UNIVERSITY OF GONDAR

COLLEGE OF SOCIAL SCIENCES & HUMANITIES

Department of Geography & Environmental Studies

Agro ecology and farming system (GeES3103)

CHAPTER ONE
INTRODUCTION

1.1, The Concept of Ecology and Agro ecology and Farming System

A, Ecology

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. It views each locale/ environment as an integrated whole of interdependent parts that function as a unit. The interdependent parts are *Nonliving* such as dead organic matter, nutrients in the soil and water; Producers such as green plants; *Consumers* such as herbivores and carnivores; Decomposers such as fungi and bacteria.

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 nonliving environment.

B, Agro ecology

A wider understanding of the agricultural context requires the study between agriculture, the global environment and social systems given that agricultural development results from the complex interaction of a multitude of factors. It is through this deeper understanding of the ecology of agricultural systems that doors will open to new management options more in tune with the objectives of a truly sustainable agriculture.

Different scholars' definition

Gliessman 2000 defined: "The application of **ecological concepts and principles** to the **design and management** of **sustainable farming systems.**

- **Ecological concepts and principles**: understanding science
- **Design and management**: practice (technology)

- **Sustainable**: goal and motivation (What is sustainability? How does sustainability vary? What makes a farming system sustainable? Is sustainability always attainable?)
- **Farming systems**: techniques

B. Boeken defined that: The application of ecological concepts and principles to farming systems

- **Ecological concepts and principles**: ecological processes associated with farming
- **Farming systems**: All agro-systems (Conventional, traditional and Alternative agriculture)

The science of **agro ecology**, is defined as the application of ecological concepts and principles to the design and management of sustainable agro ecosystems, provides a framework to assess the complexity of agro ecosystems. **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 agrochemical 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 has emerged as the discipline that provides the basic ecological principles for how to study, design and manage agro ecosystems that are both productive and natural resource conserving, and that are also culturally sensitive, socially just and economically viable. Agro ecology goes beyond a one-dimensional view of agro ecosystems —their genetics, agronomy, and so on to embrace an understanding of ecological and social levels of co evolution, structure and function. Instead of focusing on one particular component of the agro ecosystem, agro ecology emphasizes the interrelatedness of all agro ecosystem components and the complex dynamics of ecological processes.

Agro-ecology has been defined **as a science, as a set of practices, and even as a social and political movement.**

1. **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". This can apply not just at the farm-level, but also across the global network of food production, distribution and consumption, including food production systems, processing and marketing, the role of the consumer, and the policy level. As such, it uses knowledge from a range of disciplines, including agricultural and ecological science, and traditional knowledge systems. It questions conventional approaches which are centered on the use of science to promote economic growth.
2. **Agro-ecology as practice** -seeks ways to enhance farming systems by mimicking natural processes, using biological interactions and synergies to support production.
3. **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 a discipline that defines, classifies and studies agricultural systems from an ecological and socio-economic perspective, and applies ecological concepts and principles to the design and management of sustainable agro ecosystems. Agro ecology is first and foremost a response to the negative ecological, social and economic impacts of industrial agriculture.

- The **ecological** perspective, focusing on how natural resources - soil and water are used and managed for sustainable agricultural production;
- The **economic** perspective, focusing on the marketing of agricultural products through competitive value chains which link farmers to the consumer; and
- The **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

Hot topics in agro ecology

- Pesticide effects on biodiversity
- Mixtures of pesticides and effects on organisms
- Endocrine disrupting effects of pesticides and industrial chemicals
- Genetic engineering and "genetic pollution" in environment
- Soil food web- function of diversity
- Nutrient cycles
- Industrial waste--toxic waste and application to land of heavy metals and dioxin in fertilizers

C, Farming system

Farming as a system

A farm = A system

- *Inputs* into the system
- *Processes* taking place in it
- *Outputs* from the system
    - ✓ e.g. profits can be reused back in the system

1. Physical inputs
    - ✓ Climate
    - ✓ Amount and season of rain
    - ✓ Summer and winter temperature
    - ✓ Growing season
    - ✓ Relief
    - ✓ Soils and drainage
2. 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

A system is a set of inter-related, interacting and interdependent elements acting together for a common purpose and capable of reacting as a whole to external stimuli. It is unaffected by its own output and it has external boundaries based on all significant feed backs.

Farms are systems because several activities are closely related to each other by the common use of the farm labour, land and capital, by risk distribution and by the joint use of the farmer's management capacity. The analysis of farms is quite important to the subject of development.

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?

