AGRICULTURE

STUDENT TEXTBOOK

GRADE 11

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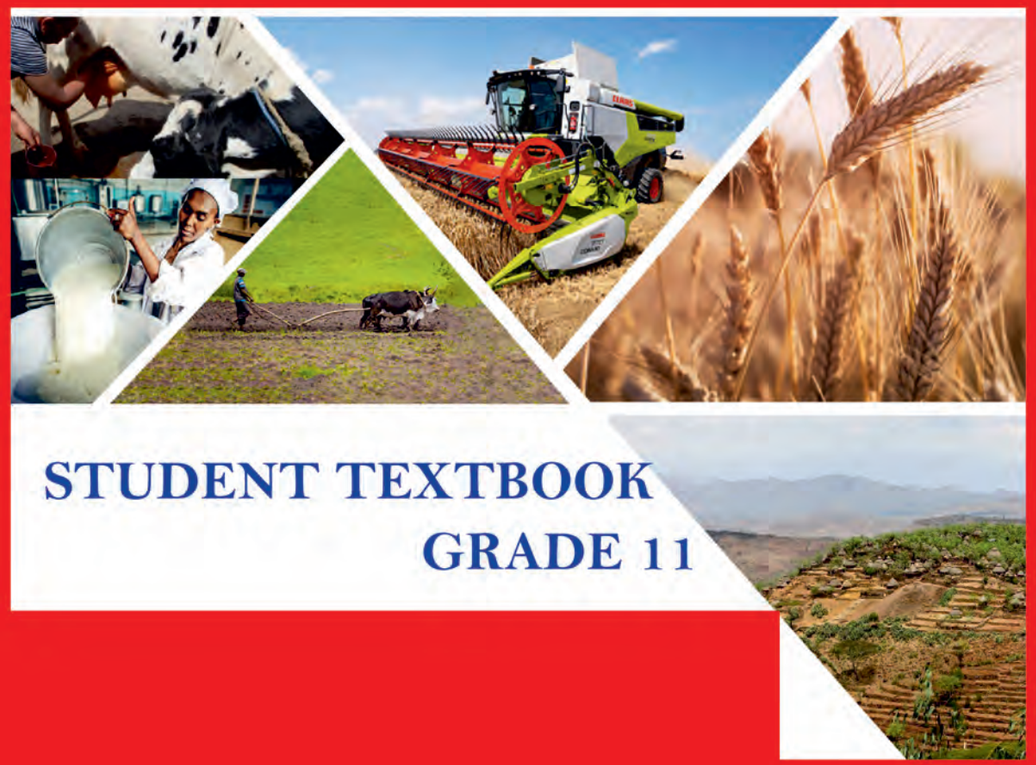

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Contents

Unit 1 Introduction to Crop Production

Contents	Learning Outcomes
1.1. Definition of common terms used in crop production 1.2. The origin of domesticated crops 1.3. Status of crop production 1.4. Classification of crop plants 1.5. Cropping systems 1.6. Indigenous knowledge in crop production	At the end of this unit, you will be able to: ▪ define crop production related terms/phrases ▪ explain origin of different domesticated crops ▪ describe the status of crop production ▪ classify crop plants ▪ analyze different cropping systems and principles of crop husbandry ▪ explain indigenous knowledge used related to crop production

1.1. Definition of Common Terms Used in Crop Production

Brainstorming 1.1

Answer the following questions independently before reading the notes and share your answers with your classmates

1. What is agriculture?
2. How do you think agriculture started?
3. What practices does the term agriculture include?
4. What is the difference between agriculture and farming?

Agriculture is defined as the deliberate cultivation of crops and rearing of animals.

Before the introduction of agriculture, societies survived by hunting animals and gathering plants for food. Studies indicate that hunter-gatherers had to be insightful in order to survive. Today, hunting animals and gathering plants for food may be viewed as primitive and unskilled activities. However, the hunter-gatherer life-style has not completely disappeared with the expansion of agriculture. Even today, there are hunter-gatherers in areas where the land and climate conditions do not favour deliberate crop culture. Desert areas, Arctic region and pockets of tropical rain forest are examples of such places. Agriculture involves the deliberate cultivation of crops and the rearing of animals. Before development of agriculture, people started to domesticate animals mainly for food production. Later, people started to breed animals in order to produce non-food materials. Crop and livestock production has gradually become the major means of survival for societies.

Shifting cultivation: is a form of agriculture in which an area of ground is cleared of vegetation and cultivated for a few years and then abandoned for a new area.

Early crop production involved temporary cultivation of land called shifting cultivation. This required clearing trees and cultivating the land for just one or two seasons. Abandoning the land cultivated after it had been cultivated once and shifting to a new location was common. Unlike the familiar practice known today, crop cultivation and animal rearing

continued without requiring the application of scientific knowledge.

Settled agriculture: the practice of using the same plot of land continuously over a long period to grow crops or rear livestock.

In a settled agriculture, the land is cultivated continuously. The cultivation of land in a settled agriculture involves the use of yield enhancing practices. Crop management practices such as using manure, fertilizer, the construction of soil bunds for erosion control, and the optimized use of water have now become associated with cultivation of land in a settled agriculture. This means that a settled agriculture is a more advanced activity than traditional shifting cultivation.

Subsistence farming: the practice of growing crops and raising livestock sufficient only for one's own use, without any surplus for trade.

Subsistence farming refers to a situation in which a farmer produces crops and livestock sufficient only for household use without any surplus for trade. The major aim of this type of farming is to produce crops and animals for the farmer's own consumption. Subsistence farming often requires simple techniques that often do not go beyond a household capacity. If there is any excess production, it might be stored for times of poor harvest or sold to generate income for the household.

1.2. The Origin of Domesticated Crops

It is not possible to know the exact place and time that agriculture began. However, growing crops and rearing animals in a specific area is a deliberate activity that took a long time to develop. Evolution of agricultural economies transformed wild plant species to the fully domesticated ones.

It is possible that religion may have influenced agriculture as particular animals and plants were kept as they were required for religious practices. There may be many reasons why the hunter-gatherer culture gradually changed to agriculture and this change took place over thousands of years.

No strong evidence is available on how hunter-gatherers chose their food sources. A fair estimate could perhaps be that the hunter-gatherers were influenced by certain features of the plant species they selected as food sources. This selection as food source probably influenced

the domestication process of the plant species. Ease of harvest, wide availability and ease of transport to the desired place could have been some useful features hunter-gatherers considered in their plant selection. Plants selected for food could also have been those available with high predictability and seasonal distribution. Possessing climatic tolerance, having good flavour and suitable grain size could also have been other desirable characteristics of plants considered for selection. The wild plant species that hunter-gatherers consumed include wild rice, grass species, wild oats and legumes. Legumes used by hunter gatherers are known to have been toxic. This suggests that the societies detoxified and used the legumes as food. Their detoxifying skills were based on trial and error. Presumably, they used the poisonous substances they extracted from such toxic legumes as poisons on arrowheads in hunting. This discovery may suggest that in hunter-gatherer life style survival required insight.

Root crops were widely used as food by hunter-gatherers particularly in the tropical region. Wild onions and sweet potatoes were also important food sources for hunter-gatherers. Hunter-gatherers used hunted animals and plant species such as coconut, oil palm and olive as sources of oil.

Activity 1.1.

Group discussion

- In a small group, discuss the criteria that hunter-gatherers could have used to select their food sources.

1.3. Status of Crop Production

Brainstorming 1.2

Crop production

Discuss the following questions in pairs and share your ideas with your class mates

- What do you think are the major activities in crop production? Discuss with your partner and then share your ideas with the class.
- List the major differences between the ancient and the modern crop productions in terms of yield.

Agriculture provides food and other goods for society. Crop plants provide food for humans and feed for livestock. Crop production is mainly determined by the crop type, and the environment in which it is grown. Agriculture involves selection of a crop species, selection of specific types of crop and land preparation before planting. It also involved planting at the right time, protecting the crop from diseases and pests and adopting techniques to increase productivity. Primitive agriculture used primitive tools that had a low efficiency and were not easy to operate. Over time, agriculture has evolved into a more complex process with enormous technological advancement. The technological advancement in agriculture resulted in:

- access to improved seeds
- better production practices
- better harvesting and storage facilities

Modern agriculture also involves crop rotation (rotating or shifting between different crops in different growing seasons, as opposed to planting the same crop on the same plot every year), fallowing (leaving a plot of land free of crop growth for 2 or three seasons for soils to recover) and use of various soil conservation practices to control soil erosion. The use of efficient technologies to improve production also characterizes modern agricultural practices. Efficient technologies include the use of machinery,

agrochemicals, irrigation, biotechnology and genetic improvement of plants (plant breeding). These have enhanced the productivity of modern agriculture. Regions with better economic capacities are able to adopt advanced technologies in agriculture.

Figure 1.1. a) manual soil cultivation b) animal drawn plough

One of the first technological changes in agriculture was the transfer of some tedious manual work to draft animals. The draft animals were used to prepare and plough land and transport materials. The development and use of agricultural machineries has further reduced the labour requirement. This enables an individual farmer to operate a large farm.

Agriculture in industrialized regions is often classified into three Eras:

- Mechanical Era (1930 - 1950)
- Chemical Era (1950 - 1970) and
- Biotechnology/Information Technology Era (1970 - present)

Agricultural productivity in industrialized regions has increased as a result of the use of industrial technologies. Land preparation and planting can be completed at the best time with machinery. Crop diseases, weeds and pests can be easily controlled with agricultural chemicals. These modern crops have higher yields and improved resistance to diseases and pests, which has contributed to improved agricultural productivity in these regions.

