CHAPTER ONE

Concepts and definitions of ecology, agro ecology and farming system

Origin of the word "***ecology***" that is, it is a Greek origin: **OIKOS** = household, **LOGOS** = study. Therefore, ***study*** of the "***house/environment***" in which we live.

Ecology is study of interactions between ***non-living components*** in the environment such as light, water, wind, nutrients in soil, heat, solar radiation, atmosphere, etc. And ***living organism***, such as plants, animals, microorganisms in soil, etc.

Then, ***ecology*** **is** an integrated and dynamic study of the ***environment***; the study of ***living organisms*** in the ***natural environment***.

How they *interact with one another*? How they *interact with their non-living environment*?

Agro ecology is the study of the role of agriculture in the world.

- It provides an interdisciplinary framework with which to study the activity of agriculture
- ***Agro ecology*** is the study of the interactions between living organisms and their environment in agricultural systems.

- The idea of ***agro ecology*** is to go beyond the use of alternative practices and to develop agro ecosystems with the minimal dependence on high agro-chemical and energy inputs, emphasizing complex agricultural systems in which ecological interactions and synergisms between biological components provide the mechanisms for the systems to sponsor their own soil fertility, productivity and crop protection.

- ***Agro-ecology as a science*** in its simplest form is seen as the "***application of ecological science to the study, design and management of sustainable agro-eco systems***".

- ***Agro-ecology as practice*** - seeks ways to enhance farming systems by mimicking natural processes, using biological interactions and synergies to support production.

- ***Agro-ecology as a social and political movement*** is about how individuals, communities and societies contribute to building sustainable, fair food models through what they buy, but also in the ways in which they shop and organize food distribution.

- Agro-ecological movements seek to influence national and international policies through grassroots cooperation, participation and action to create more sustainable management systems for food and seeds.

- ***Agro ecology*** is first and foremost a response to the negative ***ecological, social*** and ***economic*** impacts of *industrial agriculture*.
  - ✓ ***Ecological perspective***: focusing on how natural resources - soil and water are used and managed for sustainable agricultural production;
  - ✓ ***Economic perspective***: focusing on the marketing of agricultural products through competitive value chains which link farmers to the consumer; and
  - ✓ ***Social perspective***: focusing on how stakeholders interact, who controls change in agricultural practices, and how to ensure that the benefits of innovation are enjoyed by all sectors of society including the poor and previously disadvantaged

Farming as a system

- ✓ *Inputs* into the system
  - ✓ *Processes* taking place in it
  - ✓ *Outputs* from the system

Physical inputs

- ✓Climate
- ✓Amount and season of rain
- ✓Summer and winter temperature
- ✓Growing season
- ✓Relief
- ✓Soils and drainage

Human and economic inputs

- ✓Labor
- ✓Rent
- ✓Transport costs
- ✓Machinery
- ✓Fertilizers and pesticides
- ✓Government control
- ✓Seeds – livestock
- ✓Farm buildings
- ✓Energy (electricity)

- ***Farming systems vary within and between countries because of different:***
  - ✓Physical conditions
  - ✓Human conditions
  - ✓Economic conditions e.g. rice farming in India is quite different from the system of mixed farming in England
- ***Farmer as a decision maker***
  - ✓has to decide which crops to grow or which animals to rear decision based on
    - physical factors
    - human factor
    - economic factors
  - ✓chooses the type of farming most suitable to the conditions
  - ✓using the most efficient method to gain maximum profit

- **Farms** are systems because several activities are closely related to each other by the common use of the farm labor, land and capital, by risk distribution and by the joint use of the farmer’s management capacity.

- **Farming system** is a unique and reasonably stable arrangement of farming enterprises that a household manages according to well defined practices in response to the physical, biological and socio-economic environment and in accordance with the household goals preferences and resources.

- **Farming systems** refers to an ordered combination of crops grown, livestock produced, husbandry methods and cultural practices followed.

- What do we mean by cropping systems and farming systems?

Cropping systems refer to:

- ✓key information about type of crops being grown and for what number of crops in a season cropping intensity
- ✓intercropping is similar but the crops are grown in lines
- ✓mixed cropping different crops in the same field – planted more or less randomly
- ✓mono cropping

- ***Farming systems is more holistic:***
  - ✓all farm enterprises
  - ✓describes how agriculture fits the farmers' livelihood strategy
  - ✓influence on environment, socio-economic factors, rural economy and politics

Characteristics of farms:

1. Goal orientation

- A farm is taken to be an organized decision-making unit in which crop and/ livestock production is carried out with the purpose of satisfying the farmers goals on large scale market production and profits are the main objectives whereas for the small-holder farmer who farm most of the tropics the farm is a multi-objective system to provide food for the household, raw materials for building huts, accumulation of capital in form of animals or plantations and accumulation of wealth.

2. Boundaries

- The farm as a system has a boundary that separates the system from the environment.
- The system embraces all workers and resources which are under the management of the farmer.

Ecosystem and agro ecosystem

Eco system is a biological environment consisting of all the organisms living in a particular area, as well as all the non-living

- physical components of the environment with which the organisms interact, such as air, soil, water, and sunlight

Levels of Organization; - a hierarchy of organization in the environment:

- **Biosphere**; Surface of the earth and it composed of many ecosystems
- **Ecosystems**: communities of organisms interacting with each other and with their physical environment i.e. Community + Abiotic environment, interacting
- **Biodiversity:** the variety of organisms living in an ecosystem. The total number of different species in an ecosystem and their relative abundance

- **Organism:** simplest level of organization (e.g., fish)
- **Population:** one species lives in one place at one time (e.g. many fish)
- **Community:** all populations (diff. species) that live in a particular area (e.g. many fish +other organisms). All the populations of the diffèrent species living and inter-acting in the same ecosystem.
- **Habitat:** physical location of community. The characteristics of the type of environment where an organism normally lives (e.g. a stoney stream, deciduous temperate woodland)

Agro ecosystem

- **Agro ecosystems** are communities of plants and animals interacting with their physical and chemical environments that have been modified by people to produce food, fiber, fuel and other products for human consumption and processing.
- The main focus of **sustainable agro ecosystems** lies on the reduction or elimination of agrochemical inputs through changes in management to assure adequate plant nutrition and plant protection through organic nutrient sources and integrated pest management, respectively

3.Fundamental principles of Agro ecology

- ✓Enhance recycling of biomass and optimizing nutrient availability and balancing nutrient flow.
- ✓Securing favorable soil conditions for plant growth, particularly by managing organic matter and enhancing soil biotic activity.

- Minimizing losses due to flows of solar radiation, air and water by way of microclimate management, water harvesting and soil management through increased soil cover.
- Species and genetic diversification of the agro ecosystem in time and space.
- Enhance beneficial biological interactions and synergisms among agro biodiversity components thus resulting in the promotion of key ecological processes and services.
- promote agro-biodiversity, as the point of entry for the re-design of systems ensuring the autonomy of farmers and Food Sovereignty; significance to resilience and adaptability properties;
- promote the spatio temporal variability (diversity and complementarities) of resources,

- **In general, principles of Agro ecology are important to :**

1. **Use Renewable Resources**
   - ✓Use renewable sources of energy instead of non-renewable sources.
   - ✓Use biological nitrogen fixation.
   - ✓Use naturally-occurring materials instead of synthetic, manufactured inputs.
   - ✓Use on-farm resources as much as possible.
   - ✓Recycle on-farm nutrients.
2. **Minimize Toxics**
   - ✓Reduce or eliminate the use of materials that have the potential to harm the environment or the health of farmers, farm workers, or consumers.
   - ✓Use farming practices that reduce or eliminate environmental pollution with nitrates, toxic gases, or other materials generated by burning or overloading agro ecosystems with nutrients.
3. **Conserve Resources**

a. **Conserve Soil**
   - ✓ Sustain soil nutrient and organic matter stocks.
   - ✓ Minimize erosion.

b. Conserve Water

- ✓ Use efficient irrigation systems.

c. Conserve Energy

- ✓ Use energy efficient technologies.

d. Conserve genetic resources

- ✓ Save seed.

E. Conserve Capital

- ✓ Keep bank debt to a minimum.
- ✓ Reduce expenditures.

4. Manage Ecological Relationships

- ✓ Manage pests, diseases, and weeds instead of "controlling" them.
- ✓ Use intercropping and cover cropping
- ✓ Integrate Livestock
- ✓ Enhance beneficial biota.
- ✓ Recycle Nutrients
  - Shift from through flow nutrient management to recycling of nutrients.
  - Return crop residues and manures to soils.
  - When outside inputs are necessary, sustain their benefits by recycling them.
- ✓ Minimize Disturbance
  - Use reduced tillage or no-till methods.
  - Use mulches.
  - Use perennials

5. Adjust to Local Environments

- ✓ Match cropping patterns to the productive potential and physical limitations of the farm landscape.
- ✓ Adapt Biota
  - Adapt plants and animals to the ecological conditions of the farm rather than modifying the farm.

6. **Diversify**

- ✓ **Landscapes**
  - Maintain undisturbed areas as buffer zones.
  - Use contour and strip tillage.
  - Use rotational grazing.
- ✓ **Biota**
  - Intercrop
  - Rotate crops
  - Use poly culture
  - Integrate animals in system
  - Use multiple species of crops and animals on farm
  - Use multiple varieties and landraces of crops and animals on farm.