1. 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

2. 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/or 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 (elements of the system) which are under the management of the farmer

1.2, Ecosystem and agro ecosystem

A, Eco system = the Community + Abiotic environment, interacting

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 live 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 different 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)

B, 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. **Agro ecology** is the holistic study of agro ecosystems, including all environmental and human elements. It focuses on the form, dynamics and functions of their interrelationships and the processes in which they are involved. An area used for agricultural production, e.g. a field is seen as a complex system in which ecological processes found under natural conditions also occur, e.g. nutrient cycling, predator/prey interactions, competition, symbiosis and successional changes. Implicit in agro ecological research is the idea that, by understanding these ecological relationships and processes, agro ecosystems can be manipulated to improve production and to produce more sustainably, with fewer negative environmental or social impacts and fewer external inputs

1.3, 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;
- foster and equip the multi-criteria steering of agro ecosystems in a perspective of long term transition, including arbitrations between short time and long time and attaching significance to resilience and adaptability properties;
- promote the spatio temporal variability (diversity and complementarities) of resources, i.e. take advantage of local resources and characteristics and work with diversity and variety rather than seek to overcome it;
- Stimulate the exploration of situations far removed from optima already known, e.g. “extreme” systems at very low levels of inputs and/or organic in livestock as well as in vegetable production
- Promote the construction of arrangements for participatory research that allow the development of “finalized” research while guaranteeing the scientificity of approaches. The design of sustainable systems indeed is complex and implies the acknowledgment of interdependence of actors, of their ambiguities, as well as of the uncertainty of socio-economic impacts of technological innovations;
- create knowledge and collective capacity of adaptation through networks including producers, citizens-consumers, researchers and technical advisers of public authorities, which promote deliberative forums, public debate and knowledge dissemination;
- promote possibilities of choices of autonomy compared with global markets by the creation of a public goods-friendly environment and the development of socio-economic practices and models which strengthen democratic governance of food systems, notably via systems managed by producers and citizens-consumers and via systems (re)territorialized highly labor intensive;

- Promote the diversity of knowledge to be taken into account: local or traditional knowledge and practices, ordinary knowledge in the construction of problems and the construction of publics concerned by these problems, than in the search of solutions.

Specific interpretations are given as follows

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.
  - ✓ use perennials
  - ✓ Use no-till or reduced tillage methods.
  - ✓ Mulch.

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**
- Reestablish ecological relationships that can occur naturally on the farm instead of reducing and simplifying them.
- Manage pests, diseases, and weeds instead of “controlling” them.
- Use intercropping and cover cropping
- Integrate Livestock
- Enhance beneficial biota
  - ✓ free-living nitrogen fixers in soils
  - ✓ Enhance beneficial populations by breed and release programs.
- 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 to meet the needs of the crops and animals.

6. Diversify

- ➢ **Landscapes**
  - ✓ Maintain undisturbed areas as buffer zones.
  - ✓ Use contour and strip tillage.
  - ✓ Use rotational grazing.

7. 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.

8. 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
- ✓ Avoid dependence on external subsidies
- ✓ Use multiple crops to diversify seasonal timing of production over the year.

9. Empower People

- a. Ensure that local people control their development process.
- b. Use indigenous knowledge
- c. Promote multi-directional transfer of knowledge, as opposed to "top-down" knowledge transfer.
- d. Teach experts and farmers to share knowledge, not "impose" it.

10. Engage in people-centric development.

11. Increase farmer participation.

- e. Link farmers with consumers

12. Strengthen communities.

- f. Encourage local partnerships between people and development groups.
- g. Ensure intergenerational fairness.

13. Guarantee agricultural labor.

- ✓ Ensure equitable labor relations for farm workers.

14. Teach principles of agro ecology & sustainability.

15. Manage Whole Systems

16. Use planning processes that recognize the different scales of agro ecosystems.

- ✓ Landscapes
- ✓ Households
- ✓ Farms
- ✓ Communities
- ✓ Bioregions
- ✓ Nations

17. Minimize impacts on neighboring ecosystems.

18. Maximize Long-Term Benefits

a. Maximize intergenerational benefits, not just annual profits.
b. Maximize livelihoods and quality of life in rural areas.
c. Facilitate generational transfers.
d. 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.

19. 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
- ➢ Plant Health

CHAPTER TWO

2.1: MAJOR AGRO-ECOLOGICAL ZONES OF THE WORLD AND ASSOCIATED FARMING SYSTEM

Description of Koppen and Thornwaith's methods of climatic classification

A, Koppen's methods of climatic classification

Köppen climate 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) that were being mapped for the first time during his lifetime. 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. Other climatologists have modified portions of Köppen's procedure on the basis of their experience in various parts of the world.

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 for B is defined by temperature criteria. Type B designates climates in which the controlling factor on vegetation is dryness (rather than coldness). Aridity is not a matter of precipitation alone but is defined by the relationship between the precipitation input to the soil in which the plants grow and the evaporative losses. Since evaporation is difficult to evaluate and is not a conventional measurement at meteorological stations, Köppen was forced to substitute a formula that identifies aridity in terms of a temperature-precipitation index (that is, evaporation is assumed to be controlled by temperature).

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; each type is designated by a capital letter.

- 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.

Further subgroups are designated by a second, lower case letter which distinguishes specific seasonal characteristics of temperature and precipitation.

- f - Moist with adequate precipitation in all months and no dry season. This letter usually accompanies the A, C, and D climates.

- m - Rainforest climate in spite of short, dry season in monsoon type cycle. This letter only applies to A climates.
- s - There is a dry season in the summer of the respective hemisphere (high-sun season).
- w - There is a dry season in the winter of the respective hemisphere (low-sun season).

To further denote variations in climate, a third letter was added to the code.