Agriculture in less developed regions, (e.g., in sub-Saharan Africa), is often traditional with draft animals still in use for cultivation, transport and other agricultural activities. As a result, agricultural productivity in these regions remains very low compared to industrialized regions.

Figure 1.2. a) Tractor spraying pesticides (Chemical Era) and b) tractor cultivation (Mechanical Era)

Status of crop production in Ethiopia

Ethiopian crop agriculture is complex. There are different agro ecologies in different regions of the country and a wide range of crop types are grown. Ethiopia has about 51 million hectares of arable land, of which only about 20% is cultivated, mainly by smallholders. Five major crops constitute approximately 75% of the country's cultivated area:

- teff
- wheat
- maize
- sorghum and
- barley

These grain crops supply approximately 64% of the calories consumed in the country. Cereals are grasses cultivated for their grains. Table 1.1 shows the increase in production of cereals (million tons) from 1961 to 2019. As shown in the table, between 1961 and 2000, there was also an increase in cultivated area (million ha). This can be associated mainly with the expansion of cultivated area as shown in table 1.1 and to some extent, increased use of agricultural inputs. However, there is limited evidence to support a parallel increase in productivity per unit area cultivated. The yield level is mainly limited by the recurrent droughts and climate changes. Achieving food security requires an increase in yield and a decrease in yields variability. The general yield level in the country is low compared to the international standards. The principal factors responsible for low crop yields in Ethiopia are:

- soil degradation
- traditional farming systems with little technology use
- uncertain and variable rainfall
- very low level of irrigation and
- low use of inputs like improved seeds, fertilizers and pesticides

Table 1.1. Trends in cultivated area and yields of the major cereal crops in Ethiopia

Production year	Cultivated area (million ha)	Yields in tons/ha	Production (million tons)
1961-1970	6.23	0.73	4.53
1971-1980	5.25	0.90	4.63
1981-1990	4.89	1.15	5.63
1991-2000	5.87	1.18	6.88
2001-2009	8.24	1.30	10.68
2011-2019	10.5	1.57	16.5

Source: Food Balance Sheets Database http://faostat.fao.org/

Activity 1.2.

Group discussion

- Ethiopian agriculture is often characterized by low level of crop yields or low productivity in general. Make a group of 3 to 5 students and discuss the possible reasons for low crop productivity in the country. Discuss your personal experience of any of the factors that contribute to low yield and how this may have affected you or your families or the community in general. Report the summary of your discussion orally to the whole class.

1.4. Classification of Crop Plants

Crop plants can be classified into four major categories: food crops, oil crops, fiber crops and sugar crops.

1.4.1. Major food crops

Globally, the three most important food crops are wheat, rice and maize in terms of volume of production. Other important crops include sorghum, barley and oats. In the Ethiopian context, in terms of area of cultivation, the top five major crops are teff, wheat, maize, sorghum and barley.

Crops can be generally classified into **monocots** and **dicots**. Monocot crops store food primarily in their **endosperm**. The endosperm contains starch and small quantities of protein and other nutrients. On the other hand, **dicots** such as legumes and oil seeds, store food in their cotyledons. Legumes and oil seeds are used as grain crops. The cotyledons have high amounts of protein, oil and some carbohydrates. The most important food and feed legumes or oil seed grains are soybean, peanut, beans and peas. However, protein in dicot plants is low in certain essential amino acids.

Figure 1.3. Major food crops in Ethiopia: a) teff, b) wheat and c) maize

Key terms

Monocots: grass and grass-like flowering plants whose seeds contain only one embryonic leaf or cotyledon.

Dicots: these are flowering plants whose seeds contain two embryonic leaves cotyledons.

Cotyledon: seed leaf within the embryo of the seed that serves as food source for the plant embryo to germinate

Endosperm: tissue produced inside the seeds of flowering plants and provides nutrition in the form of a starch. It is a source of nutrition in animal diet.

1.4.2. Major Oil Crops

Oil crops or oil seed crops are grown in order to extract the oil contained in their seeds. Major oil seeds include olive, linseed, sesame and sunflower. Soybean, coconut, palm, maize and peanut are also oil seeds. Plant-derived oils are used for food as well as for industrial purposes. Oils supply two

essential fatty acids: linoleic and alpha-linolenic acids. They also supply vitamins A, K, D and E. Oils and fats are composed of triglycerides. Triglycerides are composed of glycerine and three fatty acids. A fatty acid is generally composed of long chains of carbon, hydrogen and oxygen atoms..

1.4.3. Major fibre crops

Plant fibres are used for making clothing and in textile industry. Cotton lint is the most important fibre for cloth-making. Plant fibers can be obtained from cotton, inner barks of certain plant species: stems (flax, jute, hemp, ramie, Kenaf, nettle, bamboo). Fibers obtained from cotton are used to manufacture sewing threads and cloth. Fibers from barks of certain plants are often used to manufacture packaging materials. Vegetable fibers such as jute are often hard and used in rope manufacturing.

1.4.4. Major forage crops

Forage crops are plants used as food for livestock or farm animals. The major forage crops include alfalfa, Sesbania sesban, Leucaena leucocephala, clovers and Timothy. Elephant grass, Desho grass, Rhodes grass, Panicum grass, Sudan grass and Johnson grass are other forage crops. Cereal grain crops at their early growth stages might be used as livestock feed. Plants used as livestock feed are often grown for their vegetative parts such as roots, shoots, shoot buds and leaves. Forage crops may be selected for the protein, fiber and nutrients they provide. Some forage crops can provide farm animals with vitamins A and E, sodium, potassium, calcium, phosphorus and magnesium.

Figure 1.4. a) Sunflower (oil crop), b) cotton (fibre crop) and c) tropical grass (forage crop)

1.4.5. Classification of crops into C3 and C4 plants

Crop plants transform carbon dioxide (CO_2) in the atmosphere into carbohydrates by the process of **photosynthesis**.

Key term:

Photosynthesis: is a process by which plants use sunlight, water and carbon dioxide to produce oxygen and energy in the form of sugar.

Depending on their photosynthetic pathway, crop plants can be classified into either C3 or C4 types. In the C3 photosynthetic pathway, the first stable carbon compound formed from assimilation of carbon dioxide contains 3 carbon atoms. In the C4 photosynthetic pathway, the first stable carbon compound formed from CO_2 assimilation contains 4 carbon atoms. For C3 plants, rates of photosynthesis increases with increased levels of CO_2. C4 plants have a mechanism to accumulate CO_2 inside the chloroplast and therefore their photosynthetic rates do not increase with an increase in CO_2 levels. This means that C4 plants can reach higher photosynthetic rates at low levels of CO_2 while C3 plants cannot. This is because C3 plants do not possess a CO_2 accumulation mechanism. Moreover, C4 plants are more efficient in using water and require less nitrogen compared to C3 plants. Generally, C4 plants have higher photosynthetic rates at a given temperature, compared to C3 plants. Examples of C3 crops include: wheat, barley, teff, soy bean, ground nut and sweet potato. Examples of C4 plants are: sorghum, maize, sugar cane and most weed species.

Activity 1.3.

Group task

- Make a group of 3 to 5 students and visit a nearby market. List the types of grain crops available at the market.
- Classify these grain crops in to the different categories and submit the report to your teacher
- Climate change results from increased concentration of CO_2 and other greenhouse gases in the atmosphere. How do C3 and C4 plants respond to increased CO_2 that results from climate change? Why? Submit written answers to your teacher

1.5. Cropping Systems

Brainstorming 1.3

Answer the following questions. Compare your answers with your classmates'.

1. What is a cropping system?
2. What are the major crops grown in your locality? Are the crops grown every year on the same plot of land similar? Why?

Cropping system refers to the types and sequences of crops and the different practices used to grow them. Different cropping systems require different types of management and possess their own advantages and disadvantages. There are several forms of cropping systems, including mono cropping, mixed cropping (including intercropping and relay planting) relay planting and crop rotation.

1.5.1. Mono cropping

Mono cropping is growing a single crop type in a given plot of land. Mono cropping is commonly practiced in large scale commercial crop production. Some smallholder crop production systems may also practice mono cropping. In this system, a single crop species occupies the whole farm. One disadvantage of mono cropping is the risk of total crop failure, as a result of crop pests and diseases. Mono cropping also results in reduced soil fertility. On the other hand, mono cropping has the advantage that it enables farmers to use uniform management and increases the efficiency of practices like planting and harvesting.

1.5.2. Mixed cropping

Mixed cropping is growing two or more crops simultaneously on the same piece of land. Mixed cropping reduces the risk of total yield loss as the farmer is not dependent on the yield of only one crop. Mixed cropping also allows for more efficient use of soil nutrients, water and light radiation. In addition, mixed cropping helps to break the cycle of crop pests and diseases which are very common in mono cropping systems. The most common types of mixed cropping are intercropping and relay planting.

Intercropping

Intercropping is the planting of more than one crop in regular rows on the same field at the same time. As shown in Figure 1.5, intercropping often involves the planting of cereal crops such as maize alongside legumes. Relay and intercropping systems provide better soil cover and reduce soil erosion. Crop diseases also spread less rapidly in relay and intercropping systems compared to the mono cropping systems.

Figure 1.5. Intercropping

Relay planting

Relay planting is where a second crop is planted after the first crop has grown alone for a certain period. This system reduces the risk of total crop failure as the farmer doesn't depend on the yield of one crop only.