7. **Economics**

- ✓ Avoid dependence on single crops/products.
- ✓ Use alternative markets.
- ✓ Organic markets.
- ✓ Community Supported Agriculture
- ✓ Add value to agricultural products.
- ✓ Process foods before selling them.
- ✓ Find alternative incomes.
- ✓ Agro tourism
- ✓ Use multiple crops to diversify seasonal timing of production over the year.

8. **Manage Whole Systems**

- ✓ Use planning processes that recognize the different scales of agro ecosystems.
  - Landscapes
  - Households
  - Farms
  - Communities

9.Empower People

- Use indigenous knowledge
- Promote multi-directional transfer of knowledge, as opposed to "top-down" knowledge transfer.
- Teach experts and farmers to share knowledge, not "impose" it.
- Increase farmer participation.
- Link farmers with consumers
- Guarantee agricultural labor.
- Teach principles of agro ecology & sustainability.

10.Manage Whole Systems

- Use planning processes that recognize the different scales of agro ecosystems.
- Landscapes
- Households
- Farms
- Communities
- Bioregions
- Nations
- Minimize impacts on neighboring ecosystems.

10.Maximize Long-Term Benefits

- ✓ Maximize intergenerational benefits, not just annual profits.
- ✓ Maximize livelihoods and quality of life in rural areas.
- ✓ Facilitate generational transfers.
- ✓ Use long-term strategies.
  - Develop plans that can be adjusted and reevaluated through time.
- ✓ Incorporate long-term sustainability into overall agro ecosystem design and management.
- ✓ Build soil fertility over the long-term.
  - Build soil organic matter.

11.Value Health

- ✓ Human Health
- ✓ Cultural Health
- ✓ Environmental Health
  - Value most highly the overall health of agro ecosystems rather than the outcome of a particular crop system or season.
  - Eliminate environmental pollution by toxics and surplus nutrients.
- ✓ Animal Health and Plant Health

Major Agro-ecological zones of the world and associated Farming system

- There are two types of methods of climate classification:
  1. Koppen's methods of climatic classification
  2. Thornwaith's methods of climatic classification

- **1**. *Koppen's methods of climatic classification*

- widely used vegetation based empirical climate classification system developed by German botanist-climatologist Wladimir Köppen.

- His aim was to devise formulas that would define climatic boundaries in such a way as to correspond to those of the vegetation zones (biomes)

- Köppen published his first scheme in 1900 and a revised version in 1918. He continued to revise his system of classification until his death in 1940.

- Köppen’s classification is based on a subdivision of terrestrial climates into five major types, which are represented by the capital letters A, B, C, D, and E.

❑ Each of these climate types **except B is defined by temperature criteria**.

- **Type B designates** climates in which the controlling factor on vegetation is dryness (rather than coldness).
- The Köppen Climate Classification System is the most widely used system for classifying the world's climates.
- Its categories are based on the annual and monthly averages of temperature and precipitation.

❖ The Köppen system recognizes ***five major climatic types***; :

A - Tropical Moist Climates: all months have average temperatures above 18° Celsius.

B - Dry Climates: with deficient precipitation during most of the year.

C - Moist Mid-Latitude Climates with Mild Winters.

D - Moist Mid-Latitude Climates with Cold Winters.

E - Polar Climates: with extremely cold winters and summers.

1. *Tropical Moist Climates (A)*

- Tropical moist climates extend northward and southward from the equator to about 15 to 25° of latitude.
- In these climates all months have average temperatures greater than 18° Celsius.
- Annual precipitation is greater than 1500 mm.

2. *Dry Climates (B)*

- this climate is that potential evaporation and transpiration exceed precipitation.
- These climates extend from 20 - 35° North and South of the equator and large continental regions of the mid-latitudes often surrounded by mountains.

3. *Moist Subtropical Mid-Latitude Climates (C)*

- This climate generally has warm and humid summers with mild winters. Its extent is from 30 to 50° of latitude mainly on the eastern and western borders of most continents.
- Convective thunderstorms dominate in summer months.

4.Moist continental mid-latitude climates (D)

moist continental mid-latitude climates have warm to cool summers and cold winters.

The location of these climates is pole ward of the C climates.

The average temperature of the warmest month is greater than 10° celsius, while the coldest month is less than 3° celsius.

Winters are severe with snowstorms, strong winds, and bitter cold from continental polar or arctic air masses.

5. *Polar Climates (E)*

- Polar climates have year-round cold temperatures with the warmest month less than 10° Celsius.
- Polar climates are found on the northern coastal areas of North America, Europe, Asia, and on the landmasses of Greenland and Antarctica.

Thornwaith's methods of climatic classification

- In 1931 Thorn Thwaite devised a complex and empirical classification, which is very close to Koppen's scheme.
- It also attempts to define climatic boundaries quantitatively and is based on plant associations.
- However, Thorn Thwaite's classification is based on **precipitation effectiveness and thermal efficiency.** Under this classification climatic types were subdivided by the use of a term to denote the seasonal distribution of precipitation.
- The climatic types and their boundaries were defined empirically by observing the characteristics of natural vegetation, soil, and the drainage pattern.

- Thorn Thwaite established the fact that not only the amount of precipitation, but the rate of evaporation as well is significant for the growth of natural vegetation.
- besides the precipitation amount and the evaporation rate, temperature was made a very important basis for Thorn Thwaite's climatic classification.
- An expression for precipitation efficiency was obtained by relating measurements of pan evaporation to temperature and precipitation.
- For each month the ratio 11.5 (rt-10)10/9 where r=mean monthly rainfall (in inches) t=mean monthly temperature (in °F) is calculated.
- The sum of the 12 monthly ratios gives the precipitation effectiveness (also called precipitation efficiency) index.
- On the basis of P/E indices and boundary values for the major vegetation regions, five humidity provinces were defined.

- ***Main Climatic groups*** based on precipitation effectiveness:

humidity Province	Vegetation	P/E Index
1. A (Wet)	Rain Forest	127
2. B (Humid)	Forest	64-127
3. C (Sub humid)	Grassland	32-63
4. D (Semiarid)	Steppe	16-31
5. E (Arid)	Desert	16

- Again, the world was divided into 6 temperature provinces on the basis of T/E index.
- **Main Climatic groups based on thermal efficiency**

Temperature Province	T/E index
A-Tropical	127
B-Mesothermal	64-127
C-Microthermal	32-63
D-Taiga	16-31
E-Tundra	1-15
F-Frost	0

World climatic Types

- Based on the above classification there are three basic climate groups found in the world. These three major climate groups show the dominance of special combinations of air-mass source regions.

Group I, Low-latitude Climates:

- These climates are controlled by equatorial and tropical air masses.

1.Tropical Moist Climates (Af) rainforest

- Rainfall is heavy in all months. The total annual rainfall is often more than 250 cm. (100 in.).
- There are seasonal differences in monthly rainfall but temperatures of 27°C (80°F) mostly stay the same.
- Humidity is b/n 77 and 88%. High surface heat and humidity cause cumulus clouds to form early in the afternoons almost every day.

- The summers are warm and very humid. It also rains a lot in the winter
  - Average temperature: 18 °C (°F)
  - Annual Precipitation: 262 cm. (103 in.)
  - Latitude Range: 10° S to 25 ° N
  - ***Global Position***: Amazon Basin; Congo Basin of equatorial Africa; East Indies, from Sumatra to New Guinea.

2. *Wet-Dry Tropical Climates (Aw) savanna*

- A seasonal change occurs between wet tropical air masses and dry tropical air masses.
- As a result, there is a very wet season and a very dry season.
- Trade winds dominate during the dry season.
- It gets a little cooler during this dry season but will become very hot just before the wet season.
  - Temperature Range: 16 °C
  - Annual Precipitation: 0.25 cm. (0.1 in.).
  - All months less than 0.25 cm. (0.1 in.)
  - Latitude Range: 15 ° to 25 ° N and S
- ***Global position***: India, Indochina, West Africa, southern Africa, South America and N coast of Australia

3. *Dry Tropical Climate (BW) desert biome*

- These desert climates are found in low-latitude deserts approximately between 18° to 28° in both hemispheres. these latitude belts are centred on the tropics of Cancer and Capricorn, which lie just north and south of the equator.

- Winds are light, which allows for the evaporation of moisture in the intense heat.
- They generally flow downward so the area is seldom penetrated by air masses that produce rain.
- This makes for a very dry heat. The dry arid desert is a true desert climate, and covers 12 % of the Earth's land surface.
  - Temperature Range: 16° C
  - Annual Precipitation: 0.25 cm (0.1 in).
  - Latitude Range: 15° - 25° N and S.
  - ***Global position***: south western United States and N Mexico; Argentina; N Africa; south Africa; central part of Australia.

Group II, Mid-latitude Climates:

- Climates in this zone are affected by two different air-masses. The tropical air-masses are moving towards the poles and the polar air-masses are moving towards the equator.