- a - Hot summers where the warmest month is over 22°C (72°F). These can be found in C and D climates.
- b - Warm summer with the warmest month below 22°C (72°F). These can also be found in C and D climates.
- c - Cool, short summers with less than four months over 10°C (50°F) in the C and D climates.
- d - Very cold winters with the coldest month below -38°C (-36°F) in the D climate only.
- h - Dry-hot with a mean annual temperature over 18°C (64°F) in B climates only.
- k - Dry-cold with a mean annual temperature under 18°C (64°F) in B climates only.

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. Three minor Köppen climate types exist in the A group, and their designation is based on seasonal distribution of rainfall.

- Af or **tropical wet** is a tropical climate where precipitation occurs all year long. Monthly temperature variations in this climate are less than 3° Celsius. Because of intense surface heating and high humidity, cumulus and cumulonimbus clouds form early in the afternoons almost every day. Daily highs are about 32° Celsius, while night time temperatures average 22° Celsius.
- Am a **tropical monsoon** climate. Annual rainfall is equal to or greater than Af, but most of the precipitation falls in the 7 to 9 hottest months. During the dry season very little rainfall occurs.
- The **tropical wet and dry or savanna** (Aw) has an extended dry season during winter. Precipitation during the wet season is usually less than 1000 millimeters, and only during the summer season.

2. Dry Climates (B)

The most obvious climatic feature of this climate is that potential evaporation and transpiration exceed precipitation. These climates extend from 20 - 35° North and South of the equator and in large continental regions of the mid-latitudes often surrounded by mountains. Minor types of this climate include:

- BW - **dry arid (desert**) is a true desert climate. It covers 12% of the Earth's land surface and is dominated by xerophytic vegetation. The additional letters h and k are used generally to distinguish whether the dry arid climate is found in the subtropics or in the mid-latitudes, respectively.
- BS - **dry semiarid (steppe**). Is a grassland climate that covers 14% of the Earth's land surface? It receives more precipitation than the BW either from the inter tropical convergence zone or from mid-latitude

cyclones. Once again, the additional letters h and k are used generally to distinguish whether the dry semiarid climate is found in the subtropics or in the mid-latitudes, respectively.

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. During the winter, the main weather feature is the mid-latitude cyclone. Convective thunderstorms dominate summer months. Three minor types exist:

- Cfa - humid subtropical;
- Cs - Mediterranean; and
- Cfb - marine.

The humid subtropical climate (Cfa) has hot muggy summers and frequent thunderstorms. Winters are mild and precipitation during this season comes from mid-latitude cyclones. A good example of a Cfa climate is the southeastern USA.

Cfb marine climates are found on the western coasts of continents. They have a humid climate with short dry summer. Heavy precipitation occurs during the mild winters because of the continuous presence of mid-latitude cyclones.

Mediterranean climates (Cs) receive rain primarily during winter season from the mid-latitude cyclone. Extreme summer aridity is caused by the sinking air of the subtropical highs and may exist for up to 5 months. Locations in North America are from Portland, Oregon to all of California.

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. Like the C climates there are three minor types:

- Dw - dry winters;
- Ds - dry summers; and
- Df - wet all seasons.

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. Two minor climate types exist.

- ET or polar tundra is a climate where the soil is permanently frozen to depths of hundreds of meters, a condition known as permafrost. Vegetation is dominated by mosses, lichens, dwarf trees and scattered woody shrubs.
- EF or polar ice caps has a surface that is permanently covered with snow and ice.

B, Thornwaith's methods of climatic classification

In 1931 Thornthwaite 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, Thornthwaite's classification is based on precipitation effectiveness and thermal efficiency (temperature 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.

Thornthwaite 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. Thus, besides the precipitation amount and the evaporation rate, temperature was made a very important basis for Thornthwaite'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. In other words, the effectiveness of precipitation is taken to be a function of precipitation and evaporation and is calculated by dividing the monthly precipitation by the monthly evaporation to get the P/E ratio (precipitation effectiveness ratio).

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
3. A (Wet)	Rain Forest	127
4. B (Humid)	Forest	64-127
5. C (Sub humid)	Grassland	32-63
6. D (Semiarid)	Steppe	16-31
7. E (Arid)	Desert	16

Thornthwaite introduced an index of thermal efficiency which is expressed by the positive departure of monthly mean temperatures from the freezing point. The index is thus the annual sum of (t-32)/4 for each month. In other words, the sum of twelve monthly temperature-efficiency ratios (T/E) gives a T/E index

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

T/E Index-sum of 12 monthly values of (T-32)14, where T is mean monthly temperature in °;F.

On the basis of the seasonal distribution of precipitation the humidity provinces were subdivided into the following

- r-Rainfall adequate in all seasons
- s-Rainfall deficient in summer
- w-Rainfall deficient in winter
- d-Rainfall deficient in all seasons.

When precipitation effectiveness, seasonal distribution of rainfall, and thermal efficiency are taken together, there would be in all 120 climatic types, at least on theoretical grounds. However, Thornthwaite has shown only 32 climatic types on the world map depicting his 1931 climatic classification.

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 a tropical air masses.

- ***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 between 77 and 88%. High surface heat and humidity cause cumulus clouds to form early in the afternoons almost every day. The climate on eastern sides of continents is influenced by maritime tropical air masses. These air masses flow out from the moist western sides of oceanic high-pressure cells, and bring lots of summer rainfall. 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.