1.5.3. Crop rotation

Crop rotation is the practice of growing different crop species on the same plot of land sequentially. For example, planting maize in the first season can be followed by bean production in the next season, and cultivation of teff in the third season. The sequence might be repeated many times. Rotations could also involve more crop species depending on the environment. The objectives in crop rotation include improving soil fertility, especially if legumes are included in the rotation, and controlling of some crop pests and diseases. On the other hand, crop rotation may also develop resistant diseases and weeds. Besides, changing climates may be a challenge to crop rotation.

1.6. Indigenous Knowledge in Crop Production

Brainstorming 1.4

Discuss the following questions in pairs.

1. What is indigenous knowledge? How different is indigenous knowledge from scientific knowledge?
2. What indigenous knowledge is used in your locality to produce crops?
3. Is indigenous knowledge sufficiently exploited in your locality? If not, what are the reasons?

Indigenous knowledge is traditional or local knowledge. It is the knowledge that local communities have accumulated over generations of living in a particular geographic location. It is often referred to as 'home grown' or 'local knowledge' that is unique to a particular culture. Indigenous knowledge often develops independently of scientific knowledge. It often includes beliefs and traditions intended to preserve, communicate, and contextualize indigenous relationships with culture and landscape over time.

Indigenous knowledge often develops from agricultural production related problems. These problems might include land becoming less fertile (land degradation), soil erosion, changes to the climate, as well as working with the natural physical features of an area (topography). Other issues such as farmers having only small landholdings along with social and cultural settings of the community.

Communities with indigenous knowledge possess knowledge about their natural resources and environment based on a long period of observation and experience. For example, indigenous knowledge about natural resource management is vital among the Gumuz society. They believe that natural resources are a gift, a blessing and creation of the Yamba (God). They also believe that natural resources have been sources of livelihood for the past, are sources of livelihood for the present generation and will continue to be the sources for future generations. Conserving the natural resource has an impact on the soil fertility, on the rainfall pattern and on soil moisture and temperature. Overall, it improves crop productivity.

Another popular example of indigenous knowledge is the traditional skills in terracing demonstrated by the *Konso* people. Their land is extensively terraced to protect against soil erosion. The Konso people also practice traditional irrigation to supplement the unpredictable and variable rainfall. These practices have helped to reduce soil erosion and maintain soil quality.

Other examples of indigenous knowledge in agriculture include the following:

- Farmers in Bale prepare trench around potato plots to protect the crop from porcupine attack.
- In Gondar, farmers shift their barns from one farmland to another in search of cow dung to fertilize the land.
- Farmers in highland areas use kitchen ash to fertilize the soil and reduce soil acidity and smoke to reduce frost damage

Activity 1.4.

Field Visit

- Visit villages in your vicinity in groups of 3 - 5 students and ask the people (the elders, development agents, and/or community leaders) about the indigenous knowledge they use for crop production and how that has affected crop production. Prepare a report on your findings and present it to the class for discussion.

Unit Summary

In this unit you have learnt that:

- agriculture has gradually evolved from simple hunter-gatherer form to a settled agriculture
- in shifting from primitive hunter-gatherer forms to a settled agriculture, humans have selected crops for domestication based on suitable features of the crops
- agriculture has passed through different phases of development (Mechanical, Chemical, Biotechnology or Technology Era). Each Era has had its own significant contribution to agricultural productivity.
- low average national crop yields in Ethiopia are mainly attributed to soil degradation, erosion, compaction, climate change and low status of irrigation.
- crops are generally classified into food crops, oil crops, fiber crops and forage crops depending on their end use.
- crop plants are also classified into C3 and C4 depending on their photosynthetic pathways.
- C4 plants like maize and sorghum possess a mechanism to accumulate CO_2 in the chloroplast and can reach high photosynthetic rates at low CO_2 levels
- C3 plants cannot achieve high photosynthetic rates at low concentration of $CO_{2;}$ they do not possess CO_2 accumulation mechanism.
- different cropping systems are recognized: mono cropping, mixed cropping, relay planting and crop rotation.
- various indigenous knowledge practices that are very useful in crop production as well as in agriculture in general exist in local communities.

Review Exercise

Part I: Choose the best answer from the given alternatives.

1. Which one of the following cereal grain crops is not grown widely in in Ethiopia?
   A. Teff
   B. Maize
   C. Wheat
   D. Rice
2. What are the three major crops produced globally?
   A. Maize, Teff and Wheat
   B. Maize, Rice and Wheat
   C. Maize, Barley and Wheat
   D. Maize, Sorghum and Millet
3. Which one of the following crops is not a legume crop?
   A. Lentil
   B. Teff
   C. Beans
   D. A and C
4. Why are the national average yields of major cereals very low compared to global yield levels?
   A. Low soil fertility
   B. Low fertilizer use
   C. Low irrigation
   D. All of these
5. Which one of these is not a major factor used in the selection of crops for domestication?
   A. Resistance to crop pests
   B. Attractive flavour
   C. High yield
   D. Susceptible to crop pests
6. What is planting of two or more different crops on the same farm at the same time called?
   A. Crop rotation
   B. Intercropping
   C. Relay cropping
   D. Mono cropping
7. Which one of the following is not a forage crop?
   A. Alfalfa
   B. Johnson grass
   C. Cotton
   D. Elephant grass
8. What is the name for knowledge that local people develop from living in a particular location for long periods?
   A. Modern knowledge
   B. Indigenous knowledge
   C. Scientific knowledge
   D. Chemical knowledge

9. Which of the following is a C3 crop?
   A. Sorghum
   B. Barley
   C. Maize
   D. Sugar cane
10. What is the definition of forage crops?
    A. A crop grown to provide animal feed
    B. A crop grown to provide human food
    C. Plants found by hunter-gatherers
    D. Crops grown to produce industrial raw materials

Part II: Answer the following questions.

1. Write the definition of the following terms:
   a. Agriculture
   b. Shifting cultivation
   c. Settled agriculture
   d. Subsistence farming
2. Compare subsistence farming with commercial farming in terms of inputs and outputs. Mention at least 4 points.
3. Over the last few decades, Ethiopian cereal production has generally increased, but the yield per unit area has not increased as much as the total yield. Explain why this is so?
4. What are the most common cropping systems? Describe the advantages and disadvantages of each of these cropping systems.
5. How is indigenous knowledge useful in crop production? Give specific examples.

Unit 2 Field Crops Production and Management

Contents	Learning Outcomes
2.1. Cereal crops production and management 2.2. Pulse crops production and management	At the end of this unit, you will be able to: ▪ define field crops, cereal and pulse crops ▪ identify the major cereals and pulses produced in Ethiopia, describe their uses and management ▪ describe the status of cereal and pulse crops production ▪ explain the growth requirements of the major cereals and pulses produced in Ethiopia

2.1. Cereal Crops Production and Management

Brainstorming 2.1.

Discuss the following questions in pairs.

1. What types of food crops do you know?
2. What are cereal crops? Give three examples.
3. Name cereal crops produced in your locality.
4. What uses of cereal crops do you know, apart from their use as food?

Crop production is influenced by various factors. Some of the factors are under the farmer's control. Others cannot be fully controlled by the farmer. Selection of crop site is the principal factor that determines crop production. Crop selection requires knowledge of the crop requirement. Knowledge of soil properties, water and other growth factors is important in crop site selection. The soil type suitable for root or tuber crops is different from that of cereal or legume crops. It is important to select the best crop type that best fits the soil selected for the crop.

The farmer also needs to decide the amount of land to allocate for a specific crop and the types of management needed for a maximum yield. The management practices include;

- appropriate planting time
- deciding planting distance
- pest control strategies
- deciding when to harvest
- post-harvest management

The farmer is also able to control the type and amounts of agricultural inputs to use. This could include:

- fertilizer to improve the nutrients available in the soil
- irrigation to supplement rainfall
- adding lime to modify the acidity of the soil.

However, there are crop production factors that cannot be manipulated by the farmer. For example, the unexpected end of favorable weather may

result in a huge crop loss. Similarly, a locust invasion cannot be planned for ahead of time.

Field crops

Field crops are crops grown on a wide scale mainly for human consumption. These crops are annuals which means that they complete a life cycle in a single season. The major field crops are classified into two major groups called cereals and pulses (legumes).

Cereals are crops with grass characteristics grown mainly for their edible seeds. Cereals can grow in a wide range of environmental conditions, from low lands to highlands and in different soil types and climates. Cereal crops are monocots, which means that their seeds have a single cotyledon (embryonic leaf). As a result, during emergence they produce a single leaf. These crops contain:

- carbohydrates
- proteins
- fats
- fibers

The five major cereal crops produced in Ethiopia are teff, maize, wheat, barley and sorghum.

2.1.1. Teff (*Eragrostis abyssinica (Zucc.) Trotter*)

Teff is a cereal crop that is native to Ethiopia where it is used as staple food. It is used as livestock feed in South Africa. Teff is a very nutritious cereal crop preferred by many people to other cereal crops. Moreover, teff does not contain gluten, which causes allergy in some people. Maize and sorghum are other examples of cereals that do not contain gluten. Teff is now a high value cereal food crop being used even outside Ethiopia. In addition to the seeds that are consumed as food by humans, teff straw is also a valuable feed for animals. It is a high value crop with high price compared to other cereals and has a high acceptability by consumers. Also, teff can be stored for a long time. Compared to other cereals, teff is less affected by pests and diseases. These qualities make the crop reliable with

low levels of risk compared to other cereals.