1. Dry Mid-Latitude Climates (BS) steppe

- Characterized by grasslands, this is a semiarid climate. It can be found between the desert climate (BW) and more humid climates of the A, C, and D groups. This dry climate exists in the interior regions of the North American and Eurasian continents.
- Moist ocean air masses are blocked by mountain ranges to the west and south.
- These mountain ranges also trap polar air in winter, making winters very cold. Summers are warm to hot.
  - Temperature Range: 24° C (43° F).
  - Annual Precipitation: less than 10 cm (4 in) in the driest regions to 50 cm (20 in) in the moister steppes.
  - Latitude Range: 35° - 55° N.
- ***Global position***: Western North America (Great Basin, Columbia Plateau, Great Plains); Eurasian interior, from steppes of eastern Europe to the Gobi Desert and North China.

2.Mediterranean Climate (Cs) chaparral biome

- This is a wet-winter, dry-summer climate. Extremely dry summers are caused by the sinking air of the subtropical highs and may last for up to five months.

- Plants have adapted to the extreme difference in rainfall and temperature between winter and summer seasons.
- Sclerophyll plants range in formations from forests, to woodland, and scrub.
- Eucalyptus forests cover most of the chaparral biome in Australia.
- Fires occur frequently in Mediterranean climate zones.
  - ➢Temperature Range: 7 °C (12 °F)
  - ➢Latitude Range: 30° - 50° N and S

- ***Global Position***: central and southern California; coastal zones bordering the Mediterranean Sea; coastal Western Australia and South Australia; Chilean coast; Cape Town region of South Africa.

3. *Dry Mid-Latitude Climates (Bs) grasslands biome*

- These dry climates are limited to the interiors of North America and Eurasia. Ocean air masses are blocked by mountain ranges to the west and south. Annual temperatures range widely. Summers are warm to hot, but winters are cold.
  - Temperature Range: 31 °C (56°F).
  - Annual Precipitation: 81 cm. (32 in.).
  - Latitude Range: 30° - 55° N and S
- ***Global Position***: western North America (Great Basin, Columbia Plateau, Great Plains); Eurasian interior.

4. *Moist Continental Climate (Cf) Deciduous Forest biome*

- This climate is in the polar front zone - the battleground of polar and tropical air masses.
- Seasonal changes between summer and winter are very large.
- It is increased in the summer season by invading tropical air masses. Cold winters are caused by polar and arctic masses moving south.
  - Temperature Range: 31 °C (56 ° F)
  - Average Annual Precipitation: 81 cm (32 in).
  - Latitude Range: 30° - 55° N and S (Europe: 45° - 60° N).
- *Global Position*: eastern parts of the United States and southern Canada; northern China; Korea; Japan; central and eastern Europe.

Group III, High-latitude climates:

- Polar and arctic air masses dominate these regions.
- Canada and Siberia are two air-mass sources which fall into this group. Air masses of arctic origin meet polar continental air masses along the 60th and 70th parallels.

1. *Boreal forest Climate (Dfc) taiga biome*

- This is a continental climate with long, very cold winters, and short, cool summers.
- Very cold air masses from the arctic often move in. The temperature range is larger than any other climate.
- Precipitation increases during summer months, although annual precipitation is still small.

➢ Temperature Range: 41 °C (74 °F),

➢ lows; -25 °C (-14 °F), highs; 16 °C (60 °F).

➢ Average Annual Precipitation: 31 cm (12 in).

➢ Latitude Range: 50° - 70° N and S.

- ***Global Position***: central and western Alaska; Canada, from the Yukon Territory to Labrador; Eurasia, from northern Europe across all of Siberia to the Pacific Ocean.

2.Tundra Climate (E) tundra biome

- The tundra climate is found along arctic coastal areas.
- Polar and arctic air masses dominate the tundra climate. The winter season is long and severe.
- A short, mild season exists, but not a true summer season.
  - Temperature Range: -22 °C to 6 °C (-10 °F to 41 °F).
  - Average Annual Precipitation: 20 cm (8 in).
  - Latitude Range: 60° - 75° N.
- ***Global Position***: arctic zone of North America; Hudson Bay region; Greenland coast; northern

Siberia bordering the Arctic Ocean.

3. *Highland Climate (H) Alpine Biome*

- Highland climates are cool to cold, found in mountains and high plateaus. Climates change rapidly on mountains, becoming colder the higher the altitude gets.
- The highlands have the same seasons and wet and dry periods as the biome they are in.
- Mountain climates are very important to midlatitude biomes.
- Temperature Range: -18 °C to 10 °C (-2 °F to 50°F)
  - Average Annual Precipitation: 23 cm (9 in.)
  - Latitude Range: found all over the world
- ***Global Position***: Rocky Mountain Range in North America, the Andean mountain range in SouthAmerica, the Alps in Europe, Mt. Kilimanjaro in Africa, the Himalayans in Tibet, Mt. Fuji in Japan.

FAO global ecological Zoning framework for 2010

- **Criteria:** (Approximate equivalent of Köppen – Trewartha Climatic types, in combination with vegetation physiognomy and one orographic zone within each domain)

1.**Tropical**: All months without frost: in marine areas over 18°C

✓Tropical rain forest: Wet: 0 – 3 months dry, during winter

- ✓Tropical moist deciduous forest: Wet/dry: 3 – 5 months dry, during winter
- ✓Tropical dry forest: Dry/wet: 5 – 8 months dry, during winter
- ✓Tropical shrub land: Semi-Arid: Evaporation > Precipitation
- ✓Tropical desert: Arid: All months' dry
- ✓Tropical mountain systems: Approximate > 1000 m altitude (local variations)

2.**Subtropical**: Eight months or more over 10°C

- Subtropical humid forest: Humid: No dry season
- Subtropical dry forest: Seasonally Dry: Winter rains, dry summer
- Subtropical steppe: Semi-Arid: Evaporation > Precipitation
- Subtropical desert: Arid, All months’ dry
- Subtropical mountain systems: Approximate > 800-1000 m altitude

3.**Temperate**: Four to eight months over 10°C

- Temperate oceanic forest: Oceanic climate: coldest month over 0°C
- Temperate continental forest: Continental climate: coldest month under 0°C
- Temperate desert: Arid: All months’ dry
- Temperate mountain systems: Approximate > 800 m altitude

4.Boreal: Up to 3 months over 10°C

- Boreal coniferous forest: Vegetation physiognomy: coniferous dense forest dominant
- Boreal tundra woodland: Boreal mountain systems:
- Approximate > 600 m altitude

5.Polar: All months below 10°C

Chapter Two

Agro ecology and its approach

The science of agro ecology as a solution for the environmental problems

- From a management perspective, the agro ecological objective is to provide balanced environments, sustained yields, biologically mediated soil fertility and natural pest regulation through the design of diversified agro ecosystems and the use of low-input technologies (Glassman 1998).
- Agro ecologists are now recognizing that intercropping, agro forestry and other diversification methods mimic natural ecological processes, and that the sustainability of complex agro ecosystems lies in the ecological models they follow.
- By designing farming systems that mimic nature, optimal use can be made of sunlight, soil nutrients and rainfall (Pretty 1994).
- Agro ecological management must lead management to optimal recycling of nutrients and organic matter turnover, closed energy flows, water and soil conservation and balance pest- natural enemy populations. The strategy exploits the complementarities and synergisms that result from the various combinations of crops, tree and animals in spatial and temporal arrangements (Altieri 1994).

- In essence, the optimal behavior of agro ecosystems depends on the level of interactions between the various biotic and abiotic component.
- By assembling a functional biodiversity, it is possible to initiate synergisms which subsidize agro ecosystem processes by providing ecological services such as the activation of soil biology, the recycling of nutrients, the enhancement of beneficial arthropods and antagonists, and so on (Altieri and Nicholls 1999).
- Today there is a diverse selection of practices and technologies available, and which vary in effectiveness as well as in strategic value.
- Key practices are those of a preventative nature and which act by reinforcing the "immunity" of the agro ecosystem through a series of mechanisms.

Various strategies to restore agricultural diversity in time and space include:.

- ***Poly cultures***: Complex cropping systems in which two or more crop species are planted within sufficient spatial proximity to result in competition or complementation,

- thus enhancing yields (Francis 1986, Vandermeer 1989).

- ***Agro forestry Systems***: An agricultural system where trees are grown together with annual crops and/or animals, resulting in enhanced complementary relations between components increasing multiple use of the agro ecosystem (Nair 1982).
- ***Cover Crops***: The use of pure or mixed stands of legumes or other annual plant species; under fruit trees for the purpose of improving soil fertility, enhancing biological control of pests and modifying the microclimate (Finch and Sharp 1976).
- ***Animal integration*** in agro ecosystems aids in achieving high biomass output and optimal r

- All of the above diversified forms of agro ecosystems share in common the following features (Altieri and Rosset 1995):
  - ✓ Maintain vegetative cover as an effective soil and water conserving measure, met through
  - the use of no-till practices, mulch farming, and use of cover crops and other appropriate methods.
  - ✓ Provide a regular supply of organic matter through the addition of organic matter (manure, compost, and promotion of soil biotic activity).
  - ✓ Enhance nutrient recycling mechanisms
  - ✓ Promote pest regulation through enhanced activity of biological control agents achieved by introducing and/or conserving natural enemies and antagonists.