- ***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 the north coast of Australia

- ***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. They coincide with the edge of the equatorial subtropical high pressure belt and trade winds. 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). All months less than 0.25 cm (0.1 in).
- Latitude Range: 15° - 25° N and S.

Global position: south western United States and northern Mexico; Argentina; north 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. These two air masses are in constant conflict. Either air mass may dominate the area, but neither has exclusive control.

Dry Midlatitude 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. If it received less rain, the steppe would be classified as an arid desert. With more rain, it would be classified as a tallgrass prairie. 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 poasition: Western North America (Great Basin, Columbia Plateau, Great Plains); Eurasian interior, from steppes of eastern Europe to the Gobi Desert and North China.

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)
- Annual Precipitation: 42 cm (17 in).
- 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.

Dry Midlatitude 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. This allows polar air masses to dominate in winter months. In the summer, a local continental air mass is dominant. A small amount of rain falls during this season. 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.

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. Daily temperatures also change often. Abundant precipitation falls throughout the year. 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. A southern hemisphere counterpart to these continental centers does not exist. Air masses of arctic origin meet polar continental air masses along the 60th and 70th parallels.

Boreal forest Climate (Dfc) taiga biome

This is a continental climate with long, very cold winters, and short, cool summers. This climate is found in the polar air mass region. 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. Much of the boreal forest climate is considered humid. However, large areas in western Canada and Siberia receive very little precipitation and fall into the subhumid or semiarid climate type.

- 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.

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. Moderating ocean winds keep the temperatures from being as severe as interior regions.

- 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.

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 climate of a highland area is closely related to the climate of the surrounding biome. 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. They work as water storage areas. Snow is kept back until spring and summer when it is released slowly as water through melting.

- 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 South America, the Alps in Europe, Mt. Kilimanjaro in Africa, the Himalayans in Tibet, Mt. Fuji in Japan.

C, 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 steppe: Semi-Arid: Evaporation > Precipitation
- 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 : Vegetation physiognomy: woodland and sparse forest dominant
- Boreal mountain systems: Approximate > 600 m altitude

5, Polar: All months below 10°C

2, Agro ecology and its approach

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

- *Crop Rotations*: Temporal diversity incorporated into cropping systems, providing crop nutrients and breaking the life cycles of several insect pests, diseases, and weed life cycles (Sumner 1982).
- *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 recycling (Pearson and Ison 1987).

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.

Research on diversified cropping systems underscores the great importance of diversity in an agricultural setting (Francis 1986, Vandermeer 1989, Altieri 1995).

Diversity is of value in agro ecosystems for a variety of reasons (Altieri 1994, Gliessman 1998):

- ✓ As diversity increases, so do opportunities for coexistence and beneficial interactions between species that can enhance agro ecosystem sustainability.
- ✓ Greater diversity often allows better resource-use efficiency in an agro ecosystem. There is better system-level adaptation to habitat heterogeneity, leading to complementarities in crop species needs, diversification of niches, overlap of species niches, and partitioning of resources.
- ✓ Ecosystems in which plant species are intermingled possess an associated resistance to herbivores as in diverse systems there is a greater abundance and diversity of natural enemies of pest insects keeping in check the populations of individual herbivore species.
- ✓ A diverse crop assemblage can create a diversity of microclimates within the cropping system that can be occupied by a range of non crop organisms - including beneficial predators, parasites, pollinators, soil fauna and antagonists - that are of importance for the entire system.
- ✓ Diversity in the agricultural landscape can contribute to the conservation of biodiversity in surrounding natural ecosystems.
- ✓ Diversity in the soil performs a variety of ecological services such as nutrient recycling and detoxification of noxious chemicals and regulation of plant growth.
- ✓ Diversity reduces risk for farmers, especially in marginal areas with more unpredictable environmental conditions. If one crop does not do well, income from others can compensate.

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 consumers 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

- Increased indebtedness induced by various factors including farmers' growing expenses related to the use of pesticides (notably due to the use of their increased quantities as a consequence of pests' resistance development).
- Significant contribution to climate change and increased vulnerability to its impacts. The use of huge amounts of chemical fertilizers, the expansion of the industrial meat industry, and the ploughing under of the world's savannahs and forests to grow agricultural commodities are together responsible for global greenhouse-gas (GHG) emissions that cause climate change.
- Industrial agriculture has particularly badly affected women. As the main food producers and caregivers in most communities in developing countries, they are most affected where there is erosion of biodiversity. Environmental degradation impacts their daily life, for example by forcing them to walk long distances for water because of water scarcity. Higher exposure of women to health problems resulting from the use of synthetic pesticides is another example. They are often the ones that are assigned these hazardous tasks, and are therefore particularly affected. Weight gain, lack of energy, falling air, obstructive pulmonary diseases, Leukemia in children, Parkinson's disease are a few examples of health risks women commonly confront.

Agro ecology as an alternative path to industrialized agriculture

- 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 an agricultural approach

Realizing agro ecological principles consists primarily in mimicking natural processes, thus creating beneficial biological interactions and synergies among the components of the Agro ecosystem (De Schutter, 2010) through multiple, context-specific combinations of strategies and practices that are designed, applied and managed primarily by farmers themselves, building first and foremost on their traditional knowledge and know-how.

