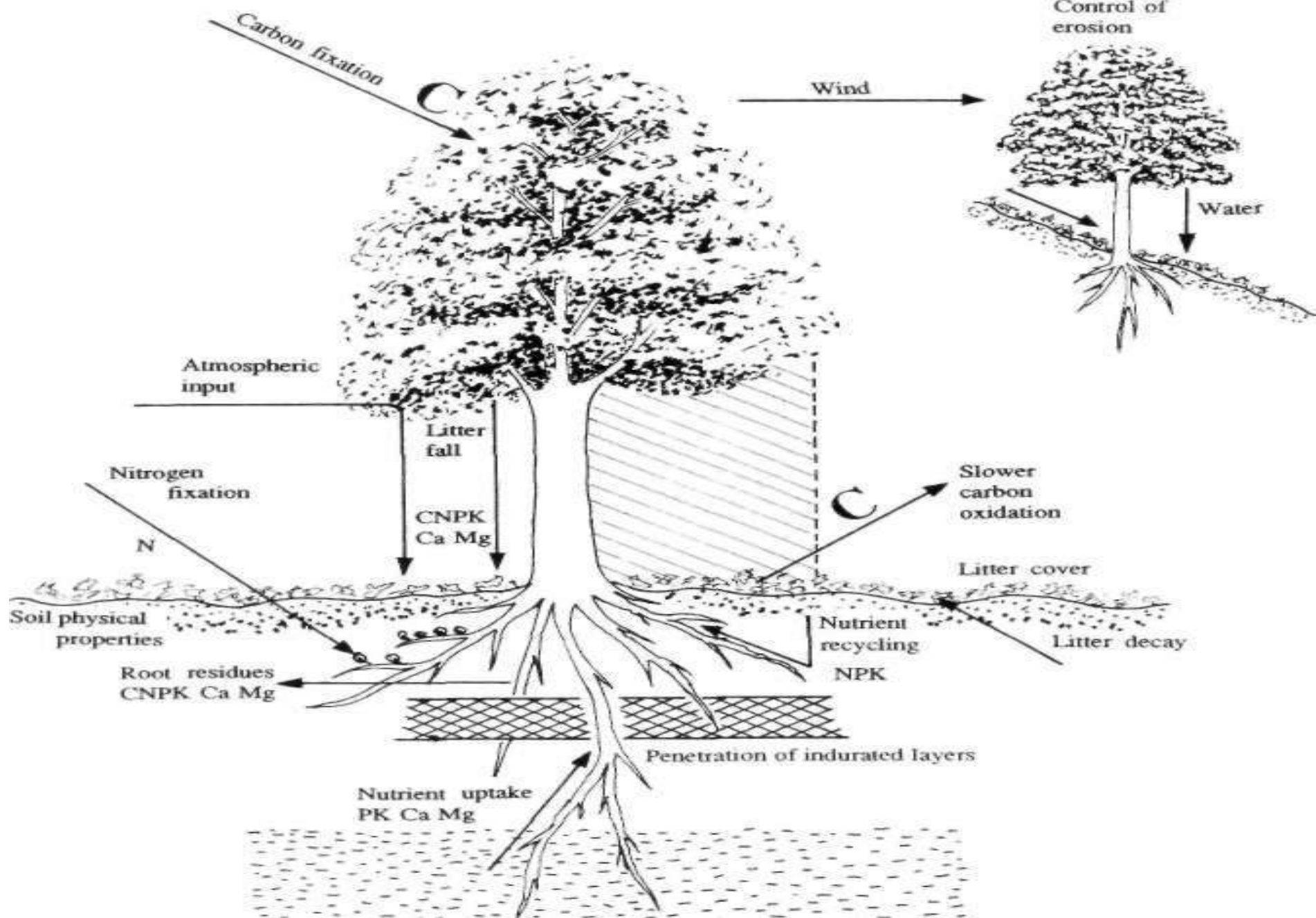
- ✓ Maintenance of soil properties through organic matter and effects of roots
- ✓ Penetration of compact or indurated layers by roots
- ✓ Modification of extremes of soil temperature, by shade and litter

(d) Processes, which affect soil chemical conditions

- ✓ Reduction of acidity, or rate of acidification, through bases in litter
- ✓ Reduction of salinity and sodicity, by trees in association with other management measures
- ✓ Reduction of soil toxicities caused by pollution

(e) Soil biological processes and effects

- Production of leaf litter of high quality, containing a balanced nutrient supply, and its transfer to the soil by litter decomposition
- Improvement in nitrogen mineralization through the effects of shade
- Increased availability of phosphorus through mycorrhizal associations
- Increased nodulation on roots of nitrogen-fixing trees in close proximity to roots of non nitrogen-fixing plants, with possible direct transfer of nutrients between root systems



Processes by which trees improve soils.

4.2 Nutrient cycling in Agro-forestry systems

- ❖ Nutrient cycling refers to the continuous transfer of nutrients that are already present in a soil – plant system, such as AF system (Nair,1993; Sanchezz Palm, 1996).
- ❖ these nutrients continuous transfer within and between different components of an ecosystem .
- In a soil-plant system, plant nutrients are in a state of continuous, dynamic transfer

