

CLIMATE SMART AGRICULTURE, FOOD SECURITY AND SUSTAINABLE DEVELOPMENT

GLOBAL ISSUES & LOCAL PERSPECTIVES volume One

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CLIMATE SMART AGRICULTURE, FOOD SECURITY AND SUSTAINABLE DEVELOPMENT

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Climate Smart Agriculture

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Preface

This book adopts an exegetical approach as well as a pedagogic model, making it attractive agriculture and environmental economics teachers, professional practitioners and scholars. It eschews pedantry and lays bare the issues in such clarity that conduces to learning. The book elaborates on contemporaneous **Climate Smart Agriculture, Food Security and Sustainable Development** issues of global significance and at the same time, is mindful of local or national perspectives making it appealing both to international and national interests. The book explores the ways in which climate smart agriculture (CSA) food security, Sustainable Development issues are and should be presented to increase the public's stock of knowledge, increase awareness about burning issues and empower the scholars and public to engage in the participatory dialogue climate smart agriculture, food security, and sustainable development necessary in policy making process that will stimulate increase in food production and environmental sustainability.

Climate Smart Agriculture, Food Security and Sustainable Development: Global Issues & Local Perspectives is organized in three parts. Part One deals with The Concept of **Climate Smart Agriculture**, Part Two is concerned with The Concept of **Food Security And** and Part Three deals with the Concept of **Sustainable Development**

Eteyen Nyong; October 2025

Chapter Seventeen

Climate Smart Agriculture

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Introduction

The chapter will enable the readers to understand that agriculture encompasses the production of crops for human consumption, livestock for meat, milk and leather and forestry for wood and timber used for construction. The importance of agriculture for meeting food security, provision

of raw materials to industries and rural development is highlighted. It describes the types of agriculture as agro-ecology, sustainable agriculture, urban agriculture/ peri-urban agriculture, organic agriculture, conservation agriculture, precision agriculture, industrial agriculture, bio-dynamic agriculture, community supported agriculture and slash and burn agriculture. Agricultural production and management, principles, crop production practices and agricultural crops are classified. Livestock, importance of livestock, livestock species, livestock management and how to start a livestock business are discussed. Forestry, types of forests, forest services and functions, protective role of forests and forest recreational activities are explained. Agricultural engineering, engineering principles for improving farming practices, developing new technologies, and ensuring sustainable agricultural systems are shown. Bee production, importance of bees, types of bees, bee products and beekeeping practices are dealt with. Fisheries, importance of fisheries, fish production methods and fish preservation methods are emphasized. Poultry, importance of poultry, methods of poultry production and poultry business are taught. Agricultural economics, principles of agricultural economics are shown. Agricultural extension, objectives of agricultural extension, specific functions of agricultural extension are identified.

1.1 Definition of Agriculture

According to Arya et al. (2025), agriculture is defined as the process for crop, livestock, aquaculture and forestry production. It is a key factor in the rise of human civilization leading to the domestication animal species, creating food surpluses enabling people to live in the cities. Agriculture greatly influence rural economies, shape rural society and affect agricultural workforce and broader businesses that support the farms and farming populations. Agriculture encompasses the cultivation of land, the production of crops, and the raising of livestock for human consumption and other uses. It includes a wide range of activities, from farming and animal husbandry to forestry and aquaculture. Agriculture is crucial for food security, economic development and rural livelihoods.



Figure 1: Planted crop



Figure 2: Cattle in grazing area



Figure 3: Turkey

1.2 Importance of Agriculture

Agriculture is important for the following reasons:

1. *Food security sourcing sufficient* food for the global population.
2. *Rural development* supporting rural communities and economies.
3. *Raw materials* provision for various industries.
4. *Environmental impact* making the environment conducive.
5. *Cultural significance* intertwining human culture and traditions shaping the societies.
6. Contributes to nations export earnings.
7. Enhancing rural domestic savings improving resource mobilization.
8. Constant supply of sufficient food at subsidized rate.
9. Maintaining biological equilibrium in nature.
10. Creation of peace, prosperity, harmony, health and wealth.

1.3 Types of Agriculture

The reader is expected to be able describe agro-ecology, explain sustainable agriculture, identify urban agriculture/ peri-urban agriculture, verify organic agriculture, discuss; conservation agriculture, precision agriculture, industrial agriculture, bio-dynamic agriculture, community supported agriculture and slash and burn agriculture. The major types of agriculture are:

1. Agro-ecology provides the conceptual framework to draw the basic ecological principles.
2. Sustainable agriculture is the production food without damage to land ecosystem health.
3. Urban agriculture is the cultivating, processing and distributing food around a town or city.
4. Organic agriculture is a system that sustains the health of soils, ecosystems and people.
5. Conservation agriculture is a resource-saving agricultural production for profits together with the conservation the environment.
6. Precision agriculture uses Global Positioning System (GPS) and Geographic Information System (GIS) for application of information by farmers.
7. Industrial agriculture refers to adoption of machinery for achieving economies of scale in livestock and crop production.
8. Bio-dynamic agriculture emphasis on the utilization of manures and composts and exclusion of the use of artificial chemicals on soil and plants.
9. Community supported agriculture gives growers up-front cash to finance their operations and higher prices for produce by eliminating middlemen .
10. Slash and burn agriculture consists of cutting and burning of forests or woodlands to create fields for agriculture or pasture for livestock, or for a variety of other purposes.
11. Basic agriculture/agricultural education deals with the study of agricultural science as a subject, the teaching of agriculture in schools.
12. Animal science deals with the study of the various farm animals. A specialist are called animal scientist.