Why agro ecology and genetically modified organisms (GMOs) are incompatible? The development of GMOs presents potential or proven risks including the following:

- Increased peasants' dependence on the agro-industry and thus reduced autonomy of farmers (notably by prohibiting farmers' to save seeds themselves);
- Biodiversity reduction (weakening flexibility offered by the natural environment to design adequate context-specific agro ecological strategies);
- Harmful impacts on the environment (e.g. through adverse impacts on beneficial insects and other organisms); increased environmental threats to farming systems (e.g. through the development of secondary pests resistance);
- Increased vulnerability of farming systems (notably due to biodiversity reduction);
- Reduced natural soil fertility;
- Increased economic costs for peasants and restricted experimentation by individual farmers while potentially undermining local practices for securing food and economic sustainability;

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.

5. *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.

6. *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. Some innovative farmers cross lines for crop improvement.
- *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.

According to GRAIN (2009): some practices for reducing GHG emissions and increasing carbon sequestration

- by using agro-ecological practices to rebuild the organic matter in soils lost from industrial agriculture, sequestration equivalent to 20–35% of current GHG emissions can be achieved;
- by stopping land clearing and deforestation for plantations, total GHG emissions can be reduced by 15–18%.
- by distributing food mainly through local markets instead of transnational food chains, total GHG emissions can be reduced by 10–12%; by decentralizing livestock farming and integrating it with crop production, total GHG emissions can be reduced by 5–9%.

Brought together, these measures would lead to reduction and sequestration of one-half to three fourths of current global GHG emissions.

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
- Agroecological Systems
- Low-input

Why Sustainable Agriculture?

- Environmental Damage
- Economic concentration of agribusiness gives farmers little power or control over production, marketing and distribution.
- Loss of farms --155,000 farms were lost from 1987 to 1997 and 30 million acres have been lost to development.

“The best way to communicate the meaning of sustainable agriculture is through real-life stories of farmers who are developing sustainable farming systems on their own farms.” (-John Ikerd)

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

- Perennial and biennial sod crops, annual green manures, and annual cover crops all build soil. Examples include vetch, rye, oats, fava beans, clover, buckwheat, sudangrass and sunnhemp.
- Increase nutrient availability.
- Temperature, moisture conditions, placement of the residue and quality of the cover crop influence nutrient release.

Soil Fertility: Cover Crops

- 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 allelopathy.
- 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: Soil Amendments & Supplemental Fertilizers

- Organic amendments and fertilizers are useful as long as they are in balance with the rest of the system. Use soil test to find deficiencies.
- Balance nutrient inputs with nutrient outputs each year.
- Inputs>outputs=accumulation. Results in risk of excess nutrients creating nonpoint source pollution and enhancing disease and pest incidence.

- Inputs<outputs=soil depletion. Potential risk of plant nutrient deficiencies and stress, reduced yield, and increased susceptibility to pest and pathogens.

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.

Crop Rotation Considerations

- Avoid rotation of crop species that share similar pests and diseases. Intersperse with different crops to break pest and disease cycles.
- Rotate crops to maximize use of nutrient inputs and distribute nutrient demand placed on soil.
- Think about fallow periods and perennial cover crops.
- Intercropping is the growing of two or more crops in proximity to promote interaction between them.

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

Ecological Pest Management

- Intercropping, diversity and cover cropping
- Crop rotation

- Use of resistant varieties
- Biological controls
- Organic chemical controls
- Basic framework used to decide when and how pests are controlled.
- Goal is to give growers management guidelines in order to make pest control economic and environmental.
- Integrates habitat modification and cultural, physical, biological and chemical practices to minimize crop losses.
- Monitoring, record keeping, and life-cycle information about pests and their natural enemies are used to determine which control measures are necessary.

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.

Sustainable Pasture Management

- Management is key to healthy and sustainable pastures.
- Lands most susceptible to erosion can be maintained as permanent sod.
- Land used for row crops benefits from a year or more in pasture as part of a crop rotation plan.
- Soil health improves as the content of organic matter increases under good grazing management.
- Soil structure improves over time as compaction and hardpan is reduced.
- Good pasture mixes include a variety of grasses, forbs and legumes.

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.

On the other hand, 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

Most people involved in the promotion of sustainable agriculture aim at creating a form of agriculture that maintains productivity in the long term by (Pretty 1994, Vandermeer 1995):

- optimizing the use of locally available resources by combining the different components of the farm system, i.e. plants, animals, soil, water, climate and people, so that they complement each other and have the greatest possible synergetic effects;

- reducing the use of off-farm, external and non-renewable inputs with the greatest potential to damage the environment or harm the health of farmers and consumers, and a more targeted use of the remaining inputs used with a view to minimizing 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 levels;
- working to value and conserve biological diversity, both in the wild and in domesticated landscapes, and making optimal use of the biological and genetic potential of plant and animal species; and
- Taking full advantage of local knowledge and practices, including innovative approaches not yet fully understood by scientists although widely adopted by farmers.