- **Some of the main social and ecological costs associated with industrial agriculture:**
  - ✓ Loss of vegetal and animal genetic diversity, notably due to deforestation, the standardization of farming systems or the elimination of beneficial organisms resulting from the use of synthetic pesticides;
  - ✓ Soil degradation, resulting for example from their overexploitation and the use of synthetic inputs;
  - ✓ Water pollution and depletion of water resources, for example due to water contamination by nitrate contained in inorganic fertilizers, and excessive groundwater withdrawals due to inadequate irrigation techniques such as deep tube-well irrigation;
  - ✓ Increased vulnerability to pest and disease outbreaks and related economic losses;
  - ✓ Adverse impacts on farmers and/or consumer’s health, due to pesticides’ intrinsic toxicity, combined with unsafe conditions of use (lack of adequate equipment of protection and/or unsafe storage conditions), and/or excessive concentration of their residues in food products

Agro ecology as an alternative path to industrialized agriculture

- But it is equally possible to reverse this approach, to find the ways and means to restore and build on the resilience and strength of the agro ecosystem in the struggle to fight pests, diseases or soil deficiencies, or to augment crop yields through pollination.
- The component of agro biodiversity which we call “agricultural ecosystem services” is a potent tool to be encouraged and fostered.
- Agro biodiversity can be used to reestablish natural balances in farming systems with healthier environments, a more rational use of resources, and a greater dependence on internal rather than purchased controls. And to do this, the primary technique is “bio diversification” of agro ecosystems, to evoke self-regulation and sustainability.

Key principles for the conservation of agricultural ecosystem services are:

- ✓ It is important that everyone- farmers and policymakers both- understand the concept that agricultural ecosystem services can sustain themselves with proper design.
- ✓ Ecosystem services have the potential to reduce both off-site inputs and on- and off-site pollution.
- ✓ Promoting identification and taxonomy is necessary.
- ✓ Assessment of risks over time, relative dependence, and sustainable livelihoods are critical issues for agricultural biodiversity, and need to be in appropriate balance.
- ✓ Policy makers are biased toward large scale plans, whereas much of agro biodiversity is fine-scaled.
- ✓ Costs and benefits of agro biodiversity goods and services need to be identified.
- ✓ Costs and benefits need to be distributed on the basis of careful assessment of possible trade-offs, paying attention to incentives and subsidies, and making them appropriate.
- ✓ Creating popular awareness and education is necessary for change
- ✓ It is necessary to enhance capacity for adaptation to change.

Agro ecology as a science

- As a first step, agro ecology developed through an attempt to integrate the principles of ecology to the redefinition of agronomy (Stassart et al., 2012).
- The term was first used in two scientific publications by Bensin (1928, 1930), a Russian agronomist, for describing the use of ecological methods in research on commercial crop plants.
- In 1965, in what is probably the first book titled ‘agro ecology’, the German ecologist/zoologist Tischler analyzed the different components such as plants, animals, soils, and climate, and their interactions within an agro ecosystem as well as the impact of human agricultural management on these components, thus applying an approach combining ecology, especially the interactions among biological components at the field or agro ecosystem level, and agronomy with a focus on the integration of agricultural management (Wezel et al., 2009).

Agro ecology as an agricultural approach

- Since the 1970s, agro ecology no longer referred simply to a scientific discipline or research area, but also to farming practices and a number of collective mobilizations (mainly in response to the Green Revolution) (Schaller, 2013).
- In terms of farming systems, agro ecology could be synthetically defined as a holistic approach consisting in seeking to make agro ecosystems economically, ecologically and socially more sustainable by realizing key agro ecological principles (that are precisely understood as those which form the basis of agricultural sustainability as explained above) for meeting local needs.
- Agro ecological farming indeed promotes community-oriented approaches that look after the subsistence needs of its members, and very much privileges the local: providing for local markets that shorten the circuits of food production and consumption, simultaneously avoiding the high energy needs of ‘long-distance food’ (Altieri and Toledo, 2011).

Types of practices typically promoted as agro ecological

- Jules Pretty (2008), from University of Essex in the United Kingdom (UK), has highlighted seven agro ecological practices and resource-conserving technologies:

1. ***Integrated pest management (IPM)***, which uses ecosystem resilience and diversity for pest, disease and weed control, and seeks only to use pesticides when other options are ineffective.
2. ***Integrated nutrient management***, which seeks both to balance the need to fix nitrogen within farm systems with the need to import inorganic and organic sources of nutrients, and to reduce nutrient losses through erosion control.
3. ***Conservation tillage***, which reduces the amount of tillage, sometimes to zero, so that soil can be conserved and available moisture used more efficiently.
4. ***Agro forestry***, which incorporates multifunctional trees into agricultural systems, and collective management of nearby forest resources.

2. ***Aquaculture,*** which incorporates fish, shrimps and other aquatic resources into farm systems, such as into irrigated rice fields and fishponds, and so leads to increases in protein production.

3. ***Water harvesting in dry land areas***, which can mean formerly abandoned and degraded

- lands can be cultivated and additional crops grown on small patches of irrigated land owing to better rainwater retention.

7. ***Livestock integration into farming systems***, such as dairy cattle, pigs, and poultry, including using zero-grazing cut and carry systems.

Applying a bottom-up, farmer-led approach

- While the Green Revolution model has favored a top-down approach which tends to reduce peasants to no-choice passive recipients of technology received from extension agents or inputs suppliers, agro ecological transition requires bottom-up processes in which farmers take the front seat.
- Conventional top-down extension can be demobilizing for farmers, as technical experts have all too often had the objective of replacing peasant knowledge with purchased chemical inputs, seeds and machinery (Rosset and Martinez-Torres, 2013).
- On the contrary, agro ecological farming is highly knowledge-intensive and based on techniques that are not delivered top-down but developed on the basis on farmer's knowledge, experimentation and innovation (De Schutter, 2010a; Altieri and Toledo, 2011; Rosset and Martinez-Torres, 2013).

Traditional knowledge helps adaptation in agriculture in the following ways:

- ✓ ***Resilient properties***: Traditional farmers often live on marginal land where climate change impacts and selection pressures are greatest. This enables them to identify
- resilient crop species and varieties for adaptation.
- ✓ ***Plant breeding***: Traditional farmers – particularly women and the old – are active plant breeders, conserving local landraces and selecting seeds for preferred and adaptive characteristics over generations.
- ✓ ***Wild crop relatives***: Local communities often draw on wild areas for crop improvement and domestication as well as to supplement their diet and provide food when crops fail.
- ✓ ***Farming practices***: Traditional farming practices – from water, soil or pest management
- to erosion control and land restoration – conserve key resources for resilience and adaptation, such as biodiversity, water, soil and nutrients.
- ✓ ***Climate forecasting***: Traditional knowledge can help forecast local weather, predict extreme events and provide accessible information to farmers at a local scale. Traditional
- farmers can also monitor climate change in specific locations and fill the resolution gap of scientific models.

Agro-ecology and sustainable agro-ecosystem

- **What is sustainability?**
  - ✓ "Leave the world better than you found it, take no more than you need, try not to harm life or the environment, make amends if you do." (–Paul Hawken)
  - ✓ "Sustainable design is the careful nesting of human purposes with the larger patterns and flows of the natural world..." (–David Orr)
  - ✓ The word "sustain," from the Latin *sustinere* (*sus*-, from below and *tenere*, to hold), to keep in existence or maintain, implies long-term support or permanence.
- **What is sustainable agriculture?**
  - ✓ A farm system that mimics as closely as possible the complexity of a healthy and natural ecosystem.
  - ✓ Goals include:
    - ✓ Providing a more profitable farm income.
    - ✓ Promoting environmental stewardship.
    - ✓ Promoting stable, prosperous farm families and communities

Sustainable Agriculture:

- ✓Reduces inputs.
- ✓Uses ecological pest and weed management strategies.
- ✓ Cycles nutrients back into the soil for fertility and health.
- ✓ Strengthens rural and urban communities.
- ✓ Produces viable farm income.
- ✓ Promotes healthy family and social values.
- ✓ Brings the consumer back into agriculture.

- **Sustainable** describes farming systems that are "capable of maintaining their productivity and usefulness to society indefinitely.
- Such systems... must be resource-conserving, socially supportive, commercially competitive, and environmentally sound." [John Ikerd, as quoted by Richard Duesterhaus in "Sustainability's Promise," *Journal of Soil and Water Conservation*(Jan.-Feb. 1990) 45(1).

- **Types of Sustainable Farming**
  - ✓ Organic farming
  - ✓ Biodynamic
  - ✓ Permaculture
  - ✓ Agro ecological Systems
  - ✓ Low-input
- **Environmental Sustainability**
  - ✓ Sustainable agriculture can be viewed as management of a production system where there is a multitude of complex interactions occurring between soil, water, plants, animals, climate and people.
  - ✓ The **GOAL** is to integrate all these components into a solid production system that benefits all participants.
  - ✓ Farms stay environmentally sustainable by mimicking natural processes and ecosystem function.
  - ✓ Diversifying our farms with various enterprises, both animals and crops, we manage risks a whole lot better.