Production and management

Teff can grow in wide range of environments including low fertility soils, soils with excessive moisture content and areas with moisture shortage. The crop can grow at altitudes ranging from the sea level to 2800 meters above the sea level. The major teff producing areas have altitudes between 1500 and 2800 meters above the sea level. Teff performs well on loam and clay soils, which have high nutrient contents and water storage capacity. Teff ranks first in terms of the area of production in Ethiopia.

Land preparation: teff has smaller grain size than most cereals. As a result, it requires very smooth seed bed. For teff production, the soil is usually cultivated 4 or 5 times and leveled before planting. Soils used for teff production should be free from weeds and other crop pests. Due to the small size of the seeds, teff plots should be smooth with no large soil clods. Usually animals are driven on the surface to achieve the smooth seedbed that teff requires.

Planting: teff is often planted by broadcasting seeds (seeds are randomly spread over the farm) on the smooth plots. Row planting, where seeds are planted on the plots with regular spacing, is also becoming common these days using a spacing of 20 cm between rows and drilling the seeds inside planting rows. After planting, branches could be dragged across or flock of animals could be driven on the surface of the soil to cover the seeds. Shallow furrows are usually made at an interval of 3 to 6 meters for draining (removing) excess moisture from the teff plots. The most common planting time is July/August. Teff is usually harvested in November/December in the highland areas and earlier in mid and lowland areas.

Fertilization: 60 kg nitrogen and 26 kg phosphorus per hectare is usually applied for teff production. Fertilizer application should be determined by the soil fertility level of the teff plots. Fertile soils may not require as much fertilizer.

Weed and disease management: teff competes poorly with weeds

particularly at early seedling stage. This means early weeding is important to ensure good growth of the crop. Usually manual weeding is done about a month after planting. Chemicals are also used to control different types of weeds. For example, the herbicide 2,4-D is used to control broad leaf weeds in teff fields. Teff could also be affected by fungal diseases when excess water accumulates in the soil.

Harvesting:teff crop is ready for harvest when the stems and panicle turn yellow. Average national yield for teff is about 14.6 quintals (1.46 t) per hectare. Nutritionally, teff is a rich source of carbohydrates, proteins and fats. The crop is also a good source of mineral nutrients like iron, calcium and magnesium.

2.1.2. Maize (*Zea mays L.*)

Maize most likely originated in Central America. From there, it was introduced to other parts of the world including Latin American and Africa. Maize is widely produced in various agro ecologies. It has the following beneficial features:

- gives high yield per unit area
- the seeds are covered by husk, protecting it from rain and birds
- does not shatter (lose seeds up on drying) so can be harvested at late maturity as there is no shattering loss

Maize is mainly produced for its seeds to be used as a staple food. It is also used as animal feed when green or after drying. Maize residues (the straw and cobs) are used as firewood in rural areas. Maize is also used in the production of starch and oil in industries.

Production and management

Maize grows in a wide range of environments with suitable altitudes varying from 500 to 2400 meters above sea level. In Ethiopia, maize yields per unit area are the highest compared to other cereals. Maize ranks second to teff in area of production in Ethiopia. Loam soils that do not accumulate excess moisture are better for maize production. Maize is planted as a mono crop or as a mixed crop with legumes such as haricot beans and cereals, such as teff.

Land preparation: usually the soil is plowed 2 or 3 times before planting maize. Sometimes, planting can be done after plowing the soil only once or twice if chemicals are used to control weeds.

Planting: row planting is usually used at a spacing of 25 cm between seeds and 75 cm between planting rows. Depth of seed sowing is from 5 to 7 cm. The most common maize planting time is at the start of the rainy season (March to April).

Fertilization: farmers usually apply 41 kg nitrogen and 20 kg phosphorus per hectare for maize. However, fertilization rates should be determined by the level of fertility of the soils used for maize production.

Weed, insect pest and disease management: weeds are controlled either by manual weeding 2 to 3 times during the growing season or using chemical herbicides to prevent and kill weeds. Two main types of herbicides are used: pre emergence (such as Atrazine, which are used before the weeds emerge aboveground) and post emergence (like 2,4-D, which are used after the weed has emerged aboveground). Common insects that attack maize include maize stalk borer, aphids, army worm and weevil.

Maize can also be affected by fungal (rust, gray leaf spot and blight) and viral diseases such as strike virus. These can be controlled by using crop rotation instead of mono cropping and modifying the planting time to reduce the damage from these diseases.

Around a month after planting, earthing up (piling soil around the plants) helps to reduce maize plants falling (lodging) due to wind.

Harvesting: There are different maize varieties which require different times to reach maturity. Early maturing varieties could reach harvest in 3 months while late maturing ones could take up to 5 months to mature. Maize is ready for harvest when the seeds develop a black layer at the bottom tip. When harvested, maize grains often have a moisture content of about 25% and for suitable storage, the grain moisture has to be reduced to 13% or lower by harvesting when grain moisture content is close to this value or drying the grains so that the required moisture content is achieved. Average national yield of maize is 32.5 quintals (3.25 t) per hectare.

Nutritionally, maize is an important source of carbohydrates, proteins and fats.

Figure 2.1. a) Teff and b) maize crops.

2.1.3. Wheat (*Triticum aestivum L.*)

Wheat is a cereal crop believed to have originated in the Asian continent mainly in China, Pakistan and India, from where it spread to other parts of the world. Globally, it is the most important cereal followed by rice and maize. Wheat is an important food crop for humans as it is used to make bread, macaroni, spaghetti and other food types.

Production and management

Wheat requires cool weather to grow. In Ethiopia, it grows widely at altitudes ranging from 1800 to 3000 meters above sea level. Well drained, loamy and fertile soils (black, red and brown soils) are suitable for wheat production. Wheat is usually rotated with lentils, pea, teff and potato.

Land preparation: wheat is often planted after the soil has been cultivated 2 or 3 times.

Planting: Wheat is usually planted both as broadcast and using row planting at a spacing of about 25 cm between planting rows. Seeds are often sown at a depth of about 5 cm. The most common planting time is between June and July.

Fertilization: farmers usually use 45 kg nitrogen and 25 kg phosphorus per hectare. However, fertilization rates should be governed by the level of soil fertility.

Weed, insect pest and disease management: wheat is affected by various types of weeds. Weed control often involves manual weeding starting about a month after planting and sometimes chemicals like 2,4-D are used to control broad leaf weeds. Fungal diseases such as rust and smut are common particularly in warm areas with high humidity. These can be controlled by crop rotation, using wheat varieties which are resistant to disease and modifying the planting time so that most susceptible stage of the plant does not match with peak occurrence of a certain disease.

Harvesting: wheat is ready for harvest when it dries to a golden yellow color and there are no green parts left on the plant. The national average yield for wheat is 24.5 quintals (2.45 t) per hectare. Wheat is an important source of carbohydrates, proteins, fats, minerals and fiber.

2.1.4. Barley (*Hordeum vulgare L.*)

Barley is believed to have originated in the Middle East and spread to other parts of the world. Growth requirements of barley are comparable to that of wheat. Barley is used as human food, and its residue is used as livestock feed. Barley is also used for malting during the production of alcoholic beverages. Malting is a process of controlled germination for producing enzymes that convert cereal starch to sugars. The sugars produced are fermented to produce alcohol.

Production and management

Barley grows at altitudes ranging between 2200 and 3000 meters above sea level. Well-drained loam soils are suitable for barley production.

Land preparation: barley requires soil to be cultivated 2 to 3 times before planting, similar to wheat.

Planting: barley is planted either as broadcast or row planting where seeds are drilled inside planting rows with 25 cm spacing between rows. Seeds are planted at a depth of about 5 cm.

Fertilization: farmers usually use 60 kg nitrogen and 26 kg phosphorus per hectare for food barley production. However, for barley used for malting purpose, the nitrogen application rate has to be reduced because

high levels of nitrogen application reduces the malt quality.

Weed, insect pest and disease management: most of the weeds and diseases that affect wheat also affect barley. Therefore, the control measures that are used to control these weeds and diseases are also usually similar, including the use of resistant varieties, crop rotation and changing planting times. Army worm, grasshopper and barley shoot fly are the major insect pests affecting barley production..

Harvesting: barley usually matures in 3 to 4 months. As with wheat, the indicator for maturity is drying and yellowing of the plant. The national average yield of barley is 19 quintals (1.9 t) per hectare. Nutritionally, barley is a source of carbohydrates, proteins, fats and fiber.

Figure 2.2. a) barley and b) wheat crops

2.1.5. Sorghum (*Sorghum bicolor L.*)

Sorghum is a cereal crop which originated in Africa. It is a staple food crop in the drier parts of Africa. Sorghum stalk is used as animal feed and for construction of fences and houses in rural Ethiopia.

Production and management

Most sorghum producing areas in Ethiopia have altitudes ranging between 500 and 1500 meters above the sea level. The crop gives reasonable yields on soils that are too poor for other crops. Well-drained, fertile clay soils are suitable for sorghum production. This crop is well-adapted to drier parts of the country. Sorghum has the capacity to remain dormant during dry periods and resume growth as soon as soil moisture becomes sufficient. As a result, this crop is usually called 'the camel crop'. It is often rotated with haricot bean, soybean, sesame and cotton.

Land preparation: it is necessary to cultivate the soil 2 or 3 times before planting sorghum.