13. Soil science is the study of soil appearance, composition and nature. A specialist are called soil scientist .
14. Crop production deals with the study of the various type of crops that are cultivated by farmers. A specialist in this area is called a crop scientist.
15. Horticulture: deals with flowers, vegetables and fruits.A specialist is called horticulturist.
16. Agricultural extension deals with the carrying of information from the research stations to the farmers in the rural areas and vice versa. A specialist in this area is called extensionist .
17. Veterinary medicine deals with health, diagnosis, maintenance and treatment of diseases of animals. A specialist is called a veterinarian (Veterinary doctor).
18. Wildlife Conservation is the setting aside of area of land for the maintenance of wild animals. This area is called game reserve

1.4 Agricultural Production and Management

The reader is expected to be able define agricultural production and management, describe the principles of production, differentiate crop production practices and classify agricultural crops.

1.4.1 Definition of Agricultural Production

Chang (2019) emphasizes that agricultural production and management is the application of the principles of science and management to agricultural production operations. Agricultural production involves:

- a. The combination of land, water, labour, and other inputs such as seeds, nutrients, pesticides, and machinery in the production of food and fiber crops.
- b. Agricultural production and management deals with how the farmers combine land, water, farm inputs, labour, and their management skills into practices to produce agricultural crops.
- c. In the nutshell, agricultural production and management has a vital role in food production, farm income enhancement, food security, nutritional security poverty alleviation, rural employment and sustainable agriculture in the developing world.

1.4.2 Principles of Crop Production

Every crop performs best in specific climatic conditions and can best be grown in either a temperate, subtropical or tropical climate. The climatic profile of a crop is usually determined by the region of its origin. Breeding can produce crop varieties that are adapted to specific climatic conditions. A prominent example is maize, whose cultivation area in Europe was extended north by breeding for cold tolerance.

- a) The most important prerequisite for successful crop production is the choice of an appropriate crop and variety for a specific site. This does not only refer to climatic parameters.

- b) Crops also have specific demands with regard to soil conditions and biotic (e.g. pests and diseases) and abiotic (e.g. drought, contamination, salinity) stresses. In addition, the appropriate management measures need to be chosen according to the crop and site conditions.
- c) Crop rotation is the temporal sequence of crops on a field. If annual crops (seeding and harvesting in the course of 1 year) are grown, the farmer can choose a new crop every year.
- d) Perennial crops are grown on the same field for 3–25 years, depending on the optimal production period of the crop.
- e) Inter-cropping is the integration of a catch crop in between two major crops.
- f) Catch crops are often grown to prevent soil runoff (erosion) or nutrient leaching or to provide organic matter to the soil.
- g) Crop rotations are generally optimized from an economic viewpoint, i.e. those crops with the highest market value are grown. However, there are biological and physical limits to crop rotation planning. It has to allow enough time for field preparation between the harvesting of one crop and the sowing of the next.
- h) Generally, it is not recommended to cultivate the same crop in a field for two or more consecutive years because pests, diseases and weeds often remain in crop residues and soils and can attack the follow-on crop.
- i) A change of crop is also necessary due to the depletion of soil nutrients. For this reason, it is recommended to avoid growing the same crop, or crops with similar demands and susceptibility to pests and diseases, in succession.
- j) Soil cultivation is performed to loosen the soil, to incorporate residues, organic and mineral fertilizer, to control weeds and to prepare the soil for sowing or planting. The timing of and technology used for soil cultivation have to be adapted to the demands of the crop and soil conditions.
- k) Treating a wet soil and using heavy machinery can have negative impacts on the soil structure (compaction). Ploughing is the most effective soil treatment in terms of soil loosening and weed control. However, to protect soil organic matter and to avoid erosion, less intensive soil cultivation technologies are to be preferred. These, however, can lead to increased weed pressure and weed control demand.
- l) Crops are established via sowing or planting. Sowing is cheaper and easier to mechanize and is the method used for most major crops.

1.4.3 Crop

Production

Practices

Crop production practices are of utmost importance for successful and economic cultivation of field crops and national food security at large. Current agriculture directly needs scientific and rational crop production practices to enhance farm productivity with long-term sustainability. Crop production practices can be divided into various categories that farmers make to produce food, fodder and fiber, etc. The major ones are:

- 1) Soil and crop management: It deals with deciding what crops and varieties to grow and in what sequence to utilize the soil's productive capacity, and what tillage, cultivation, and soil conservation measures to undertake to physically till and preserve the soil and conserve moisture in a particular agro-ecology.
- 2) Nutrient management: It deals with determining the additional nutrients the soil needs for crop growth, and applying agricultural resources, animal manure, compost, or commercial fertilizers in appropriate forms, amounts, and ways that foster crop yields and farm profitability, while reducing nutrient loss to the environment.
- 3) Water management: It deals with determining the water needed for crop growth and applying that water efficiently, considering water availability, drainage, and off-site water quantity/quality impacts.
- 4) Weed management: It deals with determining the weed threats to crop growth, yield, and quality and the management practices to control them in field crops.
- 5) Pest management: It deals with determining insect-pest and disease threats to crop growth, yield, and quality and the preventive or remedial measures to control them besides keeping the food and environmental safety.