- **Farm as an Ecosystem: *Energy Flow***
  - ✓Energy flow is the pathway of sunlight through a biological system.
  - ✓In relation to the farm, energy capture is enhanced by maximizing the leaf area available for photosynthesis and by cycling the stored energy through the food chain.
  - ✓We make money in farming by capturing sunlight – in essence; we are farming the sun (and the soil).
- **Farm as an Ecosystem: *Water Cycle***
  - ✓An effective water cycle includes: no soil erosion, fast water entry into the soil and the soil's ability to store water.
  - ✓Management decisions on the farm that add to ground cover and soil organic matter only enhance the natural water cycle.
  - ✓Effective water use on the farm results in low surface runoff, low soil surface evaporation, low drought incidence, low flood incidence, high transpiration by plants and high seepage of water to underground reservoirs (Savory and Butterfield, 1999).

- **Farm as an Ecosystem: *Mineral Cycle***
  - ✓ In nature, minerals needed for plant and animal growth are continuously being recycled through the ecosystem.
  - ✓ An effective mineral cycle is one where there is a movement of nutrients from the soil to
  - crops and animals and then back to the soil, basically **a circle of nutrient renewal**.
  - ✓ Ways to enhance this cycle on the farm include: on-farm feeding of livestock, careful management of manure and crop residues, and practices that prevent erosion.
- **Farm as an Ecosystem: *Biodiversity***
  - ✓ A farm will be dynamic and healthy if it has a **high diversity** of plants and animals (above ground and below).
  - ✓ **Greater diversity = greater stability**

Applying the Principles: Soil Fertility Management

- ✓ Goal is to sustain high crop productivity and crop quality in food and fiber production as well as in grass farming.
- ✓ Strive to keep the soil covered throughout the year, whether with permanent pasture or cover crops and green manures.
- ✓ Maintain or build soil organic matter levels through inputs of compost or cover cropping.
- ✓ Properly timed or limited tillage.
- ✓ Irrigation management to reduce erosion and runoff.
- ✓ Sound crop rotations, soil amending and organic fertilizing techniques.
- ✓ Balanced levels of available plant nutrients and balanced PH.

- **Soil Fertility: *Cover Crops***
  - ✓ Increase nutrient availability.
  - ✓ Temperature, moisture conditions, placement of the residue and quality of the cover crop influence nutrient release.

- ✓Cover crops improve the soil's physical properties with carbon and nitrogen cycling.
- ✓Some cover crops actually suppress certain parasitic nematodes and soil borne diseases, i.e. rye, triticale, mustards.
- ✓Cover crops have superb weed suppressing effects by competing with weeds for light and smothering unwanted plants or through all elopathy.
- ✓Reduce erosion and attract beneficial bugs.

- **Soil Fertility: *Composts***
  - ✓Use of compost in crop production and grass farming is beneficial to build soil organic matter, add nutrients to the soil and retain water.
  - ✓Nutrient contribution of manure-based compost is balanced between N-P-K. Have a compost nutrient assessment done.
  - ✓ How much compost to apply and timing is different on each farm.
  - ✓Ease and economics of use, local availability and costs as well as variability of quality.

- **Animal Manure**
  - ✓ Integrate grazing animals or other livestock onto your farm to produce compost for your fields.
  - ✓ The use of fresh or un decomposed manure in agricultural systems is of great benefit to the farm.
  - ✓ There are variations in nutrient profiles of animal manures.
  - ✓ If using raw manure, cannot apply to fields for organic certification less than 120 days before harvest.
- **Soil Fertility: *Crop Rotation***
  - ✓ Break weed and pest cycles.
  - ✓ Provide complementary fertilization to crops in sequence with each other, i.e. legume crops preceding corn or tomatoes.
  - ✓ Prevent buildup of pest insects and weeds.
  - ✓ In some cases, yield increases follow from the "rotation effect."
  - ✓ Ideal rotation includes planning over the long term with fields in rotation of crops, cover crops or sod, and livestock.

- **Ecological Weed Management**
  - ✓ Improve soil tilth, aeration, water infiltration, and fertility to optimize crop growth and minimize weed pressure.
  - ✓ Thoroughly clean equipment before moving it from one farm or location to another to avoid transporting weed seeds from infested fields.
  - ✓ Do not allow weeds to form seed heads and/or perennial rooting structure in the cropping systems.
  - ✓ Thoroughly compost all imported animal manure to insure destruction of viable weed seed.
  - ✓ Work with neighbors to eliminate or minimize the potential for spread of noxious and problematic weeds from adjacent lands.
- **Cultural Weed Practices**
  - ✓ Crop Rotations
  - ✓ Tillage
  - ✓ Planting and Cultivation
  - ✓ Rotational Grazing
  - ✓ Irrigation
  - ✓ Mulches

Plant Disease Manipulations

- ✓Environment manipulations include increasing plant spacing to reduce humidity, regulating irrigation, and choosing where crop is grown.
- ✓Host manipulations include resistant cultivars, pathogen-free planting materials, crop rotation and intercropping.
- ✓Pathogen manipulations include keeping them out of the field by removal of host tissue or organic chemical controls (neem, copper, sulfur etc.)
- ✓Use crop rotations, biodiversity, resistant cultivars, clean seed and soil fertility measures to prevent plant diseases.
- ✓Compost teas can help control fungal diseases. Foliar sprays are also effective.

Bringing It All Together: *Integrated Farming Systems*

- Goal is to find and adopt "integrated and resource-efficient crop and livestock systems that maintain productivity, that are profitable, and that protect the environment and the personal health of farmers and their families," as well as "overcoming the barriers to adoption of more sustainable agricultural systems.

- The promotion of sustainable agriculture is aiming at creating a form of agriculture that maintains productivity in long term by:

  ✓ Optimizing the use of locally available resources by combining the different components of farm systems.

  ✓ Reducing the use of off-farm, external and non-renewable inputs with great potential not to damage the environment or harm the health of farmers and consumers, and a more targeted use of the remaining inputs and with a view of minimizing the variable costs.

- ✓Relying mainly on resources within the agro-ecosystem by replacing external inputs with nutrient cycling, better conservation, and an expanded use of local resources.

- ✓Improving the match between cropping patterns and the productive potential and environmental constraints of climate and landscape to ensure long-term sustainability of current production level.
- ✓Working to value and concern biological diversity and making optimum use of the biological and genetic potential of plants and animals species.
- ✓Making full advantage of local knowledge and practices including innovation approaches not yet fully understood by scientists although widely adopted by farmers.

- **The ultimate goal of agro-ecological design is to integrate components so that:**
  - ✓Overall biological efficiency is improved,
  - ✓ Biodiversity is preserved,
  - ✓Agro-ecosystem productivity and its self regulating capacity are maintained.

- **Ecological processes to optimize agro ecosystem:**
  - ✓Strengthen the immune system, for example: proper functioning of natural pest control;
  - ✓Decrease toxicity through elimination of agro-chemicals;
  - ✓Optimizing metabolic functioning/organic matter decomposition;
  - ✓ Balance regulatory systems, for instance, nutrient cycle, water balance, energy flow, and population regulation;
  - ✓Enhance conservation and regeneration of soil/water resources and biodiversity;
  - ✓Increase and sustain long term productivity.

- **mechanisms to improve agro-ecosystem's immunity include:**
  - Increase of plant species genetic diversity in time and space;
  - Enhancement of functional biodiversity;
  - Increment of soil organic matter and biological activities
  - boosting up of soil cover and crop competitive ability;
  - Elimination of toxic inputs and residual

Chapter Three

3. Agro-ecological zones of Ethiopia

The Traditional Agro ecological Zones indicate major physical conditions that are grouped into relatively homogenous area having similar agricultural land uses.

Under Ethiopian conditions elevation has a strong influence on temperature and rainfall.

Therefore, this parameter (elevation) is the basis for traditional agro ecological divisions.

These different zones are:

- ✓ **Bereha; *Hot and hyper-arid* (**hot lowlands, <500 meters, In the arid east, crop production is very limited, in the humid west root crops and maize are largely grown)
- ✓ **Kolla: *Warm, semi-arid lowlands* (**lowlands, 500 - 1,500, sorghum, finger millet, sesame, cowpeas, groundnuts)
- ✓ **Woina Dega: *Temperate, cool sub-humid, highlands* (**midlands, 1,500 - 2,300, wheat, Teff, barley, maize, sorghum, chickpeas, haricot beans)

- ✓**Dega:** ***Cool, humid, highlands*** **(**highlands, 2,300 - 3,200, barley, wheat, highland oilseeds, highland pulses)
- ✓**Wurch:** ***Cold highlands*** **(**highlands, 3,200 - 3,700, barley is common)
- ✓**Kur: (**highland, >3,700, primarily for grazing)

- The country has very diversified agro-ecologies that are may be difficult to correctly describe.
- Hence, most recently the agro-ecology of the country has been divided into 33 major zones.