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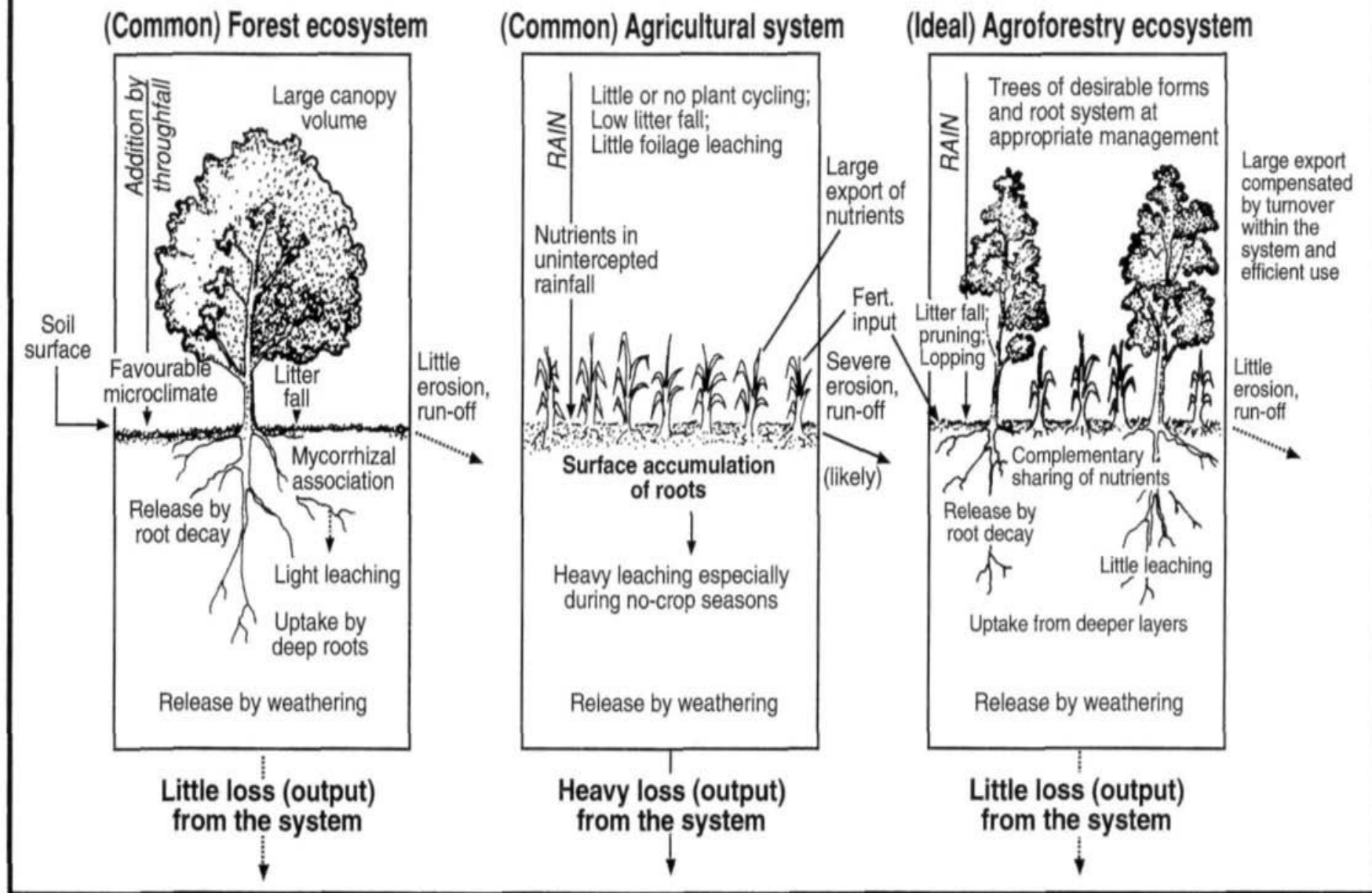
- The plants take up the nutrients from the soil and use them for metabolic processes.
- Some of the plant parts such as dead leaves and roots are returned to the soil during the plant's growth.
- Forest ecosystems represent closed and efficient nutrient cycling systems, meaning that they have high rates of turnover, and low rates of outputs or losses from (as well as inputs into) the system
- in other words, they are self-sustaining.

Cont...

- On the other hand, common agricultural systems are often open or "leaky," meaning that the turnover within the system is relatively low and losses as well as inputs are comparatively high.
- Nutrient cycling in agroforestry systems falls between these two extremes.
- more nutrients in the system are re-used by plants (compared to agricultural systems) before being lost from the system