1.4.4 Classification of Agricultural Crops
The broader classification of the agricultural crops on the basis of their economical use is described as under:

- i. Cereal crops: Rice, wheat, maize, sorghum.
- ii. Pulse crops: Pigeon pea, cowpea, chickpea, lentil, pea, etc.
- iii. Oil seed crops: Soybean, rapeseed & mustard, groundnut, sunflower, sesame, safflower, etc.
- iv. Fodder crops: Beseem, red clover, lucerne, etc.
- v. Fibre crops: Cotton, jute, mesta, etc.-
- vi. Commercial crops: Sugarcane, tea, coffee, etc

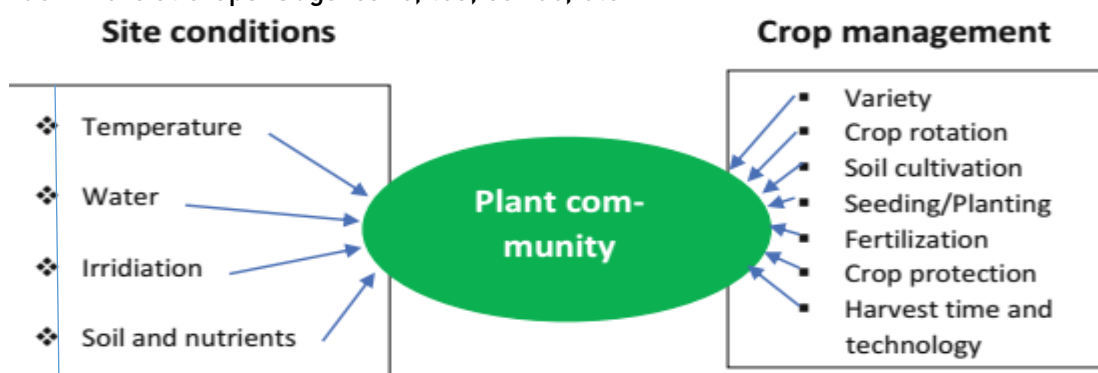


Figure 4: determining the success of crop production

1.5 Livestock Production

The reader is expected to be able to define livestock, state the importance of livestock, identify livestock species, explain livestock management and describe how to start a livestock business

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1.5.1 Definition of Livestock Production

In his contribution Gupta (2024) describes livestock production as the production of animals for meat and milk. It plays a crucial role in food security providing proteins and nutrients, contributes immensely to livelihood and support various agricultural systems. It offers products such as leather, wool and pharmaceuticals. Plays a crucial role in social and cultural practices, contribute to nutrient cycling in agriculture providing a source of renewal energy.

1.5.2 Importance of Livestock Production

The importance livestock production include:

1. Food security by providing constant and sufficient essential diets for human consumption.
2. Employment for producers and those involved in related value chain.
3. Contributing manure and draft power for agricultural operations.
4. Provision leather, wool, bones and pharmaceuticals used in industries
5. Enhancing social and cultural activities serving as indicators of wealth and status.
6. Grazing on areas unsuitable for crops production and the preventing of land degradation.
7. Waste from ruminants produce biogas used for cooking, heating and other purposes.
8. Boosting national economy by improving GDP, and export services

1.5.3 Livestock Species

The species of animal raised for agricultural purposes are cattle, sheep goats, horses, pigs and rabbits.

- a) Cattle raised mainly for meat (Beef) and milk.
- b) Sheep raised for meat (Lamb) wool and milk.
- c) Goats raised for meat, milk and sometime for wool.
- d) Pig raised for meat (Pork).
- e) Horses for work, transportation, recreation and sport
- f) Rabbits for meat and fur and
- g) Camels for meat and leather



Figure 5: Grazing cattle



Figure 6: Grazing sheep



Figure 7: Horse

1.5.4 Livestock Management

Livestock management comprises the provision of housing, conducive environment and management considerations.

- 1) Livestock housing encompasses the structure and systems used to shelter the animals, influence their health, welfare and productivity. It consists of:
 - a) Barns a structure constructed for shelter, food and machinery storage.
 - b) Shelter or shade to protect the animals from harsh weather conditions.
 - c) Stall barns to confine animals for feeding, milking and resting.
 - d) Loose barn for animals to move freely.
 - e) Free range system outdoor areas for grazing and foraging
- 2) Environmental factors touch on the following:
 - a) Ventilation to maintain air quality, remove moisture, gases and heat.
 - b) Keeping optimal temperature for specific livestock species and age.
 - c) Humidity level maintenance to prevent respiratory issues and structural damage.
 - d) Appropriate light supply for different species and production needs.
 - e) Adequacy of space for free movement, feeding and resting.
- 3) Management considerations augment:
 - a) Sanitation to maintain clean dry conditions to check disease outbreak.
 - b) Disposal of waste adequately to prevent environmental disorder
 - c) Provision of sufficient feeding and drinking facilities.
 - d) Stocking the right number of animals per unit space to avoid overcrowding.
 - e) Provision of housing system to meet behavioral and physiological animals need.