Planting: sorghum is planted either as broadcast or sown in planting rows at a spacing of 0.5 to 1 meter between rows and about 40 cm between plants. Seeds are sown at a depth of about 2.5 cm. The most common planting time is March to May. Earthling up is usually done about a month after planting to help the plant resist lodging due to wind.

Fertilization: 32 kg of nitrogen and 10 kg of phosphorus per hectare are often used for sorghum production. Fertilization rates, however, should be determined based on the local soil fertility levels.

Weed, insect pest and disease management: a parasitic weed called striga is the major weed affecting sorghum production. Striga weed causes massive yield losses in sorghum producing areas. To reduce the damage, hand weeding should be carried out before the sorghum starts producing seeds. Manual weeding should be combined with crop rotation and the use of varieties of sorghum that are resistant to pests. Sorghum is also affected by insect pests and birds. Fungal diseases like smut also affect sorghum. In general, pests and diseases control in sorghum production should involve an integrated use of crop rotation, use of resistant varieties and chemical methods.

Harvesting: sorghum matures in about 4 months. It is harvested when the grains start to dry and often grain moisture content drops to about 30% when the crop is mature. The average national yield for sorghum is 23 quintals (2.3 t) per hectare.

Figure 2.3. Different colored grains of Sorghum

2.2. Pulse Crops Production and Management

Brainstorming 2.2.

Group discussion

1. What are pulse crops? Give three examples.
2. How are pulse crops different from cereals?
3. What pulse crops are produced in your localities?

Pulses are seeds of legume crops that are grown mainly for their edible seeds. These crops are consumed as dry seeds rich in protein or as immature pods used as vegetables. Pulses are also used as a source of animal feed. Pulse crops are dicots, meaning that the seeds contain two cotyledons (embryonic leaves). Many pulses assist with nitrogen fixation. This means that these plants fix atmospheric nitrogen into the soil through their root nodules. This nitrogen is then available for subsequent crops. For this reason, pulses can be used in crop rotations to improve the fertility of soil. Pulses can also be used in mixed cropping with cereals in order to improve the yield of the cereal crop. In Ethiopia, pulses are mostly produced without mineral fertilizer application. In some cases, organic fertilizers, such as animal manure are used. Compared to cereals, soil cultivation is generally minimal – soil may be cultivated once or direct planting takes place, with no soil cultivation. These factors, together with poor weed control in grain legumes, have resulted in low yields from these crops in Ethiopia. The major pulse crops in Ethiopia are faba bean, field pea and haricot bean.

2.2.1. Faba bean (*Vicia faba L.*)

Faba bean is believed to have originated in the Mediterranean region and spread to other parts of the world. It is mainly produced for its edible seeds. Faba bean is also used as vegetable at the green stage. It grows well in altitudes ranging from 1800 to 3000 meters above the sea level. Well-drained clay soils are suitable for production of faba bean.

Planting: Faba bean is planted both by broadcasting and in rows at a spacing of 40 cm between rows and 5 to 10 cm between plants.

Weed, insect pest and disease management: faba bean is affected by weeds, fungal diseases and insects such as African ball worm and aphids.

Control measures should involve integrated use of hand weeding (twice in 6 weeks after planting), crop rotation, ensuring a clean seedbed and the use of chemicals.

Harvesting: faba bean is ready for harvest when the leaves fall off and the pods (structures containing the seeds) dry and change color from green to black. If faba bean is grown for use as vegetable, it should be harvested when it reaches the green stage (immature pods). The average national yield for faba bean is 19 quintals (1.9 t) per hectare.

2.2.2 Field pea (*Pisum sativum L.*)

field pea is produced for its edible seeds which are rich in protein. It is also an important source of animal feed. It can be planted as a mono crop or mixed with faba bean. It is usually grown in rotation with cereals like teff, wheat and barley. It grows well in altitudes ranging between 1800 and 3000 meters above sea level.

Planting: field pea is often planted by broadcasting or using row planting at a spacing of 30 cm between rows and 5 to 10 cm between plants.

Weed, insect pest and disease management: weeds, insect pests (aphids, African ball worm) and fungal diseases affect the productivity of field peas and integrated control involving manual weeding (starting around 4 weeks

after planting), crop rotation and chemical methods are used.

Harvesting: field pea is harvested once the pod is mature and the seeds are sufficiently hard. Delay in harvesting time causes seed loss from pods (shattering). The average national yield for field peas is 14 quintals (1.4 t) per hectare.

Figure 2.4: a) Faba bean plants, b) faba bean seeds, c) field pea plants and d) field pea seeds

2.2.3. Haricot beans (*Phaseolus vulgaris L.*)

Haricot bean (common bean) originated in Mexico and spread to other regions of the world. It is produced for its edible seeds. The immature pods of the haricot bean are consumed as a vegetable. It can also be used as animal feed. Haricot bean grows well in most soil types and in altitude between 1400 and 2000 meters above sea level. Haricot bean is usually grown as mono crop or mixed with cereals such as maize and sorghum. It is grown in rotation with teff, maize and sorghum. Haricot bean seeds can be red, brown, white or gray. It is an important export crop in Ethiopia.

Planting: haricot bean can be sown by broadcasting or in rows. When in rows, commonly used spacing is 40 cm between rows and 10 cm between plants. In intercropping, usually the spacing between plants is maintained (10 cm) and the rows of haricot bean come between rows of maize or sorghum. Animal manure is usually used for fertilization.

Weed and insect pest management: to control weed problems, the seedbed should be clean and manual weeding should be carried out within 4 weeks of planting. The crop is susceptible to storage pests such as weevils. To control storage pests, the grains are dried until the moisture content is below 12% and chemical treatment of the grains is used.

Harvesting: haricot beans mature within 3 to 4 months. The crop is ready for harvest when the leaves fall off and the pods turn yellow and start to dry. If produced for use as vegetable, the pods should be harvested when they are green (immature). The national average yield for haricot beans is 14 quintals (1.4 t) per hectare.

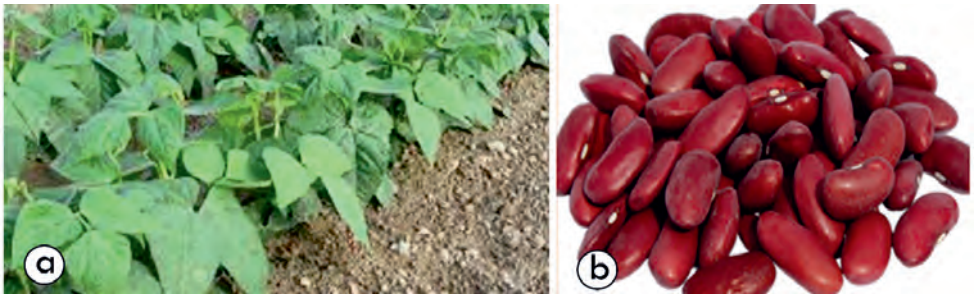


Figure 2.5: a) Haricot bean plants and b) Haricot bean seed

Activity 2.1.

Form a group of 3 to 5 students, and visit nearby farmers.

- Ask about the types of crop they produce. Are these crops all cereals? Are legumes produced in the area? If yes, which ones?
- Ask about the farmers' management practices (e.g., land preparation, seed selection, harvesting, etc.).
- Share the results of your visit with your classmates.

Activity 2.2.

Pair work

- In pairs, discuss the differences and similarities between cereal and pulse crops. Give examples of each. Share your discussion results with student pairs sitting next to you.

Unit Summary

In this unit you have learnt that:

- cereals are monocots and are rich in carbohydrates, proteins, and to some extent, fats and fibers.
- the major cereal crops in Ethiopia are teff, maize, wheat, barley and sorghum. These crops:
- are adapted to specific agro ecologies and climate
- require specific soil and management
- cereal crops are adapted to specific agro ecologies, example
  - wheat and barley are adapted to highland agro ecologies,
  - teff and maize are more adapted to mid altitude areas and
  - sorghum is more adapted to low land and moisture deficit areas.
- cereal crops require specific soil and management practices.
  - proper land preparation
  - selection of proper seeds or planting materials
  - timely planting
  - integrated management of insect pests, weeds and diseases
  - appropriate fertilization
  - proper harvesting
- pulses are seeds of legume crops. Legumes are dicots and have the capacity to change gaseous nitrogen to plant usable forms (nitrogen fixation).
- the major pulses produced in Ethiopia include faba bean, field pea and different kinds of haricot beans, among others.
- integration of cereals with legumes in cropping systems helps to improve nitrogen availability for cereals. This improves overall productivity.

Review Exercise

Part I: Choose the best answer from the given alternatives.

1. Which of the following cereal crops has the highest productivity per hectare in Ethiopia?
   A. Wheat
   B. Barley
   C. Sorghum
   D. Maize
2. Which of the following is the most effective method of weed management in cereal crop production?
   A. Manual weeding
   B. Chemical method
   C. Integrated weed management
   D. Crop rotation
3. Which of the following cereal crops contains gluten?
   A. Sorghum
   B. Teff
   C. Wheat
   D. Maize
4. Which of the following agricultural practices are used to control weeds, insect pests and crop diseases?
   A. Soil cultivation
   B. Crop rotation
   C. Broadcasting seeds at planting
   D. Both A and B
5. The amount of fertilizer that should be applied to cereals is determined by the_____.
   A. Crop type
   B. Soil fertility level
   C. Both A and B
   D. The harvest time
6. Which of the following statements apply to cereals but not pulses?
   A. They are planted in rows
   B. They can fix nitrogen
   C. Both A and B
   D. They are monocots
7. What is the practice of planting cereals and pulses in the same farm during the same growing season called?
   A. Crop rotation
   B. Intercropping
   C. Mixed cropping
   D. B and C
8. Which of these statements applies to pulses?