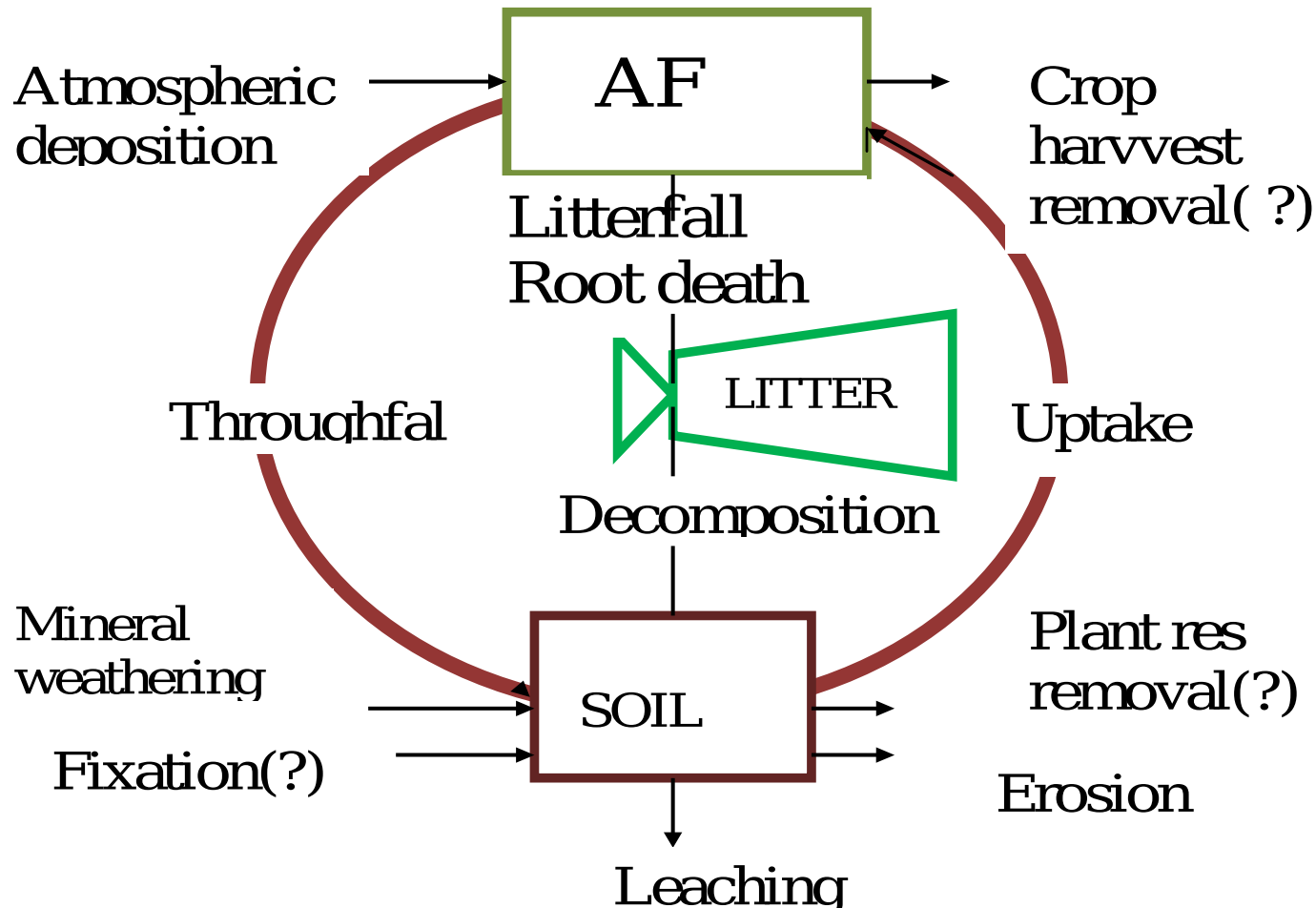
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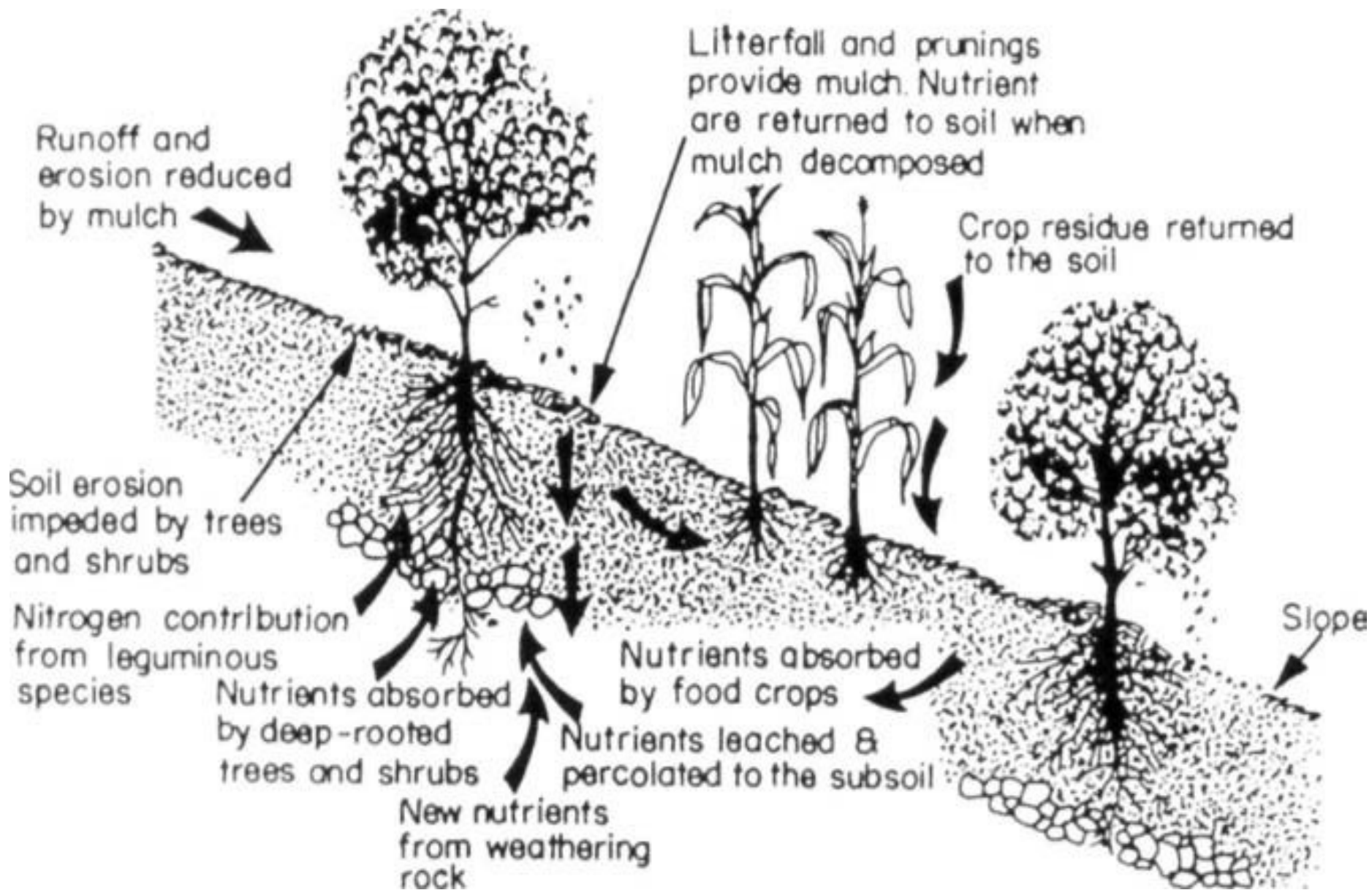
- The major difference between agroforestry and other land-use systems lies in the transfer or turn-over of nutrients within the system from one component to the other.
- and the possibility of managing the system or its components to facilitate increased rates of turn-over without affecting the overall productivity of the system.