Agro ecology provides the knowledge and methodology necessary for developing an agriculture that is on the one hand environmentally sound and on the other hand highly productive, socially equitable and economically viable. Through the application of agro ecological principles, the basic challenge for sustainable agriculture to make better use of internal resources can be easily achieved by minimizing the external inputs used, and preferably by regenerating internal resources more effectively through diversification strategies that enhance synergisms among key components of the agro ecosystem.

The ultimate goal of agro ecological design is to integrate components so that overall biological efficiency is improved, biodiversity is preserved, and the agro ecosystem productivity and its self-regulating capacity is maintained. The goal is to design an agro ecosystem that mimics the structure and function of local natural ecosystems; that is, a system with high species diversity and a biologically active soil, one that promotes natural pest control, nutrient recycling and high soil cover to prevent resource losses.

CHAPTER THREE

AGRO-ECOLOGICAL ZONES OF ETHIOPIA

Traditional zone:

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)

1 A1 (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)

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

8 H6 (Very cold humid sub-afro-alpine)

9 M1 (Hot moist lowlands)

10 M2 (Warm moist lowlands)

11 M3 (Tepid moist mid highlands)

12 M4 (Cool moist mid highlands)

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

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

15 PH1 (Hot per-humid lowlands)

16 PH2 (Warm per-humid lowlands)

17 PH3 (Tepid per-humid mid highland)

18 SA1 (Hot semi-arid lowlands)

19 SA2 (Warm semi-arid lowlands)

20 SA3 (Tepid semi-arid mid highlands)

21 SH1 (Hot sub-humid lowlands)

22 SH2 (Warm sub-humid lowlands)

23 SH3 (Tepid sub-humid mid highlands)

24 SH4 (Cool sub-humid mid highlands)

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

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

27 SM1 (Hot sub-moist lowlands)

28 SM2 (Warm sub-moist lowlands)

29 SM3 (Tepid sub-moist mid highlands)

30 SM4 (Cool sub-moist mid highlands)

31 SM5 (Cold sub-moist mid highlands)

32 SM6 (Very cold sub-moist mid highlands)

33 WB (Water body)

CHAPTER FOUR

MAJOR CATEGORIES OF FARMING SYSTEM

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 key distinguishing attributes, notably:

(i) water resource availability, e.g. irrigated, rain fed, moist, dry;

(ii) climate, e.g. tropical, temperate, cold;

(iii) landscape relief/altitude, e.g. highland, lowland;

(iv) farm size, e.g. large scale;

(v) production intensity, e.g. intensive, extensive, sparse;

(vi) Dominant livelihood source, e.g. root crop, maize, tree crop, artisanal fishing, pastoral;

Vii, dual crop livelihoods, e.g. cereal-root, rice-wheat (note that crop-livestock integration is denoted by the term mixed); and

(viii) Location, e.g. forest based, coastal, urban based.

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

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.

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, Ley systems describes where grass is planted or establishes itself on previously cropped land, i.e. the grass is allowed to grow for some years and used for grazing. Wild and unregulated Ley is common in the savannah. In regulated Ley, the swards are established during the non cropping period. These are rare in the tropics but are found in some highlands (Kenya) and in Latin America. Field systems occur where arable crops follow another and where established field are clearly separated from each other. System with perennial crops (field and tree crops) .

Classification according to the intensity of rotation between cropping and fallow period

Considerable variation and degree of intensity exists between cropping and fallow period within one cycle. The symbol R is the number of years of cultivation divided by the length of the cycle of land utilization multiplied by 100. If 20% of available land in one holding is cultivated, then R is 20%, the larger R becomes, the more stationary is farming. When is < 33%, it is shifting cultivation: When R> 33% and< 66% it is Fallow systems: while it is permanent cropping when R > 66%. Permanent cropping can again be classified according to the degree of multiple cropping. An R value of 150 would indicate that 50% of the area is carrying two crops a year and three crops a year for a value of 300

Classification according to water supply

This is in terms of whether it is irrigated farming or rain-fed farming

Classification according to the cropping pattern and animal activities

This classification is according to the leading crops and livestock activities of the holdings. Each activity has different requirements as to climate, soils, markets and inputs e.g. coffee-banana holdings or rice-jute holdings

Classification according to the implement used for cultivation

In different parts of the world, land is cultivated by methods that require no implement or simple tools. In the Sahara desert nomads sow millet without fire-farming or soil preparation, shifting cultivators frequently sow in ashes without touching the soil. Rice growers in Thailand make use of water buffalo to trample on moist fields. The main divisions vary from hoe-farming or spade farming to farming with ploughs and animal traction to farming with ploughs and tractors

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

a) Arable, Pastoral and Mixed Farming

i. **Arable farming**:- 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.

ii. **Pastoral farming:-** is the rearing of animals usually on land, which is less favorable to arable farming.

iii. **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.

b) Subsistence and Commercial Farming

i. 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.

ii. 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.

C) 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.

D) 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.

i. **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.

ii. **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.

According to carbon dating, wheat and barley were domesticated in the Middle East in the 8th millennium BC; millet and rice in China and Southeast Asia by 5500 BC; and squash in Mexico about 8000 BC. Legumes found in Thessaly and Macedonia is dated as early as 6000 BC. Flax was grown and apparently woven into textiles early in the Neolithic Period.