A. Dicots
B. Monocots
C. Nitrogen fixers
D. A and C

Part II: Answer the following questions.

1. List the major differences between cereals and legumes. Give two examples of each crop type.
2. Teff is sometimes referred to as a ‘’super food’’. Why do you think it might be considered a ‘’super food’’?
3. Describe three of the management practices used for controlling weeds, insect pests and diseases in cereals and pulse crops production?
4. Compare row planting and broadcasting methods of sowing, in terms of their advantages and disadvantages.
5. Explain some benefits of mixing cereals and legumes in crop production systems.

Unit 3 Industrial Crops Production and Management

Contents	Learning Outcomes
3.1. Oil crops production and management 3.2. Fiber crops production and management 3.3. Sugar crops production and management	At the end of this unit, you will be able to: ▪ understand the classification of industrial crops: oil, fiber and sugar crops ▪ list the major industrial crops produced in Ethiopia ▪ identify the major uses and growth requirements of industrial crops ▪ explain the agricultural practices required to grow industrial crops ▪ describe the status of industrial crops production and prospects in Ethiopia, and ▪ suggest ways of increasing the production and productivity of industrial crops

Brainstorming 3.1.

Discuss in pairs.

1. Which products you use do you think come from industrial crops?
2. List some examples of such products.

Industrial crops are crops produced mainly for use as a raw material in agro industries and other types of industries. These crops can be classified into oil crops, fiber crops and sugar crops. Examples of crops from these categories will be discussed in the following sections.

3.1. Oil Crops Production and Management

3.1.1. Sesame (*Sesamum indicum L.*)

Sesame is an oil crop believed to have originated in Africa. Sesame is mainly produced for its oil, which is used in cooking food and also in the production of other foods such as margarine. Oil extracted from sesame is also used in the production of paints and cosmetic products like soaps. By-products of sesame oil extraction are also used to produce animal feed. The crop is adapted to semi-arid, lowland areas with an altitude of up to 1200 meters above sea level. This is mainly because it requires relatively high temperatures (25 to 27 ^{o}C) during the growing season. Sesame is very sensitive to excess water and though generally drought-tolerant, it is sensitive to extreme shortages of water. High rainfall during flowering reduces yield because flowers drop off the plant. Sandy loam soils that do not accumulate excess moisture are suitable for the growth of this crop.

Land preparation and planting: sesame is sensitive to weed problems and therefore the fields should be clean from weed seeds during land preparation. Since the seeds are small, soils should be free of big clods and the seedbed should be as smooth and clean as possible. Sesame is often planted by broadcasting or row planting at a spacing of 50 cm between rows and 10 cm between plants.

Weed management: Sesame is especially sensitive to weed competition and damage during early growth stages. Weeding should start early from

emergence to about 4 to 5 weeks of growth.

Harvesting: sesame takes up to 5 months to mature. The crop is ready for harvest when one third of the leaves, stems and pods (structures that contain the seeds) turn yellow. When harvest is delayed, the pods break and there will be loss of seeds. The national average yield for sesame is 7.4 quintals (0.74 t) per hectare.

3.1.2. Noug (*Guizotia abyssinica L.*)

Noug is an oil crop that originated in Ethiopia. The country is the largest producer of noug. It is mainly produced for its oil and it accounts for about half of all food oil production in the country so it is an important source of good quality food oil. Noug oil can also be used for the production of paints and soaps. Residual material left after the oil is extracted is used as a source of animal feed. Noug grows well in areas with altitudes of between 1800 and 2000 meters above sea level. Noug does not require high rainfall and can even survive with only residual soil moisture after rains stop. It also has the capacity to tolerate excess soil moisture. This crop performs well on clay-dominated soils that often accumulate excess water.

Land preparation and planting: the seedbed needs to be well prepared to make sure that sown seeds germinate well. Noug is commonly sown by broadcasting. Alternatively, it can be planted at a spacing of 25 cm between rows and drilling of seeds within the planting rows at a depth of about 2cm. The crop is usually planted in June or July.

Weed management: the crop requires at least one weeding at early growth stage, but as it grows, it becomes very competitive against weeds, it can even dominate them. However, noug can be affected by parasitic weeds like dodder and orobanche. These weeds have to be uprooted and burned before they start producing seeds. If they are allowed to produce seeds, they will spread through the farms and the yield loss will be very high.

Harvesting: the crop is ready for harvest when the leaves change from green to brown and yellow. Harvest must be completed at the right time because late harvest causes loss of seeds by shattering. Harvesting too early results in deformed seed shape which can reduce the quality of the

yield. The national average yield for noug is 8 quintals (0.8 t) per hectare. The crop is mainly used for local consumption.

Figure 3.1. noug plants (a) and seeds (b), sesame plants (c) and seeds (d)

3.2. Fiber Crops Production and Management

Fiber crops are crops which produce fibers used in textiles and other industries. Fiber crops include cotton and sisal, among others. Fiber crops such as cotton are also sources of vegetable oil for cooking and industrial purposes.

3.2.1. Cotton (*Gossypium hirsutum L.*)

Cotton is a fiber crop that produces lint, which is a soft fluffy fiber that grows in a ball (protective case) around the seed. The lint is used as raw material in the textile industry. Cotton requires a warm climate to grow and is generally drought-tolerant. It does not perform in areas with high rainfall because the lint in the cotton boll will become discolored. This will reduce the quality of the yield. Loam soils are suitable for cotton growth.

The textile industry is a rapidly growing sector in Ethiopia. The textile

industry processes cotton and produces garments and fabric for sale in local and international markets. Cotton is a major raw material for textile firms. There were more than 50 garment or cloth manufacturers, and 14 textile factories in Ethiopia in 2021. The numbers of textile manufacturers, both local and international, are increasing and hence the demand for cotton is increasing.

The contribution of the textile industry to foreign currency earning is growing. The supply of cotton to the textile industry from within Ethiopia is not sufficient to meet the demand. That is why textile manufacturers import raw cotton from other countries. In order to meet the demand of the local textile industry, it will be necessary to increase the production of cotton in the country.

Land preparation and planting: cotton seeds for planting are usually treated with acid to remove the hairs on the seed. The crop is often planted in rows at a spacing of 1 m between rows and 30 cm between plants. The seed sowing depth is about 8 cm.

Weed and insect pest management: weeds are one the major problems that limit cotton production in Ethiopia. Starting with a clean seedbed before planting can reduce this problem. Manual weeding at least twice within one month after the weeds begin to emerge is recommended. Chemicals are also used to control weeds in cotton farms.

Harvesting: cotton is ready for harvest when at least half of the plants have their bolls burst open. Cotton requires 6 to 7 months to mature. After harvest (picking), cotton goes through different stages before it is used to make clothes. The first step in cotton processing is drying and ginning of the cotton from the cotton plant. Ginning is the process of separating seeds and plant debris from the cotton fiber. Then the cotton fibers are cleaned for dust and other impurities.

Once the cotton fibers are cleaned, they are transported to textile mills where spinning takes place to twist the raw cotton fibers into a thread. This is followed by weaving the thread into fabric or cloth. There were more than 35 mills producing fabrics (woven and knitted clothes) for the export

and domestic market in Ethiopia in 2021.

Figure 3.2. a) Ginning and b) Spinning of cotton

3.2.2. Sisal (*Agave sisalana L.*)

Sisal is a fiber crop believed to have originated in Central America. It is widely cultivated in the tropics. Sisal is mainly produced for its hard fibers that are used in textile industry for the production of ropes, sacks and carpets. Sisal fibers are also used in paper making and in the textile industry for polishing clothes. Sisal stem is also used for fencing, fire wood and as a house construction material. Sisal fiber is derived from the leaf of the plant. The plant is drought-resistant and can be grown as a rain-fed crop. This means that it can be grown using only rainfall for water and no other irrigation is required. Sisal can grow in a wide range of altitudes from sea level up to 1800 meters above sea level.

Land preparation and planting: sisal is propagated vegetatively. This means that a new plant will grow from the cutting of the parent plant. In sisal reproduction occurs through suckers growing around the plant or bulbils (young produced from buds in the flower stalk). The suckers or bulbils are first grown in a nursery. When they are about 40 cm high, they will be transplanted to the field. Often row planting is used at a spacing of 2.5 m between rows and 80 cm between plants.

Harvesting: it takes 2 to 3 years after transplanting for the first harvest of leaves. After that, leaves can be harvested annually. Leaves are ready for harvest when they reach a height of 1.2 m and width of about 15 cm. After harvest, sisal leaves are scraped manually or using machinery to separate the fibers from the leaf. This process is called decortication. The fiber is then washed and dried. The dried fiber is mechanically brushed to straighten

tangled and wavy fibers. The next step is grading of the fibers according to length and color. Packing for market is the last step in fiber processing.

Figure 3.3. a) Sisal plant and b) Fibers extracted from sisal

3.3. Sugar Crops Production and Management

Sugar crops are crops used as raw materials in the production of sugar. Sugar cane and sugar beet are examples of these crops. In Ethiopia sugar cane is by far the most significant crop used for the production of sugar.