Schematic representation of nutrient relations and advantages of "ideal" agroforestry systems in comparison with common agricultural and

Figure1. A simplified model of nutrient cycling in a agro-forestry ecosystem.





❑ nutrient cycling and erosion control in an alley-cropping system.

❑ Source: Kang and Wilson (1987)

Cont...

- In perennial vegetation and grassland ecosystems, litter and dead roots are important nutrient store.
- The nutrient status of soil is determined by:
 - the total litter produced in a unit time,
 - decomposition rate and loss determine
 - the amount of litter present.

Cont...

- ❖ Agroforestry systems are commonly important for more efficient nutrient cycling than many other systems because ;
- ✓ woody perennials produce more extensive and deeper root systems than herbaceous plants, and have a potential to capture and recycle a larger amount of nutrients.
- ✓ litter contribution to the soil's surface is probably also greater than that of herbaceous plants

4.3 Soil organic matter

- ❑ Soil organic matter (SOM) is the fraction of the soil consisting of plant and animal residues in various stages of decomposition.
- ❑ Organic matter contains mainly **organic carbon and nitrogen**.
- ❑ **Carbon is a source of energy and nitrogen is a source of protein** for microorganisms in the soil. SOM consists of three distinct parts.
- ❑ **SOM consists of three distinct parts.**
 - 1 Living organic matter** (about 15%) consists mainly of decomposers .i,e Bacteria, Fungia, Protozoa etc

Cont...

- 2. *Dead organic matter*** (about 15%)
serve as food for living organisms and include dead microbes, old plant roots, crop residues and bodies of larger insects and animals.
- 3 . *Very dead organic matter*** (about 70%) are well decomposed, **dark colored organic substances also called humus.** Humus continues to decompose, but at a very slow rate.

4.4 Role of roots

- **Roots have various functions in agroforestry:**

- ❖ Physical support
- ❖ Uptake of water and nutrients for plant growth even from deeper horizon
- ❖ Nutrient and organic matter addition
- ❖ Reduce leaching process
- ❖ Through root exudates to assist the binding of soil particles into structure aggregates
- ❖ The root biomass production of trees is **20-30% of total biomass**(equivalent to 25-43% of above-ground biomass)
- ❖ Conversely the proportion of root becomes higher on **soil in low nutrients or where there is water stress**

Types of tree root system

a. Coarse or structural roots, of medium to large diameter.

- ✓ they are relatively permanent and used for support
- ✓ pruning of the above ground part temporally may checks root growth

b. Fine or feeder roots;

- Fine roots are root that have diameter $\leq 2\text{mm}$
- die back and regrowth, annually in seasonal climate.
- The **dieback and shedding of root residues** are in most respects comparable with aboveground litter production
- In terms of **higher carbon allocation, root may take a larger share than** is indicated by simple comparison of biomass mentioned above

Cont...

- c. Very fine or root hairs- nutrient uptake and major nitrogen fixing hosting sites.
- d. Mycorrhizae root-symbiotic association with soil fungi.

4.5 Trees and shrubs for soil improvement

❑ PROPERTIES OF TREES WHICH FAVOUR Soils IMPROVEMENT

- high biomass production nitrogen fixation
 - a well-developed rooting system
 - high nutrient content in the biomass, including roots
 - fast or moderate rate of litter decay
 - absence of toxic substances in foliage or root exudates.
- ❑ Generally Trees/shrubs in AF system maintaining soil organic matter levels through.
- ✓ the supply of litter; and
 - ✓ root residues is the major cause of soil fertility improvement

Chapter 5 ;Agro-forestry Practices (the 20 agro-forestry practices)

. 5.1 Shifting cultivation

- Shifting cultivation may be the oldest system devised by humans to exploit the forest ecosystems. Known as slash and burn systems
- A simple definition “ Shifting cultivation is any continuing agricultural system in which temporary clearings are cropped for shorter periods in years than they are fallows”

Types of Shifting cultivation

- a. **Pioneering shifting cultivation** can be defined as the type of shifting cultivation where new land is cleared continuously and settlements move frequently.
- b. **Rotation shifting cultivation** is where settlements are fixed and field are rotated with in “walking” distance form the settlement
- The pioneering type is normally referred to as “**nomadic**” whilst the rotational type is referred to as “**stable**” by some authorities.

5.2 fallow

- ❑ The term 'fallow' as conventionally used refers to agricultural land **lying idle**, either abandoned or as a means '**to rest tired soils**'.
- ❑ Tropical fallows can be described **as natural, enriched, or improved**.

A) Natural fallow

- are early succession stages of secondary vegetation after a cropping period (Nye and Greenland, 1960; Uhl and Jordan, 1984).
- Natural woody fallows are the backbone of shifting cultivation systems. They are known by a variety of names such as bush fallow and *jachere* in Africa and *barbecho*, *purma*, and *capoeira* in Latin America.
- Natural grass fallows are either (i) weeds left after crop production together with re-growth of grass vegetation or (ii) the result of fire climax vegetation after cropping.