1.5.5 Starting a Livestock Business

Starting a livestock business requires the following considerations:

- A. Identifying passion, interests and resources needed for a animal.
- B. Developing a business plan outlining goals, strategies and financial projections.
- C. Choosing the right livestock breed based on goals and resources available
- D. Securing land and facilities with adequate housing, grazing area and infrastructures.
- E. Proper management of health, nutrition, feeding, veterinary care and disease control.
- F. Effective marketing strategies for the products.

1.6 Branches Of Agriculture

The reader is expected to be able to define agronomy, describe forestry, discuss livestock production, explain fisheries, show bee production, identify agricultural engineering and distinguish agricultural economics and state agricultural extension .

1.6.1 Agronomy

Agronomy is defined as the study dealing with principles and practices of crop production and field management. Encompasses the principles and practices of soil, water and crop management. It is branch of agricultural science that deals with methods which provide favorable environment to the crop for higher productively.

1.6.2 Importance of Agronomy

According to Watson (2023) agronomy is crucial for food security, promoting sustainable agriculture and enhancing crop and soil health.

- a. Food security for meeting food demands of growing global population.
- b. Improving crop yield through plant breeding and efficient nutrient management.
- c. Developing crop varieties that resist pests, diseases and the adverse weather conditions
- d. Promoting sustaining agriculture to minimize adverse environment effects.
- e. Integrating farming systems to maximize resource utilization and reduce waste.
- f. Focusing on soil conservation for sustainable agriculture and production.
- g. Improving soil health and fertility.
- h. Optimizing nutrient management for crop growth and health.
- i. Enhancing microbial activities for long term soil health.
- j. Improving economic stability for farmers and rural community.
- k. Augmenting crop yield for increasing farmers income and profitability.
- l. Sustainable practices for long term cost savings and environment benefits.
- m. Adapting to the challenges posed by climate changes.
- n. Developing crop that are drought resistant and heat tolerant.
- o. Optimizing water utilization to promote conservation of soil.

1.6.3 Scope of Agronomy

Agronomy is a dynamic discipline with the advancement of knowledge and better understanding of planet, environment and agriculture. Agronomy science becomes imperative in agriculture in the following areas.

- 1) Identification of proper season for cultivation of wide range of crops.
- 2) Proper methods of cultivation to reduce cost and maximize yield and profit.
- 3) Adequate application of fertilizers to reduce crop losses.
- 4) Control of weeds using appropriate chemical, time and method of its application.
- 5) Effective water management practices for proper growth of crops.
- 6) Intensive cropping not only increase production but reduces the environmental hazards.
- 7) New technology exploration on dry land agriculture.
- 8) Packages of practices for boosting full potential of new varieties of crops.
- 9) Keeping farm implements in good shape and utilization in efficient manner.
- 10) Maintaining balance in the management of crops, livestock and their feedings.
- 11) Care and disposal of farm and animal products and proper maintenance of accounts.

1.7 Forestry and Forests

The reader is expected to be able to define forestry and forest, list the types of forests, enumerate forest services and functions, state the protective role of forests and describe forest recreational activities.

7.1 Definition of Forestry and Forest

Lippe (2023) defined forestry as the practice and science of utilization, management, protection and regeneration of forests. This comprises the exploitation of both natural and near-natural forests. Near-natural forests are those where the original tree species composition is still apparent and the original ecosystem dynamics have been maintained, at least to some extent. The artificial establishment of forests following either recent or historical removal of the original forest cover (reforestation) is also becoming increasingly important. This can be done with native tree species, which were part of the original forest cover, or with so-called exotic species from other ecosystems and often even continents. Forests are an accumulation of trees, which are lignified, erect, perennial plants. They develop a climate which differs considerably from the open land and is characterized by much more balanced temperature fluctuations and extremes, reduced wind speeds and a higher relative humidity. The forest provides a multitude of habitats and ecological niches supporting diverse plant and animal communities (FAO,2000)

7.2 Types of Forest

Types of forest reflect on environmental conditions and are therefore an important classification for ecology, productivity and management options. The types include:

1. Boreal Forests: Found in the Northern hemisphere and comprise the huge conifer-dominated forests of northern Europe, northern Russia, Canada and Alaska. The area is characterized by extreme temperature fluctuations, with permafrost soils where the average annual temperature drops. The vegetation period is on average 3–5 months, with a maximum of 6 months. The resulting forests are more or less single-layered with a maximum tree height of up to 20 m.
2. Temperate Forests mainly occur in the Northern and Southern hemisphere such as the mountain forests of Patagonia and New Zealand. Temperate forests are characterized by more balanced climatic conditions than boreal forests. Temperate forests mainly grow on young, post-glacial soils, often brown soils. Economically, temperate forests are still important providers of pulp wood, and especially construction timber.
3. Mediterranean Forests: Are defined by a set of climatic conditions rather than the locality. As such, they not only occur around the Mediterranean. The climate is characterized by mild, rainy winters and very hot, dry summers. The vegetation is sclerophyllous; the trees are evergreen. The forest sources olive tree (*Olea europaea*) providing fruits and oil and timber.
4. Tropical Rain Forests: Tropical rain forests are the world's most diverse forests. While the climatic conditions in these forests are more or less similar around the world, structure, species composition and usability display distinct differences. The vegetation is dominated by a high diversity of woody plants, which can attain considerable heights of 30–50 m, sometimes even 70 m. Due to the high diversity, the density of individual species are usually very low. The high species diversity is also reflected in the structural diversity and associated ecological niches. Due to the shade created by the high and dense canopy, only