3.3.1. Sugar cane (*Saccharum officinarum L.*)

Sugar cane is a tropical and sub-tropical crop grown mainly for the production of sugar. Sugar cane requires a long warm season to grow well. Cane is the raw material mainly used in sugar production. The juice extracted from sugar cane is processed into sugar for human consumption. Some part of the residue from sugar cane processing is used as animal feed. The dark liquid produced from sugar cane juice is called molasses. Molasses is used in the production of ethanol. The fibrous residue left after the extraction of the juice is called Bagasse. It is used in the production of papers and plastics. It can also be used as firewood. The green top (leaf) of the plant is directly used as animal feed.

The sugar cane crop takes from 14 to 18 months between planting and first harvest. After the first harvest, the plant regenerates from the roots of the first harvest and is ready for harvest in about 12 months. The second harvest is usually called ratoon crop. Ratoon crop harvests are smaller than the first harvest. Ratoon harvests are limited to 2 or 3 times after the first planting. When ratoon harvests are over, new sugar cane plants are planted on the field. The sugar cane plant usually requires fertile soils. If grown on

soils with poor fertility, sugar cane requires a large amount of fertilization to produce reasonable yields**.**

Land preparation and planting: sugar cane is propagated vegetatively using stem cuttings prepared from young plants. The top part of young sugar cane stems is used as planting material. The stem cuttings used as planting material should be free from diseases and pests. The average size of the stem cuttings used for planting are often about 30 cm, with each cutting having at least 2 or 3 buds. Sugar cane is planted in rows with about 1.6 m. average distance between rows. The planting materials are placed end to end in a planting furrow and covered with soil layer of 2 to 5 cm.

Fertilization: The level of fertilizer required depends on the level of soil fertility. Sugar cane requires large amounts of nitrogen fertilizer to grow well. However, excessive Nitrogen fertilizer application can delay the maturity time of the cane.

Weed and insect pest management: for sugar cane, 3 weeks after planting and 14 weeks after planting are critical periods. Weed competition could cause high yield losses in this period. Weeds have to be removed manually or using chemical methods. Various weeds are known to be problems for sugar cane production in Ethiopia. Control methods often involve manual weeding, cultivation and, in some cases, the use of chemicals. Insect pests like sugar cane borers, army worms, locusts and termites are major problems in sugar cane production in Ethiopia. Control measures for insect pests include pre-planting cultivation that could destroy some insects, and use of insecticides. Fungal diseases like smut and bacterial disease like Ratoon Stunting Disease are common. The use of disease-resistant sugar cane varieties, removal of the diseased plants and using chemicals are often recommended remedies.

Harvesting: sugar cane usually matures in about 14 to 18 months from the planting time. The harvest practice includes removal of the leaves and the top of the plant before cutting the stem. Sometimes, controlled fire is used to remove dry leaves before cutting the stem. The stem is then transported to the processing facility.

In 2022, there were 8 state-owned sugar producing factories in Ethiopia. These are Wonji-Shewa, Matahara, Finchawa, Kessem, Tendaho, Arjo, Omo kuraz II and Omo kuraz III. The factories annually produce 400,000 metric tons of sugar. In Ethiopia, in 2023, the demand for sugar is greater than the production of sugar. So, it is necessary to increase production. The aim is to fulfill local demand as well as export sugar.

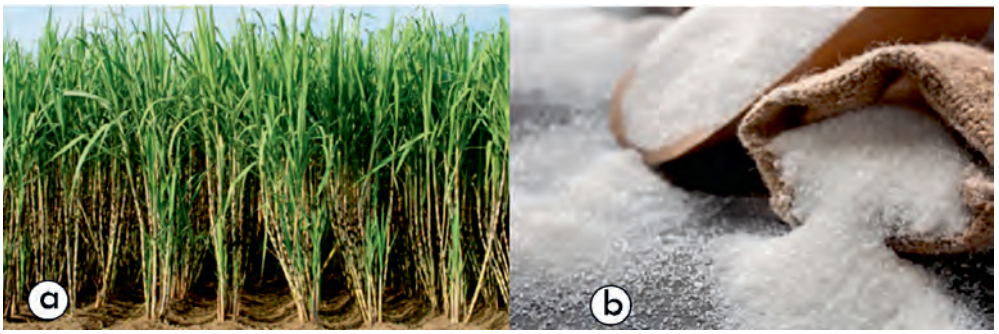


Figure 3.4. a) Sugarcane plants and b) sugar

Activity 3.1.

Group work

Form a group of 3 to 5 students and discuss:

1. Have a look at the clothes and textiles in your home or school.
   - What fabric are they made from?
   - What fiber crop would have been used to produce these fabrics?
   - Do you think these fabrics were produced locally?
2. Look at the food products in your home or school.
   - Which products contain sugar?
   - Do the labels indicate where this sugar was produced?
3. Using the internet or speaking to experts, research ways in which sugar cane and sugar production can be increased in Ethiopia.
   - Write a report recommending three key steps to increase production.

*Share the results of your search with your classmates and submit the report to your teacher.

Unit Summary

In this unit you have learnt that:

- industrial crops are crops produced mainly for use as a raw material in industries like agro industries.
- industrial crops can be classified into oil crops, fiber crops and sugar crops in the Ethiopian context.
- noug and sesame are examples of industrial oil crops. Both are used to produce food oil, paints and soaps. Their residues are used as animal feed. Noug prefers mid-altitude areas whereas sesame is adapted to low land and semi-arid areas.
- the major fiber crops are cotton and sisal. Both are adapted to warm areas with moisture deficits.
- Sugar cane is the major sugar crop used for industrial production of sugar in Ethiopia
- sugar cane is adapted to areas with long warm seasons. It requires 14 to 18 months to mature.

Review Exercise

Part I: Choose the best answer from the given alternatives.

1. Which of the following oil crops is used as a raw material for production of food oil?
   A. Noug C. Maize
   B. Sesame D. Both A and B
2. Which of these crops produces hard fiber used for the production of carpets, sacks and ropes?
   A. Cotton C. Sesame
   B. Sisal D. All
3. How long does a newly planted sugar cane take to mature?.
   A. 8 C. 18
   B. 12 D. 24
4. Which of the following sugar cane processing by-products is used for the production of ethanol?
   A. Bagasse C. Fiber residue
   B. Molasses D. Both A and B
5. What is the name for sugar cane harvested from regeneration of the crop from a previous harvest?Second harvest
   A. Second harvest C. Molasses
   B. Ratoon D. Lint

Part II: Answer the following questions.

1. Explain
   a) the uses of cotton and sisal
   b) their growth and management requirements
2. Describe sugar cane production starting from the planting stage of sugar cane to the final production of sugar.
3. Explain about the major uses of sisal and describe the major production practices.

Unit 4 Introduction to Farm Animals

Contents	Learning Outcomes
4.1. Farm animal species 4.2. Animal production and its importance 4.3. Constraints in animal production and their mitigation strategies 4.4.Animal production systems	At the end of this unit, you will be able to: ▪ define common terms used in farm animal production ▪ explain the origin and domestication of farm animals ▪ explain the importance and values of farm animal production ▪ describe the constraints in animal production and their mitigation strategies ▪ identify the features of different animal production systems

4.1. Farm Animal Species

Brainstorming 4.1.

Pair-work

1. Name some farm animals kept at your or your neighbor's home.
2. List down the purposes farm animals serve at household levels.

Farm animal species are raised for human use either for food or work functions. Domestication is the conversion of wild animals to domestic use. Domesticated animals are animals that have been selectively bred to live alongside humans. Most of the domesticated animals familiar to us today were domesticated not long after people began farming and living in permanent settlements. This was probably between 8000 and 2500 BC.

Do you know the difference between species and breed?

A species is a largest group of animals that is capable of interbreeding and producing fertile offspring. **A breed** is a specific group of animals within a species that are visibly similar in most characteristics, which distinguish it from other breeds of the same species. A species is often composed of several breeds.

4.1.1. Farm Animals in Ethiopia and Their Description

Ethiopia has a huge resource of farm animals. They are composed of the **mammalian**, **avian** and **honeybee** species. Cattle, sheep, goats, camels, donkeys, horses and mules are the major farm animals in the mammalian category. The Avian category includes chicken, ostrich and turkey. Ostrich and turkey are not widely used in Ethiopia. Stinging honeybees are the most important bee species in the country. Nearly all of the livestock population of the country is **local** breed. Some are **hybrid**, and others are **exotic breeds**.

Key terms:

Mammalia any member of the group of vertebrate animals in which the young are nourished with milk from special mammary glands of the mother.

Avian a characteristic of birds or flying creatures.

Local breed is native to a specific territory of origin. The local breeds are well-adapted to the local conditions. E.g., Horro cattle

Exotic breeds are mainly foreign and are primarily used for improving the productivity of local breeds through cross breeding. E.g., Holstein Friesian

Hybrid (also called cross breed) is produced from two genetically different parent lines. E.g., offspring produced from Horro cow x Holstein Friesian bull.

Table 4.1. Estimated livestock population in Ethiopia by species and breed

Species	Total number	Breeds (%)		
		Local	Hybrid	Exotic
Cattle	70,291,776	97.40	2.29	0.31
Sheep	42,914,865	99.52	0.41	0.08
Goat	52,463,535	99.9	0.05	0.05
Camel	8,145,790	-	-	-
Chicken	56,992,987	78.85	12.03	9.11
Beehive	6,986,100	-	-	-

Source: CSA (2021) [2013 E.C.]