- Generally, crop distribution is mosaic in Ethiopia. Some crops are found within several zones while others are restricted to only one or two agro-ecological zones. In this recent classification, length of crop growing period (LGP) was taken into account.
- **Major Agro-ecology Area in hectare Percentage**

According to (EIAR, Ethiopian Institute of Agricultural Research, 2011)

1A1 (Hot arid lowland plains)

2 A2 (Warm arid lowland plains)

3 A3 (Tepid arid mid highlands)

4 H2 (Warm humid lowlands)

5 H3 (Tepid humid mid highlands)

6 H4 (Cool humid mid highlands)

7H5 (Cold humid sub-afro-alpine to afro-alpine)

8 H6 Very cold humid sub-afro-alpine)

9 M1 (Hot moist lowlands)

10M2 (Warm moist lowlands)

11M3 (Tepid moist mid highlands)

12 12 M4 (Cool moist mid highlands)

13M5 (Cold moist sub-afro-alpine to afro- alpine)

14M6 (Very cold moist sub-afro-alpine to afro-alpine)

15PH1 (Hot per-humid lowlands)

16 16 PH2 (Warm per-humid lowlands)

17 PH3 (Tepid per-humid mid highland)

18 SA1 (Hot semi-arid lowlands)

19SA2 (Warm semi-arid lowlands)

20SA3 (Tepid semi-arid mid highlands)

21 SH1 (Hot sub-humid lowlands)

22SH2 (Warm sub-humid lowlands)

23SH3 (Tepid sub-humid mid highlands)

24 SH4 (Cool sub-humid mid highlands)

25SH5 (Cold sub-humid sub-afro-alpine to afro-alpine)

26SH6 (Very cold sub-humid sub-afro to afro-alpine)

27SM1 (Hot sub-moist lowlands)

28SM2 (Warm sub-moist lowlands)

29SM3 (Tepid sub-moist mid highlands)

30SM4 (Cool sub-moist mid highlands)

31 SM5 (Cold sub-moist mid highlands)

32SM6 (Very cold sub -moist mid highlands)

33WB (Water body)

Chapter Four

4. Major Categories of Farming System

- The decision to adopt very broad farming systems inevitably results in a considerable degree of heterogeneity within any single system.
- However, the alternative of identifying numerous, discrete, micro-level farming systems in each developing country – which could result in hundreds or even thousands of systems worldwide – would complicate the interpretation of appropriate regional and global strategic responses and detract from the overall impact of the analysis.
- Only the major farming systems have, therefore, been identified and then mapped in order to estimate the magnitudes of their populations and resource bases.

- The classification of the farming systems has been based on the following criteria:
  - ✓ available natural resource base, including water, land, grazing areas and forest; climate, of which altitude is one important determinant; landscape, including slope; farm size, tenure and organization; and
  - ✓ dominant pattern of farm activities and household livelihoods, including field crops, livestock, trees, aquaculture, hunting and gathering, processing and off-farm activities; and taking into account the main technologies used, which determine the intensity of production and integration of crops, livestock and other activities.
- Based on these criteria, the following broad categories of farming system have been distinguished:
  - ✓ Irrigated farming systems, embracing a broad range of food and cash crop production;
  - ✓ Wetland rice based farming systems, dependent upon monsoon rains supplemented by irrigation;
  - ✓ Rain fed farming systems in humid areas of high resource potential, characterized by a crop activity (notably root crops, cereals, industrial tree crops – both small scale and plantation – and commercial horticulture) or mixed crop-livestock systems;

- ✓Rain fed farming systems in steep and highland areas, which are often mixed crop-livestock systems;
- ✓Rain fed farming systems in dry or cold low potential areas, with mixed crop-livestock and pastoral systems merging into sparse and often dispersed systems with very low current productivity or potential because of extreme aridity or cold;
- ✓Dualistic (mixed large commercial and small holder) farming systems, across a variety of ecologies and with diverse production patterns;
- ✓Coastal artisanal fishing, often mixed farming systems; and
- ✓Urban based farming systems, typically focused on horticultural and livestock production.

There is also specific classification of farming system

- Farm as a unit transfers input into agricultural output and which undergoes changes over time.
- In the process of adapting cropping patterns and farming techniques to the natural, economic and socio-political conditions of each location and the aims of the farmers, distinct farming systems are developed.
- For the purpose of agricultural development, it is advisable to group farms with similar structures into classes

1.Collecting

- ✓ This is the most direct method of obtaining plant products.
- ✓ It includes regular and irregular harvesting of uncultivated plants.
- ✓ Hunting goes hand in hand with collecting. It is still being practiced to provide additional to the normal subsistence food supply.

It is only in few cases like wild oil palm in some parts of West Africa and gum Arabic in Sudan and wild honey in Tanzania that collecting is a major cash earning activity.

2.Cultivation

- **This class is more important than collecting.**

Classification according to type of rotation

Cultivation alternates with an uncultivated fallow which may take the following forms:-

- Forest fallow made up of woody vegetation with trunks,
- A bush fallow comprising of dense wood without trunks,
- A savannah fallow comprising of a mixture of fire resistant trees and grasses and in which grasses are dominant,
- A grass fallow comprising grass without woody vegetation

Classification according to the degree of commercialization

- The 1970 World Census on Agriculture classified farms into three groups based on the destination of the agricultural output:

1. ***Subsistence farming:*** if there is virtually no sale of crop and animal products,
2. ***Partly commercialized farming:*** if more than 50% of the value of the produce is for home consumption,
3. ***Commercialized farming:*** if more than 50% of the produce is for sale.

Classification according to grassland utilization

- Low yields in grassland area of the arid and semi-arid areas necessitated nomadic life, or semi- nomadic life, or development of ranching.

- Total nomadism – the animal owner does not have a permanent place of residence.
- They do not practice regular cultivation and their families move with the heards tended by herdsmen.
- Semi-nomadism where the animal owners have a semi- permanent place of residence near which supplementary irrigation is practiced however, they travel with their herds to distant grazing areas.
- Transhumance in which, farmers with a permanent place of residence send their herds tended by herdsmen for long period of time to distant grazing areas.

- Partial nomadism is characterized by farmers who live continuously in permanent settlements with their herds remaining in the vicinity.
- Stationary animal husbandry occurs where the animals remain on the holding or in the village through the entire year.
- Generally, classification of agriculture shows the contrast between different types of farming found all over the world.

Four broad types are:

(a) arable; pastoral and mixed farming;

(B)subsistence and commercial farming

(C)shifting cultivation and sedentary farming;

(D) extensive and intensive farming.

Arable, Pastoral and Mixed Farming

1. ***Arable farming***: is the growing of crop; usually on flatten lands where soils of high quality. It has led the first permanent settlers in the Tigris-Euphrates, Nile and Indus valleys.
2. ***Pastoral farming*:** is the rearing of animals usually on land, which is less favorable to arable farming.
3. ***Mixed farming***: is the growing of crops & rearing of animals together. It is practiced on a commercial scale in developed countries and subsistence level in developing countries.

Subsistence and Commercial Farming

1. ***Subsistence farming***: is the production of food by farmers for their own family or the local community-there is no surplus. Farmers rarely able to improve their product due to lack of capital, land and technology and not lack of effort or ability.

2.***Commercial farming*: it takes place on large profit making scale. Farmers produce cash crops and seek to maximize yields/hectares. Cash crops operate successfully where transport is well developed, domestic markets are large & expanding and there are opportunities for international trade.

Shifting cultivation and sedentary farming

- **Shifting cultivation** is now limited to a few place where there are low population densities and a limited demand for food. However, most of the farming systems of the world is now sedentary way of farming where farmers remain in one place to look after their crops and rear their animals.
- It is a more advance form of subsistence agriculture in tropical lowlands, where the fallowed fields are frequently reused.

Extensive and Intensive cultivation: -

- On the basis of amount of labor, capital and land involved in the farming system, agriculture is divided in to extensive and intensive farming.

1. ***Intensive farming*****:** is best defined as farming in which much capital is expended or much labor is applied to a given area of land in order to increase its productivity.
2. ***Extensive farming***: is a method of farming in which the amount of capital and labor applied to a given area is relatively small.

- In contrast to intensive farming where the aim is to get the maximum return per unit of land area, extensive farming aims at producing the maximum product per unit of
- man power.
- Therefore, extensive farming is carried out on large scale while intensive farming is usually relatively on small scale.

- Generally, ***intensive farming*** is practiced where land is scarce and the population density is higher while extensive farming is practiced in the reverse situation.

Agriculture

- Agriculture is the art, science, and industry of managing the growth of plants and animals for human use. In a broad sense agriculture includes cultivation of the soil, growing and harvesting crops, breeding and raising livestock, dairying, and forestry.

Evolution of agriculture

- The history of agriculture may be divided into five broad periods of unequal length, differing widely in date according to region: prehistoric, historic through the Roman period, feudal, scientific, and industrial. A countertrend to industrial agriculture, known as sustainable agriculture or organic farming, may represent yet another period in agricultural history:

A.Prehistoric agriculture

As archaeologists agree early farmers were, largely of Neolithic culture. Sites occupied by such people are located in:

- ✓Southwestern Asia in what are now Iran, Iraq, Israel, Jordan, Syria, and Turkey;
- ✓Southeastern Asia, in what is now Thailand;
- ✓Africa, along the Nile River in Egypt; and
- ✓Europe: along the Danube River and in Macedonia, Thrace, and Thessaly.
- ✓Early centers of agriculture have also been identified in the Huang He (Yellow River) area of China; the Indus River valley of India and Pakistan; and the Tehuacán Valley of Mexico, northwest of the Isthmus of Tehuantepec.

- The dates of domesticated plants and animals vary with the regions, but most predate the 6th millennium BC, and the earliest may date from 10,000 BC.

- Scientists have carried out carbon-14 testing of animal and plant remains and have dated finds of domesticated sheep at 9000 BC in northern Iraq; cattle in the 6th millennium BC in northeastern Iran; goats at 8000 BC in central Iran; pigs at 8000 BC in Thailand and 7000 BC in Thessaly; on agers, or asses, at 7000 BC in Iraq; and horses around 4000 BC in central Asia.