Enriched fallows

- are those where **certain tree species are planted at low densities into natural fallows** to **produce high-value products such as** fruits, medicines, or high-grade timber to provide economic benefits during the fallow period (Brookfield and Padoch, 1994).

Improved fallows

- they consist of **deliberately planted species – usually legumes** – with the primary purpose of fixing N_2 as part of a crop–fallow rotation.
- **Improved fallows with herbaceous legumes are commonly called green manures or sometimes cover crops.**
- Planted fallows are an improvement over natural fallows in that the objectives for which natural fallows have traditionally been used are attained in a shorter time through manipulation of management operations such as **choice of tree species, spacing, density, establishment, and pruning.**

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- **One of the diagnosed problems in slash and burn systems is declining soil productivity due to shortening fallows periods.**
- **Traditional fallows take long to reach the peak of biological productivity.**
- **Their efficiency is closely linked to the length of fallow period.**

Improved fallow with fertilizer shrubs

- **Improved fallows** are very different; they consist of deliberately planted species – usually legumes – with the primary purpose of fixing N_2 as part of a crop–fallow rotation.
- They cover entire fields in a farm. Improved fallows with herbaceous legumes are commonly called green manures or sometimes cover crops.
- Improved fallows with woody legumes are usually called by the tree used, for example '*sesbania* fallows'.

Characteristics of improved fallow

- Its growth is quick, closing the canopy quickly, to suppress weeds and control erosion.
- It yields much biomass of good quality that decomposes fast and becomes fertilizer for the crops.
- It is deep rooted so that it picks up well the nutrients that are leached and deep in the soil.
- It fixes nitrogen biologically from the atmosphere, building up good nutrients overall.
- It is easy to establish and manage

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- It supplies extra products such as stakes, grain and fodder that make its use attractive.
- It will not spread as a weed into cultivated areas.
- It easily produces seeds with long viability.
- It is adapted well to resist the pests and diseases in the area

5.3 Alley cropping

- Alley cropping entails growing food crops between hedgerows of planted shrubs and trees, preferably leguminous species.
- The hedges are pruned periodically during the crop's growth to provide biomass and to prevent shading of the growing crops.
- Alley cropping is, thus, a form of the so-called hedgerow intercropping and combines the regenerative properties of a bush fallow system with food-crop production
- The underlying scientific principle of this technology is that, by continually retaining fast-growing, preferably nitrogen fixing, trees and shrubs on crop-producing fields, their soil-improving attributes
- The hedgerow systems are primarily designed to improve on the capture and cycling of nutrients, directing these resources to increase the productivity of a single crop.

- **A second characteristic is the close intra-row tree spacing.**
- **Although there can be some physical resemblance between hedgerow and tree row systems, they differ greatly in the user objectives addressed.**
- **The hedgerow systems are primarily designed to improve on the capture and cycling of nutrients, directing these resources to increase the productivity of a single crop.**

Figure 9.1. Alley cropping: Leucaena leucocephala and maize in Machakos, Kenya.



Nutrient yield

- The nitrogen contribution of woody perennials is the most important source of nitrogen for agricultural crops in unfertilized alley cropping systems.
- One of the most important premises of alley cropping is that the addition of organic mulch.
- nutrient-rich mulch, has a favorable effect on the physical and chemical properties of soil.
- Kang *et al.* (1989) and Kang and Wilson (1987) reported that, with the continuous addition of *L. leucocephala* prunings, higher soil organic matter and nutrient levels were maintained.

Table 1 Nutrient yield from five prunings of hedgerows of five woody species grown at IITA, Nigeria (4 x 0.5 m spacing).

Species	Nutrient yield (kg h ⁻¹ yr ⁻¹)				
	N	P	K	Ca	Mg
<i>Alchornea cordifolia</i>	85	6	48	42	8
<i>Dactyladenia (Acioa) barteri</i>	41	4	20	14	5
<i>Gliricidia sepium</i>	169	11	149	66	17
<i>Leucaena leucocephala</i>	247	19	185	98	16

Source: Kang et al. (1989).



Photo courtesy University of Missouri,
Center for Agroforestry



Larix laricina can be effectively integrated into a forest landscape.

5.4 Biomass transfer

- Biomass transfer is a technology that refers to cutting and carrying or 'transferring' nutrient-rich leaves of agroforestry tree species to fertilise agricultural field.
- For increase of production of high value arable crops .
- Agroforestry practices can increase the total quantity of nutrients in the soil-plant system by increasing the nutrient transfers into the system
- or reducing nutrient losses from the system.

5.5 Windbreaks and Shelterbelts



Shelter belt/windbreak homegardens arrangement

5.6 Crop under tree cover

- Trees in croplands bring about **microclimate changes** under their canopies by reducing soil and air temperature, irradiance and wind speed.
- These changes will have direct influence on soil water evaporation and humidity, which in turn may significantly affect crop growth, depending on the climate.
- Aboveground competition can be reduced by side-pruning of trees and belowground competition by periodic root pruning