little undergrowth develops, and it is easy to walk through the stands. Three major tropical rain forests are usually distinguished: the American rainforest, mainly comprising the Amazon and Orinoco basins, the Indo-Malayan and Australian rainforest and the African rainforest. All of them are considered important timber sources.

5. **Mangroves:** Mangroves are forests growing in the intertidal zone of tropical and subtropical coastlines, estuaries and deltas. Their adaption to regular inundation by saltwater is unique and requires tolerance to salt as well as oxygen shortage. They are found throughout the tropics and subtropics. Mangroves have been and, in some regions, still are a considerable source of timber, firewood and charcoal as well as tannins. They are of importance as a food source for fish and shells.
6. **Natural and Planted Forests:** Regenerate themselves naturally either through succession of pioneer species following a major disturbance (fire, storm, etc.) or less obviously by the replacement of single trees or tree groups in gaps after natural mortality or smaller disturbances (lightning, local storm damage, etc.). The same processes more or less apply to human-caused disturbances, such as clear-cutting and selective logging. When a forest is re-established after a long period of other land uses, such as crop production or cattle ranching, it is called afforestation.

7.3 Forest Services and Functions

Forests have accompanied human development from time immemorial. They provide:

- A. Shelter for human being and animals
- B. Wood for fire
- C. Materials for construction purposes,
- D. Fruits for human consumption
- E. mushrooms and
- F. Meat

7.4 The Protective Role of Forests

Forests fulfil important protective functions. In mountainous regions, they protect settlements, farms and infrastructure from avalanches and rockfalls. Due to the specific forest climate, which maintains soil humidity and thus enhances water infiltration rates, forests usually:

- i. Reduce surface runoff and erosion.
- ii. The root network stabilizes the soil and acts as a buffer against landslides.
- iii. Along streams, forests stabilize river banks and often serve as water (and sediment) retention areas during periods of flooding.
- iv. In the tropics, mangroves have a protective role on shorelines, serving as wave breaks and also as spawning ground for fish, safeguarding the livelihood of fishermen.
- v. Forests are also crucial for the hydrological cycle and as water protection areas.

- vi. In urban centres, forests play a considerable role as air filters and oxygen providers.
Provision of bushmeat, skin and bones
- vii. Processing of forest products improves value chain and added values and
- viii. Carbon sequestration serving as long-term carbon sinks.

7.5 Forest Recreational Activities

Forests are important for recreational activities. People have a very close affinity to their forests. For this reason, forests are open access, and generally people are allowed to enter without permission. Hiking, jogging, biking and mushroom collection are common recreational activities.



Figure 8: Forest and forest product



Figure 9: Tourism in California National

park

1.8 Agricultural Engineering

Reader is expected to define agricultural engineering, state the importance of agricultural engineering, explain farm machinery, show the importance of farm machinery and discuss irrigation.

1.8.2 Definition of Agricultural Engineering

Arya *et al* (2025) Cheung (2019). Daum and Birner (2020). mechanization Gupta (2024). animals IPCC (2022)fish. Lippe (2023). Forestry Peter (2022). economic Rodda and Ubertaini (2024). Water science. Roffet-Salque *et al.* (2015). honeybee Shen *et al.*(2021). Guinea Fowl Watson (2023). Agricultural Innovation

Daum and Birner (2020) define agricultural engineering as a field that applies engineering principles to agriculture. It focuses on improving farming practices, developing new technologies, and ensuring sustainable agricultural systems.

1.8.3 Importance of Agricultural Engineering

Agricultural engineering involves designing machinery, optimizing resource use (like water and soil), and managing environmental impacts.

- 1) *Machinery and equipment involves* designing tractors, combines, irrigation systems, and other tools to improve efficiency and safety in farming.

- 2) *Resource management* refers to the developing strategies for efficient water and soil management, including irrigation and erosion control.
- 3) *Structures and environment* entails designing farm buildings, greenhouses, and systems for managing livestock and environmental control.
- 4) *Food processing and storage* comprises improving methods for processing, storing, and preserving agricultural products to minimize waste and maintain quality.
- 5) *Sustainability augments* implementing practices that promote environmentally friendly farming, including precision agriculture and waste management.
- 6) *Problem Solving*: Identifying and addressing challenges in agricultural production through innovative solutions.
- 7) *Integration of Disciplines*: Combining knowledge from mechanical, electrical, civil, and biological engineering with agricultural science.
- 8) *Innovation*: Striving to develop new technologies and methods to enhance agricultural practices. In essence, agricultural engineering is about using engineering knowledge and techniques to improve the efficiency, sustainability, and productivity of food production systems.