B.Historical Agriculture through the Roman Period

- With the close of the Neolithic period and the introduction of metals, the age of innovation in agriculture was largely over.
- The historical period known through written and pictured materials, including the Bible; Middle Eastern records and monuments; and Chinese, Greek, and Roman writings was highlighted by agricultural improvements.
- A few high points must serve to outline the development of worldwide agriculture in this era, roughly defined as 2500 BC to 500 AD.
- Mixed farming and stock raising, which were flourishing in the British Isles and on the continent of Europe as far north as Scandinavia at the beginning of the historical period, already displayed a pattern that persisted throughout the next 3,000 years.

- In many regions, fishing and hunting supplemented the food grown by farmers.
- The Roman Empire appears to have started as a rural agricultural society of independent farmers and tenant was attached to the land.

C.Feudal Agriculture

- The feudal period in Europe began soon after the fall of the Roman Empire, reaching its height about AD 1100. This period was also marked by development of the Byzantine Empire and the power of the Saracens in the Middle East and southern Europe.

Agriculture in Spain, Italy, and southern France, in particular, was affected by events outside continental Europe.

- As the Arab influence extended to Egypt and later Spain, irrigation was extended to previously sterile or unproductive land.
- Rice, sugarcane, cotton, and vegetables such as spinach and artichokes, as well as the characteristic Spanish flavoring saffron, were produced.
- The silk worm was raised and its food, the mulberry tree, was grown.

D.Scientific Agriculture

- By the 16th century, population was increasing in Europe, and agricultural production was again expanding.
- The nature of agriculture there and in other regions was changed considerably in succeeding centuries.
- Several reasons can be identified for this trend:
  - ✓Europe was cut off from Asia and the Middle East by an extension of Ottoman power.
  - ✓New economic theories were put into practice, directly affecting agriculture.
  - ✓A new period of global exploration and colonization was undertaken to circumvent the Ottoman Empire's control of the spice trade, to provide homes for religious refugees, and to provide new resources for European nations convinced that only precious metals constituted wealth.
  - ✓Colonial agriculture was intended not only to feed the colonists but also to produce cash crops and to supply food for the home country.
  - This meant cultivation of such crops as sugar, cotton, tobacco, and tea, and production of animal products such as wool and hides.

- ✓ From the 15th to the 19th century the slave trade provided laborers needed to fill the large workforce required by colonial plantations.
- Many early slaves replaced indigenous peoples who died from diseases carried by the colonists or were killed by hard agricultural labor to which they were unaccustomed.
- Slaves from Africa worked, for example, on sugar plantations in the Caribbean regions and on indigo and cotton plantations in what would become the southern United States.
- Native Americans were virtually enslaved in Mexico.
- By the mid-19th century the agricultural pattern was based on the relationship between the landowner, dependent on rents; the farmer, producer of crops; and the landless laborer, the hired hand of American farming lore.
- Drainage brought more land into cultivation, and, with the Industrial Revolution, farm machinery was introduced.

E. Industrial Agriculture

- Many of the innovations introduced to agriculture by the scientific and Industrial revolutions paved the way for a qualitative change in the nature of agricultural production, particularly in advanced capitalist countries.
- This qualitative change became known as industrial agriculture.
- It is characterized by:
  - ✓ heavy use of synthetic fertilizers and pesticides;
  - ✓ extensive irrigation;
  - ✓ large -scale animal husbandry involving animal confinement and the use of hormones and antibiotics;
  - ✓ Reliance on heavy machinery; the growth of agribusiness and the commensurate decline of family farming; and the transport of food over vast distances.
  - ✓ Industrial agricultural has been credited with lowering the cost of food production and hence food prices, while creating profitable businesses and many jobs in the agricultural chemistry and biotechnology industries.
  - ✓ It has also allowed farmers and agribusinesses to export a large percentage of t heir crops to other countries. Farm exports have enabled farmers to expand their markets and have contributed to aiding a country’s trade balance.

- During the 20th century, a reaction developed to industrial agriculture known as sustainable agriculture.
- While industrial agriculture aims to produce as much food as possible at the lowest cost, the main goal of sustainable agriculture is to produce economically viable, nutritious food without damaging natural resources such as farmland and the local watershed.
- Examples of sustainable agricultural practices include:
  - ✓rotating crops from field to field to prevent the depletion of nutrients from the soil,
  - ✓using fertilizers produced naturally on the farm rather than synthetic products, and
  - ✓Planting crops that will grow without needing extensive irrigation.

Types of agriculture

- Based on different guidelines, agriculture may have various types. It can constituent all rain -fed, irrigation, animal husbandry or crop production.

Rain-fed and irrigation agriculture

- Rain -fed agriculture is commonly known as dry land agriculture. It is a type of agriculture which mainly depends on the rainfall bestowed from the nature.
- Since it is nature oriented weather induced problems are the major constraints in this type of agriculture.
- Problems include:
  - ✓ Recurrent flood
  - ✓ Drought
  - ✓ Excessive run off

- Characteristics of ***rain -fed/dry land agriculture***:
  - ✓The area is less densely populated than irrigated area in the country level.
  - ✓High proportion of landless households and agricultural laborers.
  - ✓Low land and labor productivity mainly due to the tenure system.
  - ✓High poverty concentration.
  - ✓Low infrastructural development in the regions.
  - Irrigation is the provision of a supply of water from a river, lake or underground source to enable an area of land to be cultivated. It is needed where:
  - ✓Rainfall is limited and where evapotranspiration exceeds precipitation.

- ✓There is a seasonal water shortage due to drought.
- ✓Amount of rainfall is unreliable as in case of Sahel countries.
- ✓Farming is intensive either subsistence or commercial despite high annual rainfall to fall.

Crop farming and animal husbandry

- As rapid climatic fluctuations of glacial period affects plants and animal’s food sources, people experiments domestication of plants and animals.
- Animal domestication began during the Mesolithic age not as a conscious economic effort but as out growths of the keeping of young wild animals.
- The assignment of religious significant to certain animals and the docility of other to herder by hunter all strengthened the human -animal connection that ultimately leads to full domestication.

- Radioactive carbon dating suggests that the domestication of:
  - ✓Goat- at 8000 BC in central Iran
  - ✓ Sheep at 9000 BC in northern Iraq
  - ✓Pigs at 8000 BC in Thailand, etc
- The domestication of plants like that of animals appeared to have occurred independently in more than one world region over a time span between 100,000 – 200,000 years ago.
- Most wide spread European food crops were first cultivated in the near east beginning some 100,000 years ago and dispersed rapidly from there across the mid latitude.
- Although not clear, evidences also exist that African people were raising crops of wheat, barley, litters and peas on the flood plain of the Nile River as early as 185,000 years ago.

- **Fish farming**

- It is impossible to overstate the importance of fish to human populations around the world.

- Throughout history, humans have used fish protein as a food source, with wild caught fish providing the bulk of fish protein.

- Fish have also been farmed in large quantities for more than 2000 years in China.

- Recent advances in fish farming, especially with some African cichlids have alleviated hunger in many parts of the world. In industrialized countries, farm - raised fish provide relief for overfished stocks of wild fish.

- Fish also have served as a source of recreational pleasure for many people.

Forestry

- Forestry is management of forestlands for maximum sustained yield of forest resources and benefits.
- Although forestry originally concerned mainly timber production, it now also involves the management of grazing areas for domestic livestock, the preservation of wildlife habitats, watershed protection, and the development of recreational opportunities.
- The management of forestlands therefore helps to ensure that wooded areas are used for maximum benefit according to their nature.

World Agriculture

- Over the 10,000 years since agriculture began to be developed, peoples everywhere have discovered the food value of wild plants and animals, and domesticated and bred them.

- The most important crops are cereals such as wheat, rice, barley, corn, and rye; sugarcane and sugar beets; meat animals such as sheep, cattle, goats, and pigs or swine; poultry such as chickens, ducks, and turkeys; animal products such as milk, cheese, eggs; nuts and oils.

- Fruits, vegetables, and olives are also major foods for people. Feed grains for animals include soybeans, field corn, and sorghum.

- Agricultural income is also derived from nonfood crops such as rubber, fiber plants, tobacco, and oil seeds used in synthetic chemical compounds, as well as animals rose for pelts.

- Conditions that determine what is raised in an area include climate, water supply and waterworks, terrain, and ecology.
- Farm size varies widely from region to region. In the early 2000s the average farm size is by far larger in the developed countries like Canada and USA.
- By contrast, the average size of a single land holding in developing nations is too small.
- Size also depends on the purpose of the farm. Commercial farming, or product ion for cash, usually takes place on large holdings.
- In 2003, 44% of the world’s labor force was employed in agriculture.

- The distribution ranged from 66% of the economically active population in sub -Saharan Africa to less than 3% in the United States and Canada.
- In Asia and the Pacific, the figure was 60%; in Latin America and the Caribbean, 19%; and in Europe, 9%.
- Much of the foreign exchange earned by a country may be derived from a single agricultural commodity; for example, Sri Lanka depends on tea, Denmark specializes in dairy products, Australia in wool, and New Zealand and Argentina in meat products.
- In the United States, wheat, corn, and soybeans have become major foreign exchange commodities in recent decades

Chapter Five

5. Factors Affecting Farming System

- The location of different types of agriculture at all scales depends upon the interaction of physical, cultural and economic factors.