The period was characterized by:

- The transition from hunting and food gathering to dependence on food production was gradual, and in a few isolated parts of the world this transition has not yet been accomplished.
- Neolithic farmers lived in simple dwellings — caves and small houses of sun -baked mud brick or reed and wood. These homes were grouped into small villages or existed as single farmsteads surrounded by fields, sheltering animals and humans in adjacent or joined buildings.
- In the Neolithic Period, the growth of cities such as Jericho (founded about 9000 BC) was stimulated by the production of surplus crops.

- Pastoralism (individual country living) may have been a later development. Evidence indicates that mixed farming, combining cultivation of crops and stock raising, was the most common Neolithic pattern. Nomadic herders, however, roamed the steppes of Europe and Asia, where the horse and camel were domesticated.
- The earliest tools of the farmer were made of wood and stone. They included the stone adz, an ax -like tool with blades at right angles to the handle, used for woodworking; the sickle or reaping knife with sharpened stone blades, used to gather grain; the digging stick, used to plant seeds and, with later adaptations, as a spade or hoe; and a rudimentary plow, a modified tree branch used to scratch the surface of the soil and prepare it for planting. The plow was later adapted for pulling by oxen.

Although Neolithic settlements were more permanent than the camps of hunting peoples, villages had to be moved periodically in some areas when the fields lost their fertility from continuous cropping. This was most necessary in northern Europe, where fields were produced by the slash -and -burn method of clearing. Settlements along the Nile River, however, were more permanent, because the river deposited fertile silt annually from the highlands of Ethiopia.

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.

Improvements in tools and implements were particularly important. Tools of bronze and iron were longer lasting and more efficient, and cultivation was greatly improved by such aids as the ox-drawn plow fitted with an iron-tipped point, noted in the 10th century BC in Palestine. In Mesopotamia in the 3 rd millennium BC a funnel -like device was attached to the plow to aid in seeding, and other early forms of seed drills were used in China. Threshing was also done with animal power in Palestine and Mesopotamia, although reaping, binding, and winnowing was still done by hand. Egypt retained hand seeding through this period on individual farm plots and large estates alike.

- 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 silkworm was raised and its food, the mulberry tree, was grown.

By the 12th century agriculture in the Middle East had become static, and Mesopotamia declined to subsistence production levels when irrigation systems were destroyed by invading Mongols. The Crusades, however, increased European contact with Islamic lands and familiarized Western Europe with citrus fruits and silk and cotton textiles.

- Under the direction of an overseer, they produced the crops, raised the meat and draft animals, and paid taxes in services, either forced labor on the lord's lands and other properties or in forced military service.
- A large manor had a mill for grinding grain, an oven for baking bread, fishponds, orchards, perhaps a winepress or oil press, and herb and vegetable gardens. Bees were kept to produce honey.
- Woolen garments were produced from sheep raised on the manor. The wool was spun into yarn, woven into cloth, and then sewn into clothing. Linen textiles could also be produced from flax, which was grown for its oil and fiber.
- Leather was produced from the manor's cattle. Horses and oxen were the beasts of burden; as heavier horses were bred and a new kind of harness was developed, they became more important. A blacksmith, wheelwright, and carpenter made and maintained crude agricultural tools.

In all systems, the lord's fields and needs came first, but about three days a week might be left for work on the family strips and garden plots. Wood and peat for fuel were gathered from the commonly held wood lots, and animals were pastured on village meadows. When surpluses of grain, hides, and wool were produced, they were sent to market.

In about 1300 BC a tendency developed to enclose the common lands and to raise sheep for their wool alone. The rise of the textile industry made sheep raising more profitable i n England, Flanders (now in Belgium), Champagne (France), Tuscany and Lombardy (Italy), and the Augsburg region of Germany. At the same time, regions about the medieval towns began to specialize in garden produce and dairy products. With the decline in the labor force, only the best land was kept in cultivation. In southern Italy, for instance, irrigation helped to increase production on the more fertile soils. The emphasis on grain was replaced by diversification, and items requiring more care were produced, such as woine, oil, cheese, butter, and vegetables.

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. Indentured slaves from Europe, especially from the prisons of Great Britain, provided both skilled and unskilled labor to many colonies. Both slavery and serfdom were substantially wiped out in the 19th century.
- The scientific revolution resulting from the Renaissance and the Age of Enlightenment in Europe encouraged experimentation in agriculture as well as in other fields.
- Trial-and - error efforts in plant breeding produced improved crops, and a few new strains of cattle and sheep were developed. Notable was the Guernsey cattle breed, which is still a heavy milk producer.
- Crop rotation, involving alternation of legumes with grain, was more readily practiced outside the village strip system inherited from the manorial period.

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.

- It is not possible to fix a clear decade or series of events as the start of the agricultural revolution through technology. Among the important advances were the purposeful selective breeding of livestock, begun in the early 1700s, and the spreading of limestone on farm soils in the late 1700s.
- Mechanical improvements in the traditional wooden plow began in the mid-1600s with small iron points fastened onto the wood with strips of leather.
- Science and technology developed for industrial purposes were adapted for agriculture, eventually resulting in the agribusinesses of the mid-20th century.
- In the 17th and 18th centuries the first systematic attempts were made to study and control pests.
- Improvements in transportation affected agriculture. Roads, canals, and rail lines enabled farmers to obtain needed supplies from remote suppliers and market their produce over a wider area.