1.8.4 Farm Machinery

Farm machinery refers to the mechanical structures and devices used in agricultural operations. These consist of hand tools, drawn implements automated machines such as the tractors providing power to operate other implements. Agricultural machinery include advanced digital equipment and robotics. Robots have the potential to automate the three key steps involved in any agricultural operations in diagnosis, decision making and performance (Watson, 2023).

1.8.5 Types of Farm Machinery

The major agricultural machinery include tractor, combine harvester, planter, sprayers and baler.

1. Tractors do the majority of the work on a modern farm. It pulls and pushes implement use for farm operations. The implements prepare the soil for planting loosening the soil and controlling weeds competing with plant for nutrition.
2. Combine harvester is designed to harvest a variety of grain crop. The machine reap, thresh, gather and winnow in a single process. It is used to harvesting corn, rice, wheat, sorghum, soybeans etc.
3. Planter spaces seeds out equally in long rows. Some crops are planted by drills which put out more seeds in rows less than a foot apart. Transplanters automate the task of planting seedlings to the field.
4. Sprayer applies fertilizer and pesticides after planting crops on the field. They are self propelled spraying herbicides, fungicide and insecticide to control fungi, weeds and insects.

5. Baler picks up, compresses, shears and tightens grass into bales suitable for storage for use in the period of scarcity. Irrigation pump provides water quickly in a high volume to large areas of land. The machine uses special gears for pumping water.



Figure 10: A tractor harvester



Figure 11: A sprayer



Figure 12: Hay

1.8.6 Importance of farm Machinery

Farm machinery is crucial for modern agriculture and has a very significant impact on efficiency, productivity and sustainability. It enhances the cultivation of large land area, reduces labour cost, increases yield and contributes to food security.

1. Increased Efficiency and productivity depicts:
 - a) High yields in terms of cultivating more land leading to increased crop production and higher yields.
 - b) Reduced labour cost by automation of tasks like planting, tilling, harvesting, thus reducing the need for manual labour and cost.
 - c) Timeliness of operation in completing operations in good time for optimal crop growth, preventing the effects of pests, diseases and unfavourable weather conditions.
 - d) Precision farming by utilizing GPS guided tractors, variable rate applicators for fertilizers, pesticides, seeds to optimize resource use and minimize waste.
 - e) Faster task operations to cover large acreage in short periods better than manual labour.
2. Economic benefits consisting of:
 - a) Increased farm income through boosting productivity and reducing production cost to improve farmer's livelihood.
 - b) Reduced food cost as a result of increased production and efficiency making food more affordable to the populace.
 - c) Economic growth by boosting agricultural output and creating opportunities for rural development.
3. Environmental sustainability hinges on:

- a) Reduced water usage through precision technology to check wastage and conserve water resources.
 - b) Reduced land degradation by minimizing soil compaction and erosion promoting sustainable land management practices.
 - c) Reduced carbon footprint by optimizing the use of fertilizers and pesticides to ensure environmental safety.
4. Improved working conditions based on:
- a) Reduced physical strain making agricultural work less arduous and more appealing.
 - b) Improved safety by designing modern equipment with safety features to protect farmers from accidents and injuries.
 - c) Enhanced dignity of farmers making their works more efficient and rewarding
5. Food security:
- a) Increased food production to sufficiently meet the needs of the growing population of the people.
 - b) Reduced food waste through efficient harvesting and storage facilities utilization to address post harvest losses.
 - c) Reliable food supply insurance by adopting reliable and consistent food supply chain.

1.8.7 Irrigation

Rodda and Ubertini (2024) posited that irrigation is the process of artificially applying of water to land to assist in the growth of crops landscape, and lawns. It is crucial in places with insufficient rainfall, helping to ensure consistent crop yields and support plant growth..Irrigation involves providing water to plants through human made system in areas with scarcity of rainfall. Irrigation is used for the purpose landscaping and revegetation to support agricultural production of crops. Irrigation is particularly important in arid semi arid regions with rainfall scarcity and unreliability.

1.8.8 Importance of Irrigation

Irrigation is important for the following reasons:

- a) By providing consistent water supply, irrigation can significantly boost crop production and improve overall yields
- b) It enhances quality of crops ensuring the reaching of full potential in term of size, appearance and nutritional value.
- c) Enables the traditional cultivation of land in arid and semi arid regions where rainfall is insufficient.
- d) Ensures food security by increasing agricultural output to sustain the populace in sufficient and cheap rate.

1.8.9 Types of Irrigation Systems

The types of irrigation systems are:

- i. Surface irrigation involving the distribution of water over the land surface, often through channels or furrows. It consists of
 - a) Furrow irrigation in which water flows through small channels between crop rows
 - b) Basin irrigation in which the field is leveled and surrounded by dikes, creating basins that are flooded with water.
- ii. Sprinkler irrigation: Water is distributed through overhead sprinklers similar to natural rainfall.
- iii. Drip Irrigation: Water is delivered directly to the plant root zone through small tubes or emitters, minimizing water waste.
- iv. Localized Irrigation: This category includes drip irrigation and other methods that focus water application in specific areas, rather than broadly distributing it.
- v. Subsurface Irrigation: water is supplied below the soil surface, often using perforated pipes or other underground systems.
- vi. Smart Irrigation Technology: Involves the use of modern irrigation systems incorporated with sensors and remote monitoring automation to optimize water usage and efficiency.
- vii. Precision Irrigation: allows for precision control over water application, ensuring delivery needed to minimize waste.