1. Physical factors

- Although there has been a movement away from the view that agriculture is controlled solely by physical conditions, it must be accepted that environmental factors do exert a major influence in determining the type of farming practiced in any particular area. These factors include:

Temperature

- This is a critical for plant growth because each plant or crop and animal type requires a minimum growing temperature and a minimum growing season. In temperate latitudes, the critical temperature is 6ºC.
- Below this figure, members of the grass family, which include most cereals, cannot grow- an exception is rye, a hardy cereal, which may be grown in many northerly latitudes.
- For instance, in tropics, there is a continuous gr owing season, provided moisture is available.
- As well as decreasing with distance from the equator, both temperatures and the length of the growing season decrease with height above sea -level.

Altitude

- The growth of various crops is controlled by the decrease in temperature with height. As height increases, so too does exposure to wind and the amount of clouds, snow and rain while the length of the growing season decreases. Soils take longer to develop as there are fewer mixing agents as well there is a high tendency of soil erosion.
- Example:

1. *In tropical rainforest- subsistence/shifting cultivation;*
2. In mixed forest- some subsistence agriculture;
3. Dwarf forest- very little agriculture;

4. In grass lands- herding; and
5. In ice and snow- almost no agricultural activities except hunting and fishery.

Precipitation and water supply

- The mean annual rainfall for an area determines whether its farming is likely to be based up on tree crops, grass or cereals, or irrigation.
- The relevance and effectiveness of this annual total rainfall depends on temperatures and the rate of evapotranspiration.
- However, the seasonal distribution of rainfall is usually more significant for agriculture than is annual total.

Wind

- Strong winds can increase evapotranspiration rates which allow the soil to dry out and to become vulnerable to erosion. Several local winds also have harmful effects on farming.

- Hurricanes and tornadoes can all destroy crops by their sheer strength.
- Bu t it is better to understand that some other winds are important for farming activities

Angle of slope (gradient)

- Slope affects the depth of soil, its moisture content and it’s PH, and hence the type of crop which can be grown on it.
- It influences erosion and is a limitation on the use of machinery.
- Until recently, a 5º slop was the maximum for mechanized ploughing but technological improvements have increased this to 11º.

Aspect

- Aspect is an important part of the micro climate.
- South facing and north facing slopes in northern hemisphere, that are wind ward and lee ward respectively, can influence cropping.
- Crops and trees both grow to higher altitudes on the wind ward slopes as they have the chance to get higher temperature and drier soils.\

Soils (edaphic factors)

- Farming depends up on the depth, stoniness, water -retention capacity, aeration, texture, structure, PH, leaching and mineral content of the soil. For instance:
  - ✓ ***Clay soils:*** tend to be heavy, acidic, poorly drained, cold and ideally should be left under permanent grass.
  - ✓ ***Sandy soils:*** tend to be lighter, less acidic, perhaps too well drained, warmer and more suited to vegetables and fruits.
  - ✓ ***Lime soils*** (chalk): are light in texture, alkaline, dry and give high cereal yields.

Global warming

- Scientists agree that the green house effect will not only lead to an increase in temperature but also to changes in rainfall patterns.
- The global increase in temperature will allow many parts of the world to grow crops which at present are too cold for them.

2.Cultural (human) factors affecting farming

Land tenure

- Farmers may be owner's occupiers, tenants, landless laborers, or state employees on the land which they farm.
- For instance, in cash tenancy, farmers have to give as much as 80% of their income or a fixed pre arranged rent to the land owner whereas share cropping is when the farmer has to give 50% for the land owner.
- In sum tenure security affects the farming system because farmers are expected to invest more when they feel the land they use belongs to them in permanent manner.

Inheritance laws and land fragmentation

- In several countries, inheritance laws have meant that on the death of a farmer the land is divided equally among all his sons (rarely among daughters).
- This tradition has led to the sub -division of farms in to numerous scattered and small fields.
- Fragmentation results in much time being wasted in moving from one distant field to another.

Farm size

- As indicated above, inheritance laws tend to reduce the size of individual farms so that they can operate only at subsistence level or below. Differences in farm size also affect types of land use.

3. Economic factors affecting farming

- However favorable the physical environment may be, it is of limited value until human resources are added to it.

Transport

- This includes the type of transport available, the time taken and the cost of moving raw materials to the farm and produce to market.
- For perishable commodities like milk and fresh fruit, the need for speedy transport to market demands an efficient transport network, while for bulky goods, like potatoes, transport costs must be lower for output to be profitable.
- In both cases, the items should ideally be grown as near to their market as possible.

Market

- The role of markets is closely linked with transport (perishable and bulky goods). For further understanding, read the von Thünen least cost theory.

Capital

- Developed countries have large reserves of readily available finance, which over time have been used to build up capital-intensive types of farming such as dairying, market gardening and mechanized cereal growing.
- On the other hand, farmers in developing countries, often with limited capital resources, have to resort to labor intensive methods of farming. In addition,

Technology

- Technological developments such as new strains of seeds cross -breeding of animal s, improved machinery and irrigation may extend the area of optimal conditions and the limits of production.
- Lacking in capital and expertise, developing countries are rarely able to take advantages of these advances and so the gap between them and the economically developed world continuous to increase.

Government

- In centrally planned economies it is the state, not the individual, which makes the major farming decisions.
- This can affect the overall profitability of the farming business.
- For instance, the developed countries' governments provide a sustainable subsidy to their farmers; this in turn lowered the competitiveness of developing countries' farmers in international markets, who do not have any kind of subsidy.

Chapter Six
Agricultural Policy

- **Policy** is guiding principle leading to a course of action that is pursued by the government. The term '**<u>policy</u>**' has various definitions:

    1. Everything that a Government decides to do or not to do
    2. A set of interrelated decisions, including the identification of objectives and the tools to achieve them taken by a political actor(s) to address a certain issue
    3. A set of principles and directives that guide the decisions of an organization

1. Policy making

- ***Policy making***: is a long-term, interactive, and multi-stakeholder process to develop a framework to implement a certain policy, and to evaluate and modify its implementation on a regular basis.
- It also refers to elaborating a policy document or a policy statement.

- Policy or guidelines for actions and decisions" establish the setting in which an entity exists and operates.
- However, "policy" is not equivalent to "regulations" or "a legal framework", since they represent only one of a number of possible tools for policy implementation.

Policy development basic terms

1. ***Policy:* is** a set of principles and directions that guide the decisions and actions of an organization.
2. ***Objectives***: is a desired situation or outcome that one wants to achieve. Objectives can be general or specific, the latter defining the necessary components to achieve the general objective.
3. ***Strategy***: is an outline how to achieve identified objectives. Includes broad guidelines ('basic principles') to develop an action plan.

4. ***Action plan:* is** specifies the steps necessary to implement a strategy. An action plan sets out what will be done, who will do it, when, with what resources, and what are the expected results

5. ***Programes**:* is a components of an action plan related to specific topics, such as financing, energy efficiency, sectoral initiatives, etc.

6. ***Projects:*** is a smallest operational components of programmes.

Agricultural Policy

What is Agricultural Policy?

- A subset of public policy directed primarily but not exclusively at the farm and agribusiness sectors of society.

Agricultural policy applies to two markets

1. ***Agricultural input markets***

- Use of land and other natural resources
- Agricultural credit and finance
- Labor
- Industrial products

2. ***Agricultural output markets***

  - Production
  - Consumption

- Marketing
- International trade

3. Agricultural Policy in Ethiopia Policy Framework agriculture

- Ethiopia has a consistent set of policies and strategies for agriculture and rural development that reflect the importance of the sector.
  - ✓The policy framework is based on the concept of the strategy of Agricultural Development-Led Industrialization (ADLI),
  - ✓ADLI has been the central pillar of Ethiopia's development vision since the 1990s.
  - ✓ADLI envisages an economically transformed society within which agriculture will grow rapidly,

- ✓The Rural Development Policy and Strategies (RDPS, 2003) presents specific policies and strategies to guide agricultural and rural development
- ✓The Plan for Accelerated and Sustainable development to End poverty (PASDEP 2005/06 to 2009/10) also gave high priority to agriculture and rural development.

The Five Year growth and Transformation plan (FYGTP)

- FYGTP recognizes the pivotal role of agriculture, and plans for accelerated growth for the sector on the basis of solid performance in the previous plan period as well as growing demand for food and industrial raw materials.

- Increasing male and female smallholder productivity and production is the main thrust of the plan and will be achieved in three major ways:
  - ✓First, by scaling up best practices used by leading farmers whose productivity is 2-3 times higher than the average.
  - ✓Second, by improving the management of natural resources with a focus on improving water utilization and the expansion of irrigation.
  - ✓Third, by encouraging farmers to change from low value to high value products in order to increase their cash incomes.

- These initiatives will be supported by farmer training and measures to improve access to agricultural inputs and product markets using cooperatives as the delivery mechanism.
  - ✓ Encourage Private sector participation
- The FYGTP envisages differentiation among the three main agro-ecological zones.
  - ✓ Adequate moisture areas
  - ✓ Moisture deficit areas
  - ✓ Pastoral areas