Efficient use of these developments led to increasing specialization and eventual changes in the location of agricultural suppliers. A so-called green revolution , involving selective breeding of traditional crops for high yields, new hybrids, and intensive cultivation methods adapted to the climates and cultural conditions of densely populated countries.

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. At the same time, industrial -scale agriculture has had adverse environmental consequences, such as:
- Intensive use of water, energy, and chemicals. Many aquifers and other water reservoirs are being drained faster than they can be renewed.
- The energy required to produce nitrogen-based synthetic fertilizers, to operate heavy farm equipment, to manufacture pesticides, and to transport food over long distances involves burning large amounts of fossil fuels, which in turn contribute to air pollution and global warming.
- The use of synthetic fertilizers has affected the ability of soil to retain moisture, thus increasing the use of irrigation systems. Fertilizer runoff has also stimulated algae growth in water systems. Finally, herbicides and insecticides in many cases have contaminated ground and surface waters.

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.

Sustainable agricultural practices have seen great success in parts of the developing world where resources such as arable land and water are in short supply and must be carefully utilized and conserved.

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.

In economically more developed countries, technology based large dams may be built for irrigation purpose, where as in less developed and developing countries, lack of capital and technology force them to design their schemes for extremely labor intensive as they have to be constructed and operated by hand.

Crop farming and animal husbandry

As rapid climatic fluctuations of glacial period affects plants and animals 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

Once the advantages of animal domestication were learned numerous additional domestications spread. After the domestication, animal husbandry was started and Animal Husbandry is breeding, feeding, and management of animals, or livestock, for the production of food, fiber, work, and pleasure. Modern methods concentrate on one type of animal in large, efficient farming units that generate animal products at the highest rate of return for investment. Intensive husbandry conditions include large numbers of animals in small lots, enriched feed, growth stimulation by various means, and vaccination against disease. Most of the world's domestic animals, however, are raised in small units under less efficient conditions and at lower rates of return.

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.

Familiarity with plants of desirable characteristics made universal among hunters and gatherers. In those society females were assigned the primary food gathering role and thus developed the greatest familiarity with nutritive plants. Nevertheless the food scale domestication of plants like that of animals can be traced to a limited number of original areas from which its techniques spread through. There were several source regions certainly uniform them. Domestication focused on plant species selected apparently from their capability of providing large quantities of storable calories or protein. Crop Farming is extensive cultivation of plants to yield food, feed, or fiber; to provide medicinal or industrial ingredients; or to grow ornamental products. Crop farming developed in ancient times as hunters and gatherers of the Stone Age turned to the cultivation of favored species. Modern crops were gradually derived from their wild ancestors through continual selection for larger seed size, improved fruit, and other desired traits.

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. The catches from sports fisheries are far larger than commercial catches from most freshwaters and in marine waters close to large population centers. Aquariums provide an intimate acquaintance with the aquatic world. More than 20 million home aquariums are kept in the United States alone. Among the many fish kept in aquariums, the most common are minnows, characins, and cichlids.

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.

CHAPTER FIVE

FACTORS AFFECTING FARMING SYSTEM

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

- **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:

- In tropical rainforest- subsistence/shifting cultivation;
- In mixed forest- some subsistence agriculture;
- Dwarf forest- very little agriculture;
- In grass lands- herding; and
- 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.

The type of precipitation is also important. For instance, long, steady periods of rain allow the water to infiltrate into the soil, making moisture available for plant use. On the other hand, short, heavy downpours can lead to surface runoff and soil erosion and so are less effective for plants. Hail, falling during the heavy convectional storms in summer, can destroy crops. In the absence of rain, cops also fail disastrously. In regions like Sahel and Sub -Saharan Africa a fluctuation of precipitation from the mean can ruin harvests and causes the death of many animals.

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 high er 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 le ft 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.

- **Cultural (human) factors affecting farming**

Land tenure

Farmers may be owners-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 percent of their income or a fixed pre arranged rent to the land owner where as share cropping is when the farmer has to give 50 percent for the land owner. In sum tenure security affects the farming system because farmers are expected to invest more when they feel the land the y 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.

- **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, purchasing and using of modern and expensive farming machineries will be difficult for such countries.

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

AGRİCULTURAL POLİCY

Policy is guiding principle leading to a course of action that is pursued by the government.

The term 'policy' has various definitions:

- Everything that a Government decides to do or not to do
- 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
- A set of principles and directives that guide the decisions of an organization

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

- **Policy –** a set of principales and directions that guide the decisions and actions of an organization.
- **Objectives** – 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.
- **Strategy** – an outline how to achieve identified objectives. Includes broad guidelines ('basic principles') to develop an action plan.
- **Action plan –** 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
- **Programmes** – components of an action plan related to specific topics, such as financing, energy efficiency, sectoral initiatives, etc.
- **Projects** – smallest operational components of programmes

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

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