Figure 13: Center pivot



Figure 14: Irrigating gun



Figure 15: Sprinkler

1.9 Bee Production

The reader is expected to define bee production, state the importance of bees, list the types of bees, enumerate bee products and discuss beekeeping practices.

1.9.1 Definition of Bee Production

Bee production or apiculture encompasses the management of honeybee colonies for honey, beeswax, pollen, propolis and royal jelly. Beekeeping can be a hobby or commercial venture, with farmers strategically placing hives near nectar-rich areas to maximize yield (Roffet-Salque *et al.*, (2015).

1.9.2 Importance of Bees

The importance of bee farming hinges on:

1. Bee farming can be profitable venture with the potentials of both part-time and full-time income.
2. The market for bee products is fast growing with honey being the most significant in term of volume and value.
3. It an untapped wealth in Nigeria with the potentials for increased production and utilization of bee products.
4. Bees play a crucial role in pollination essential for agriculture and maintaining biodiversity.
5. By pollinating crops bees contribute in yield increment and quality of fruits and seeds.

1.9.3 Types of Bees

The types bees are broadly categorized into social bees living in colonies and solitary bees living independently

1. Social bees comprises;
 - a. Honey bees living in large colonies with a queen, worker bees and drones.
 - b. Bumble bees which are fuzzier than honey bees living in small colonies.
2. Solitary bees include:
 - a. Mason bees use mud to build nests in pre-existing cavities.
 - b. Carpenter bees tunnel into wood to create nests.
 - c. Leafcutter bees use leaf places to line their nests.
 - d. Sweat bees are small often metallic in colour nesting in ground and
 - e. Mining bees digging burrows in the ground to create nests

1.9.4 Bees Products

The products of bees include:

- A. Honey a sweet viscous liquid produced by bees from flower nectar.
- B. Beewax a waxy substance created by worker bee for build honeycomb.
- C. Pollen is used as a protein source for the colony and human consumption.
- D. Propolis a resinous substance collected by the bees to seal and protect the hive
- E. Royal jelly a secretion produced by the worker bees to feed the queen bee.
- F. Bee venom collected by the beekeeper used in some medical applications

1.9.5 Beekeeping Practices

The practices consist of:

- i. Hive management which involves providing bees with suitable housing (Hive) with proper ventilation and space for honey storage and brood rearing.
- ii. Colony health to monitor diseases and pests and take corrective measures.
- iii. Honey harvesting by carefully removing the honeycombs to extract the honey and return them for bees to refill.
- iv. Queen management to control colony size and health, often by splitting a colony to create new hives.



Figure 16: Bee hive



Figure 17: Bee colony



Figure 18:

Honeycomb

1.10 Fisheries

The reader is expected to be able to define fisheries, show the importance of fisheries, identify fish production methods and discuss fish preservation methods.

1.10.1 Definition of Fisheries

Fisheries encompass the enterprise of raising or harvesting fish and other aquatic life, as well as the sites where these activities take place. They can be broadly categorized into wild fisheries, where fish are caught in their natural environment, and fish farms, where aquatic organisms are raised in controlled environments.

1.10.2 Importance of Fisheries

Arya *et al.* enumerated the importance of fish production as:

- 1) Sourcing protein and omega-3 fatty acids crucial for brain development and
- 2) Contribution to national economies through export and revenue generation.
- 3) Provision of job opportunities to fishermen, processors and related industries.
- 4) Stimulation of rural development by creating new income sources for coastal communities.
- 5) Supporting various industries such as boat building, fishing equipment and tourism
- 6) Promotion of cultural identity, recreation, leisure and tourism activities.
- 7) Enhancing sustainable practices and protection of aquatic ecosystem.
- 8) Fish byproducts are used as fertilizer and for animal feed reducing wastage.

1.10.3 Fish Production Methods

Fish production methods encompasses:

- a. Cage culture involves raising fish in cages supported in natural water bodies
- b. Pond culture depicts raising fish in natural or artificial ponds.
- c. Recirculating system filters and recirculates water in controlled environment
- d. Integrated recirculating system incorporating other systems such as hydroponics.

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- e. Composite fish culture where multiple fish species are raised together in a pond.
- f. Flow-through system flows water constantly.

1.10.4 Fish Preservation Methods

Fish preservation increases fish shelf life and its products. It consist of:

- a. Freezing in ice or deep freezers.
- b. Sun drying in areas characterized by high ambient temperature and low relative humidity.
- c. Salt drying to permeates the flesh for 1-3 days as desired.
- d. Brining entails soaking fish in dilute until the muscle tissues permeate.
- e. Smoking where wood is burnt to create smoke essential for fish drying and preservation.
- f. Canning is creates a sealed protected environment safeguarding the spoilage of the fish.
- g. Pickling is refrigerating of fish at a temperature not higher than 40 degree F for 4-6 weeks



Figure 19: Plastic fish pond drier



Figure 20: Scooping nest



Figure 21: Fish

1.11 Poultry

The reader is expected to be able to define poultry, state the importance of poultry, list the methods of poultry production and explain poultry business.