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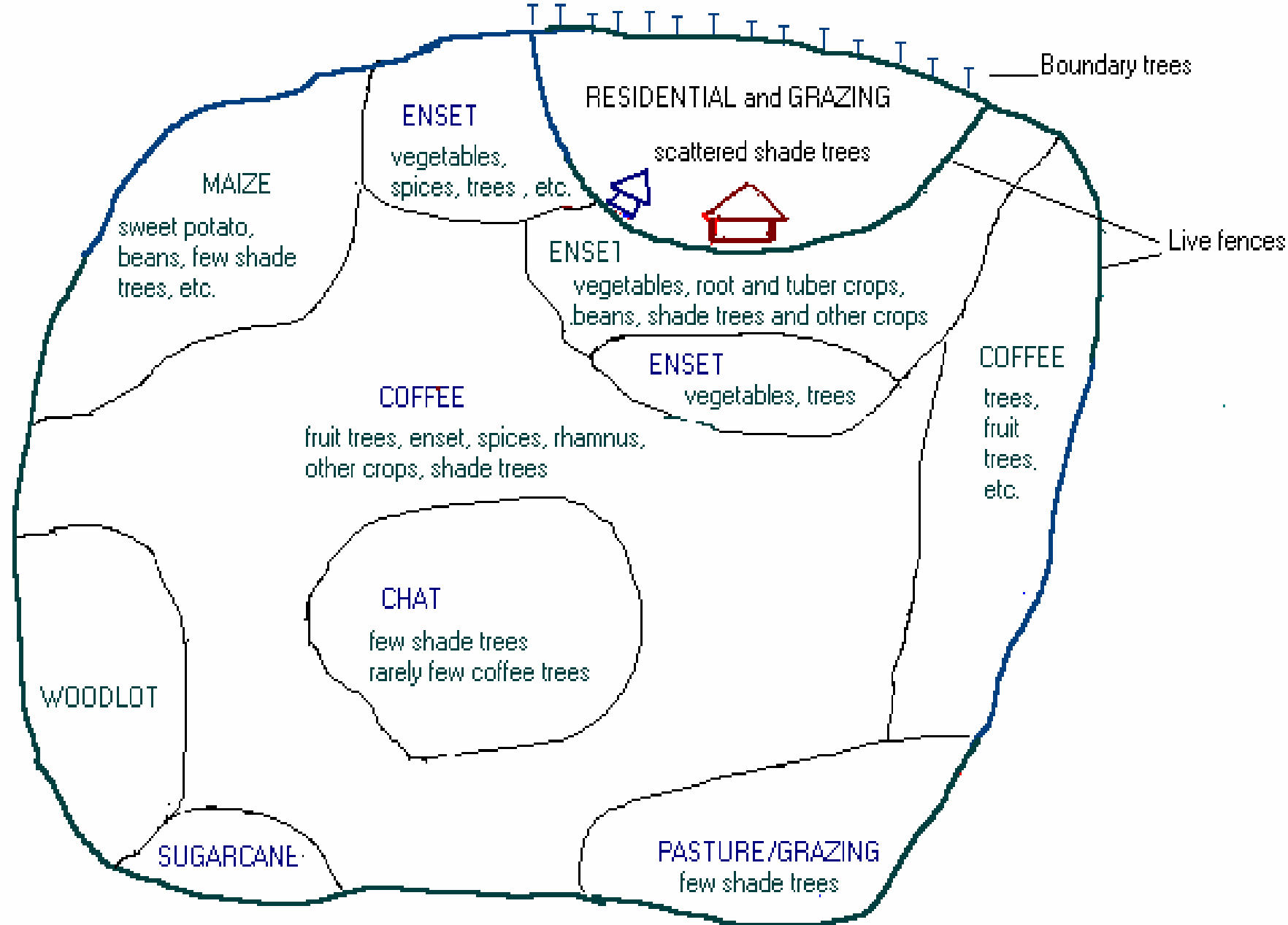
- Crop yields under trees may be unaffected during the early years of tree growth, but could increase or decrease when trees are large, depending on the tree species.
- Any positive influence of trees on crop yields through **soil fertility improvement would not be expected for many years**, as trees modify the soil environment slowly.
- It has been postulated that the beneficial effects of faidherbia on crop yields will **start only after the trees are from 20 to 40 years old** (Poschen, 1986).





7.7 Home garden

- refer to intimate association of multipurpose trees and shrubs with annual and perennial crops and, invariably livestock within the compounds of individual houses
- They are near to **dwelling places and are intensively managed by family labour.**
- A homegarden is a small scale, supplementary food production system by and for household members that mimics a natural, multi-layered ecosystem.
- They found in all tropical and sub-tropical ecozone



Examples of homegardens and their different units/plots



Structure of homegraden Af

- Homegardens are characterized by a high species diversity and usually 3-4 vertical canopy strata
- In general terms, all homegardens consist of a herbaceous layer near the ground, a tree layer at upper levels, and intermediate layers in between.
- The lower layer can usually be partitioned into two;
 - ✓ the lowermost (less than 1m height) dominated by different vegetable and medicinal plants
 - ✓ The second layer (1-3 m height) being composed of food plants such as cassava, banana, papaya, yam, and so on.

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- The upper tree layer can also be divided in two;
 - ✓ fully grown timber and fruit trees occupying the uppermost layer of over 25 m height.
 - ✓ medium-sized trees of 10-20 m occupying the next lower layer
- The intermediate layer of 3-10 m height is dominated by various fruit trees



Food production from homegardens

- The magnitude and rate of production maintenance, of the homegarden system depend on its species composition.
- choice of species is determined to a large extent by environmental and socioeconomic factors.
- This is so because food production is the predominant role of most herbaceous species. and the presence of an overstory requires that the species are shade-tolerant
- Thus, tuber crops such as taro, cassava, yam, and sweet potato dominate because they can be grown with relatively little care as understory species in partial shade

Cont...