Definition of Poultry

Poultry refers to domesticated birds raised for meat, eggs or feathers. Commonly raised poultry consists of guinea fowl, chicken, turkey, geese, duck, quells, pigeon etc (Shen *et al.*,2021).

1.11.1 Importance of Poultry

The importance of poultry include:

1. Supporting food security by providing eggs and meat for human consumption.
2. Affordable source of protein, vitamins and minerals essential for human health development

3. Provision job opportunities to people involved in its production, processing and marketing.
4. Contributes to poverty reduction being a lucrative business for people in rural communities
5. Enhancement of overall national economy in trade, investment and revenue generation.
6. Poultry byproducts are used as fertilizer and other industries.

Poultry production methods are classified as deep litter system, battery cage and free range system allowing birds to roam and forage outdoors.

1.11.3 Poultry Business

Poultry business refers to proper planning, selecting the right breed, securing suitable location and effective resource management.

- a. Business planning focuses on meat/eggs production, market research, budget and income.
- b. Starting up deals location, housing, bio security, feeders, drinkers or cage.
- c. Birds management dwells on chickens selection, balanced diet and vaccination.
- d. Marketing and sales develops farm logo, sale outlets and competitive price to attract buyers



Figure 22: Battery cage system



Figure 23: Free range system



Figure 24: Deep litter

1.12 Agricultural Economics

The reader is expected to be able to define agricultural economics and state its principles

1.12.1 Definition of Agricultural Economics

Agricultural economics applies economic principles to analyze and solve problems in agriculture and food industry. Peter (2022) reiterated that it examines how societies use resources to produce, distribute, consume food and fiber considering resource allocation, market dynamics and policy impacts.

1.12.2 Principles of Agricultural Economics

The core principles of agricultural economics hinge on how farmers and agricultural businesses make decisions under conditions of scarcity, the effect of supply and demand, prices and overall market equilibrium within the agricultural sector. Key areas are production economics, market analysis and impact of government policies on agricultural markets.

1. Production economics deals with:

- a) Scarcity of land, water, labour forcing farmers to choose what and how to produce.

- b) Description of the relationship between inputs and output.
- c) Optimum mixture of inputs to maximize production.
- d) Evaluating the additional output gained from using one more unit of input.
- 2. Market analysis focuses on:
 - a) Demand and supply the forces determining the prices of agricultural products.
 - b) Point of equilibrium of demand and supply determining market price and quantity.
 - c) Elasticity measure how quantity demanded or supplied changes price.
 - d) Impact of monopoly and competition on agricultural markets.
 - e) Influence of weather, government policies and consumer preferences on price.
- 3. Government policies and agribusiness dwells on:
 - a) Government interventions on subsidy, price supports and trade policies.
 - b) Regulatory organizations effort to improve farmers income such as marketing board.
 - c) Environment consequences of agricultural practices and sustainability.

1.13 Agricultural extension

The reader is expected to be able to define agricultural extension, state the objectives of agricultural extension and identify the specific functions of agricultural extension.

1.13.1 Definition of Agricultural Extension

Arya *et al.* (2025) define agricultural extension as an out of school education system aimed at disseminating information to the farmers. Extension specialist disseminates improved practices and input such as new methods of cultivation, soil conservation, planting, crop maintenance, harvesting and storing of crops and marketing of agricultural products; as well as information on techniques of applying fertilizers, insecticides and fungicides to the crops and enhance the output, increase farmer's efficiency and income.

1.13.2 Objectives of agricultural extension

Agricultural extension services have developed the idea of helping farmers to help themselves in the identification of their farm and home problems and finding solution to them especially in a predominantly subsistence rural agriculture where small scale farmers are less able to deal effectively with their individual problems. The objectives of agricultural extension services are:

1. It gives assistance to rural people involved in agriculture to acquire knowledge, skills and abilities that will enable them produce, distribute, process and market agricultural products more effectively.
2. It increases the efficiency of agricultural production through the dissemination of scientific information and the application of new technology of production.
3. Assists farmers to utilize agricultural services provided by government and private agencies and helping them adjust their production to meet products demand.

1.13.3 Specific Functions of Agricultural Extension

The specific functions of agricultural extension are:

- a. Stimulation of farmers to accept, try and use new agricultural practices and technology.

- b. Dissemination of research results packages and encouraging rural farmers to adopt them.
- c. Formation of farmer's cooperative societies
- d. Linking farmers with credit, financing and marketing organizations.
- e. Provision of farm management advisory services.
- f. Guidance and general education to farmers.

1.14 Conclusion

Agriculture encompasses crop, livestock, aquaculture, forestry, bee, poultry production aimed at supplying food and non-food products. A key factor in the rise of human civilization, creating food surpluses, influencing rural economies, shaping rural society and affecting agricultural workforce and broader businesses that support the farms and farming populations. Agriculture involves the cultivation of land for crop production, raising of livestock, poultry, fishery, bee using modern agricultural technology, practices and innovations. Agriculture is crucial for food security, economic development and rural livelihoods. Efforts should be geared towards supporting the development of agriculture by providing adequate funds, viable policies necessary structures and inputs for its success.

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