- A the tree-crop component in homegardens is the predominance of fruit trees and other food-producing trees.
- Apart from providing a steady supply of various types of edible products, these fruit and food trees are also compatible
- Another aspect of food production in homegardens is the almost continuous production.
- Most of this production is for home consumption

5.9.Plantation crop combination

- plantation crops occupy about 8 % of the total arable area in developing countries.
- Some of these crops are not widely cultivated and they play only a minor role in national economics.
- others produce high-value economic products for the international market.
- Plantation crops such as cacao, coconut, coffee, and black pepper often are dominant components of many homegardens of the humid tropics. These systems are also usually referred to as plantation-crop combinations

Integrated land-use systems with plantation crops

- Modern commercial plantations of crops like rubber, coffee, and oil palm represent a well-managed, profitable, and environmentally stable land-use activity in the tropics.
- Many smallholder rubber plantations in southeast Asia and Nigeria are based on integrating rubber with a variety of crops, including soya bean, maize, banana, groundnut, fruit trees, black pepper, and coconuts
- In Malaysia, poultry raising in rubber stands is also a common and remunerative practice.
- the coffee and maize holdings at Jimma in the Ethiopian highlands



5. 10 Other forms of agro-forestry practices

- ❑ Types of agroforestry systems are complex and diverse, and they are virtually innumerable
- ❑ less known and location-specific System.
- ❑ They comprise a wide range of components and practices, such as
 - ✓ fodder trees and silvopastoral practices.
 - ✓ fuelwood lots.
 - ✓ scattered multipurpose trees on farmlands.
 - ✓ tree-planting for reclamation.
 - ✓ growing food producing trees.

Chapter 6. Agro-forestry Species: The 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).
- ❑ the term "multipurpose" as applied to trees for AF refers to their use for more than one service or production function in an agroforestry system (Burley and Wood, 1991)
- ❑ In Agroforestry MTs those trees or shrubs which are deliberately kept and managed for more than one preferred use, product, and/or service.
- ❑ however, to assume that agroforestry species consist only of MPTs is in corrected
- ❑ MPT the most distinctive component in agroforestry

6.2 Herbaceous species

- ❑ In the history of agricultural domestication and improvement of plants, attention has focused on nearly 30 species
- ❑ some of these nearly 30 preferred crop species should be produced in a given agroforestry system
- ❑ the herbaceous species are also equally important with MPT in agroforestry.

Chapter 7. Component Interactions

7.1 Perception of different scientists about 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...

- 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.

Cont...

- Facilitative interaction are those in which one species directly benefit another growing in mixture .
- **FOUR MECHANISM OF FACILITATION;**
 - A) Increased efficiency of nutrient cycling ;**in which one species take up nutrient unavailable to plant of all species
 - B)Improve soil structure leading to better water and nutrient retention**
 - C) Improve Moisture status of understory plants resulting from shading of overstore tree**
 - D)Reduction of loss to insect pest , pathogen or weed**

Cont...

- 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

Cont...

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

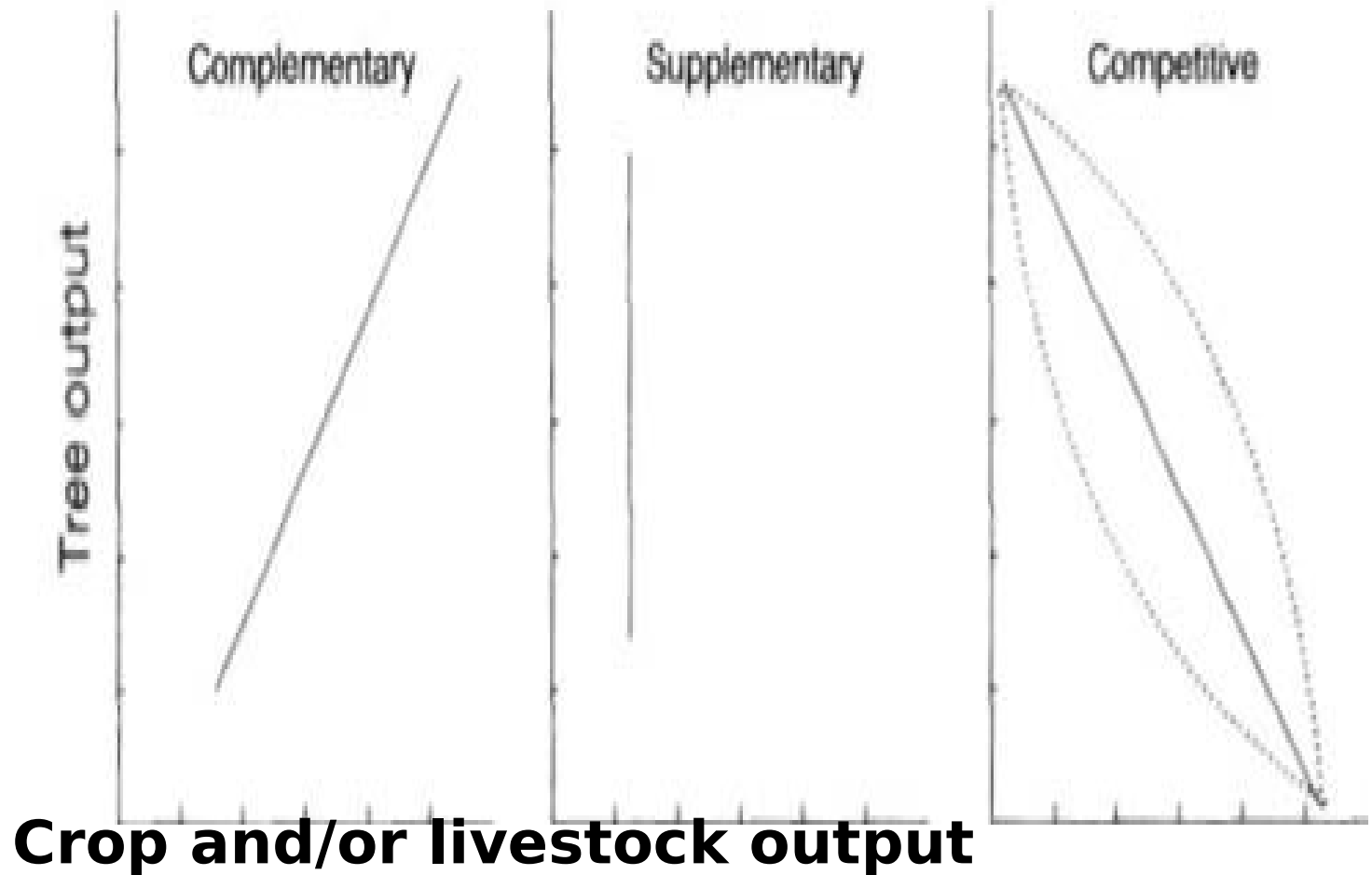
a. Direct effects

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.

Cont...



Nature of common types of biological interactions in agroforestry systems.

Cont...

- 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)

Cont...

	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

7.2 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

7.3 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

7.4 Component 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.

Chapter 8. Socioeconomic Aspects of Agroforestry

8.1 General principles of economic analysis

- o The Social and Economic objective of agroforestry include increasing agriculture subsistence yield, diversifying outputs, stabilizing yield over time ,reducing the land area required for subsistence , reducing economic and environmental cost production.
- o Achieving these social and economic objectives depends upon creating agroforestry systems with two ecosystem characteristics
 - A) high levels of biological productivity
 - B)ecological sustainability with limited artificial inputs of resource .
- o Agroforestry plantations may produce timber, fuelwood, and fodder from the tree component in addition to food crop

8.2 Financial and economic analysis

- financial analysis examines the feasibility of an undertaking from the private or individual's point of view.
- Economic analysis concentrates on the desirability of an activity from the perspective of a society as a whole.

8.3 Important Socio-cultural factors in Agroforestry

- ❑ *Land Tenure, Labor, Marketability of products and economic feasibility of the system* were the important socio-culture factor in AF.
- ❑ *Land tenure*; systems that do not guarantee continued ownership and control of land are not likely to be conducive to the adoption of longer-term strategies such as agroforestry.
- ❑ Issues associated with tree tenure include the right to own, the right to plant trees, the right to use trees and tree products as well as the right to exclude others from such uses, and the right to dispose of tree products
- ❑ Furthermore, these various rights differ widely across cultural zones and invariably have a major influence on the social acceptability of any new agroforestry initiative

Cont...

- ❑ **Labor;** Almost all agroforestry innovations demand changes in the labor practices.
- ❑ Agroforestry systems could have the advantage of helping the small producer to spread out family labor utilization more evenly throughout the year.
- ❑ **Marketability of products;** Direct and immediate income that can be derived from a land-use system will be an important criterion in the appraisal of its social acceptability
 - Products from trees on farms are considered as free goods in many farming societies
 - Creating marketing opportunities for these "free goods," and thus increasing the demand for these products, will also require making appropriate

8.4 Social acceptability of Agroforestry

- Whatever the potential advantages of agroforestry completely miss the poor unless the systems are designed to respond to the social milieu
- The best measure of the social success of a given innovation is the readiness with which farmers accept it.

Chapter 9. Agroforestry Evaluation

9.1 Biological Concepts

- Throughout the tropics, cultivation of agricultural commodities drives habitat conversion and biodiversity loss (McNeely and Scherr 2001).
- Biodiversity is under imminent threat from a wide range of activities throughout the world
- agroforestry presents an alternative that is preferable than clear cuts and monocultures.
- Although agroforestry initiatives can create corridors or buffer zones in a patchwork of forest and production areas,

Cont...

- In agroforests, there is a great diversity of species. These biological resources, **serve the farming household, through the production of a varied and well distributed food supply, and contribute to biodiversity and genetic improvement.**
- Agroforests are reservoirs, *circa situm*, of species and rare varieties whose interest for breeding programmers cannot be ignored.
- Biodiversity protection is better served by continuous intact habitat than by the fragmentation inherent in a patchwork (Laurance and Bierregaard 1997)
- Agroforestry rests on the premise that forests and the natural resource .

9.2 Socioeconomic Concepts

- ❑ For resource poor farmers, economic security is dependent upon environmental health and stability.
- ❑ Environmental degradation, such as the soil erosion occurring over much of the world's arable land.
- ❑ Thus, any activity that improves soil productivity and the environment without restricting usage improves economic security in general.
- ❑ Agroforestry techniques can protect soil and water resources and other aspects of the environment and increase the potential usage of environmental resources.

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- ❑ Agroforestry can increase the productivity of existing land thus enabling the rural poor to meet their nutritional needs on the limited amount of land.
- ❑ Though agroforestry can provide added security to food and the household economy.
- ❑ Agroforestry systems that include livestock provide potential increased productivity and economic security.
- ❑ Livestock are an important source of food and economic security for the rural poor.

Cont...

- ❑ Land shortages caused by increasing populations and degradation of available arable land are the primary causes of food shortages.
- ❑ The agroforestry system described in the cost-benefit analysis mitigates both problems.
- ❑ They provide food and capital reserves to be used in the event of a poor crop harvest such as droughts
- ❑ Furthermore, livestock convert plant matter that is unfit for human consumption, such as crop residues and tree fodder, into useful products including meat, milk and wool.

Chapter 10. Diagnosis and Design Methodology

10.1 Definition and Concepts

- ❑ 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

10.2 Procedures in Conducting Diagnosis and Design

- ❑ The basic procedures of D & D consist of five stages
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- ❑ 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.

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- 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

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- 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

Cont...

- 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.



**“...END OF THE
COURSE... ”
“LETS’ KEEP OUR
AGRICULTURAL
LANDS AND FOREST
BY PROMOTING
AGROFORESTRY
PRACTICE”**