Cattle *(Bos indicus/Bos taurus)*

Cattle are hoofed animals belong to the family Bovidae and genus Bos. The genus Bos has several species, two of the most common in Ethiopia are Bos indicus and Bos taurus. Bos indicus are humped cattle. They are commonly found in tropical countries. Bos taurus do not usually have humps and commonly found in temperate zones.

Figure 4.1. Cattle: a) *Bos indicus*, b) *Bos taurus*

Cattle are raised all over the world. There are over 1000 cattle breeds in the world. Cattle breeds serve multiple purposes. They are reared for meat, milk and use as draft animals. Their hides are processed into leather and manure is a by-products of cattle production. Cattle are **ruminant**. Their feeding habit is **herbivore**. Primarily, they feed on **pasture**. In modern farming, pasture is usually supplemented with industrially manufactured feeds.

Key terms:

Ruminants are herbivores such as cattle that have a rumen. In the rumen the plants that the animal has eaten are softened. This softened material is called cud, and is regurgitated for the animal to chew again. This helps the animal to digest the fibrous plants that they eat.

Herbivores are animals such as cattle, sheep and goats that fed on plants.

Pasture is a land with vegetation used for grazing animals.

Sheep *(Ovis aries)*

Sheep (*Ovis aries*) belong to the family Bovidae and genus Ovis. Today, over 200 breeds of sheep are recognized worldwide. Sheep are raised for their meat, wool and skin. Some farmers also keep sheep for milk. Like cattle, sheep are ruminant herbivores. They feed on short fine grasses and coarse brushy weeds.

Figure 4.2. Sheep

Goat *(Capra hircus)*

Goat (*Capra hircus*) is a hollow-horned mammal that belongs to the family Bovidae and genus Capra. There are over 300 distinct breeds of goats. Goats are important domestic animals in tropical livestock production systems. Goats are raised for their milk, meat and skins across much of the world. The Angora breed of goat is raised for its hair, which is used to make fabric or yarn called mohair. Goats are ruminant herbivores. They browse on shoots, twigs and leaves of brush plants. They also eat hay and grain-based complete feeds.

Figure 4.3. Goat

Camel *(Camelus dromedary/Camelus bactrianus)*

Camels are even-toed ungulate animals. They belong to the family *Camelidae* and genus Camelus. There are two types of camels: the Dromedary and the Bactrian. The Dromedary camel (*Camelus dromedary*) has a single hump on its back. The Bactrian camel (*Camelus bactrianus L.*) has two separate humps.

Figure 4.4. Camels: a) *Camelus dromedary*, b) *Camelus bactrianus*

Camels have peculiar characteristics that help them adapt to the drier parts of the world. This is perhaps why they are often called "*ships of the desert*". They are recognized as pack or saddle animals. Camels provide us with milk, meat, wool and hides. Camels are **pseudo-ruminant** animals. This means they do not have a rumen. They are herbivores and eat tree leaves,

branches and thorny bushes. Camels have thick and tough lips. This is why they can easily feed on thorny bushes.

Key term:

Pseudo-ruminants are animals that has only three compartments in the stomach and it lacks a rumen. They possess omasum, abomasum, and reticulum. They do not regurgitate their food and chew the cud. Camel is an examples of pseudo ruminant animal.

Poultry (*Gallus gallus domesticus*)

Chicken/fowl, duck, guinea fowl, turkey and geese are common types of poultry. Chicken is the most common type of poultry in many countries of the world. There are two types of domestic chickens. These are layers and broilers. Layers are raised for egg production. Broilers are kept for meat (usually slaughtered at 6-8 weeks). Chicken are **omnivorous** in feeding habit. Poultry in general are **monogastric** animals. This means that they have single compartment of stomach. They are dependent on less fibrous feeds; mostly grinded grains and mixed rations.

Figure 4.5. Chicken: a) Layer type, b) Broiler type

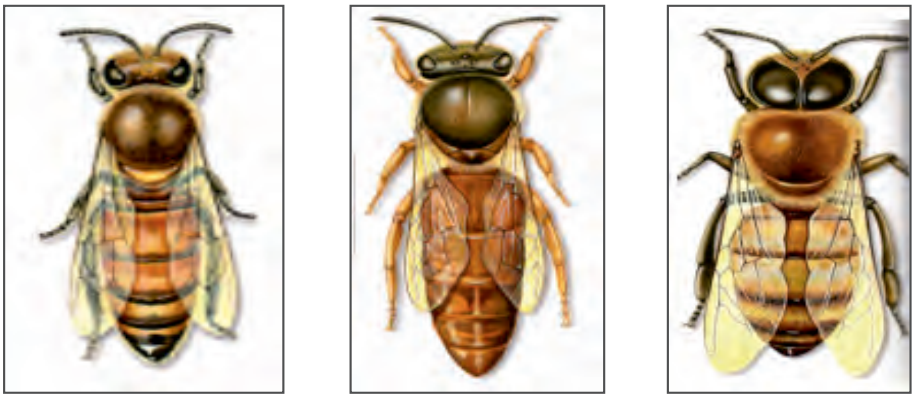
Key terms:

Omnivorous is an animal such as chicken feeding on a variety of food of both plant and animal origin.

Monogastric is an animal having a single stomach. Examples of monogastrics include poultry, pigs and horses. Most monogastrics are generally unable to digest much cellulose food materials such as grasses.

Honey bee *(Apis)*

Honey bees are known for pollination and honey production. A honey bee colony is composed of three types of bees. These are the worker, queen and drone. Each type has its own specific duty to perform in a colony. The workers and the queen are female. Queens are reproductive and are larger than the workers (Figure 4.6). The drones are male, have much larger compound eyes, and do not have stingers. Bees rely on the pollen and nectar of flowers as sources of their food.



Worker Queen Drone

Figure 4.6. Three types of honey bees

Fish

Fish have served as important sources of food worldwide. In fish farming industry, fish are raised in enclosures and used for food. Fish farming is the fastest growing area of animal food production.

Figure 4.7. Fish (Tilapia)

4.1.2. Ruminant and Monogastric Animals

Ruminant animals have a digestive system comprising of a four-chambered stomach. These animals are mainly herbivores, such as cows, sheep, and goats. They generally eat a large amount of roughage or fibre. The digestive system of ruminants is more efficient than that of the monogastric animals in breaking down food and absorbing nutrients.

Digestive system of ruminants begin with the ingestion of feed into their

mouth. The tongue and the teeth gather feed and break it down into smaller pieces in order to make it easier for the animal to digest. Food travels down the esophagus, which is a long tube that carries the feed from the mouth to the stomach.

Ruminant animals have a digestive system comprised of a four-chambered stomach: the rumen, reticulum, omasum and abomasum.

- **Rumen** is the first and the largest compartment of the stomach of a ruminant animals. The rumen is a big fermentation vat that allows ruminants to digest cellulose, which is found in plants. Microorganisms, such as bacteria, are found inside the rumen and digest feed. Ruminants chew their feed numerous times through a process called regurgitation or rumination.

- **Reticulum** is the second compartment of the stomach. The reticulum is a part of the rumen and works to help digest foods. It is also called the honeycomb because it looks like a honeycomb made by bees. It is involved in rumination and the passage of food from the rumen to the omasum. The rumen and the reticulum are connected and work in concert and are therefore sometimes called the "reticulorumen".

- **Omasum** is the third chamber of the ruminant stomach. It is situated between the reticulum and the abomasum. The omasum also helps digest feed and squeezes water from the feed. It is called "many plies" because it has many folds.

- **Abomasum in ruminants** is the fourth compartment of a ruminant's stomach. The abomasum is also called the true stomach. Here digestive juices are produced and help pass the feed into the small intestine and then into the large intestine and finally excreted from the body through the rectum or anus.

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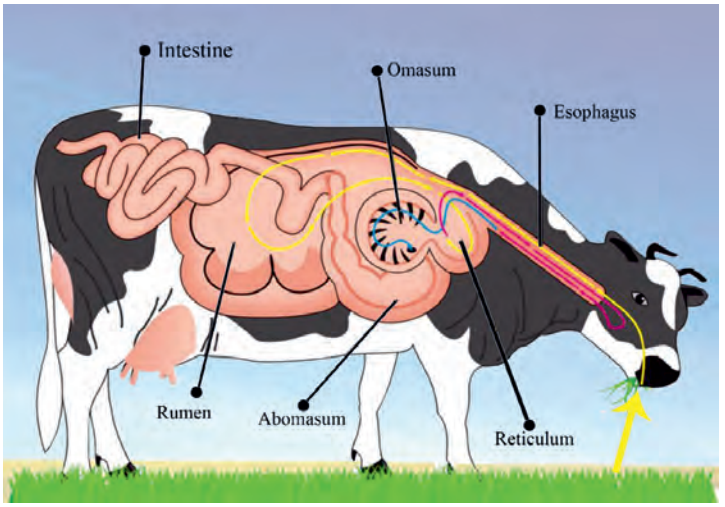

Figure 4.8. Digestive system tract of a cow (ruminant)

Monogastric animals have a single stomach. Monogastric animals generally rely on feedstuffs that are easy to digest. Monogastrics animals have all types of food habit. Horses and poultry are examples of agricultural species that are monogastrics. Some descriptions are presented below.

The Horse Digestive System

The digestive system of horse begins with the ingestion of food into the mouth. The tongue and the teeth gather feed and break it down into smaller pieces in order to make it easier for the animal to digest. Food moves from the mouth into the esophagus and reach to the stomach. The stomach serves as a reservoir for short term storage and digestion where enzymes break down the feed components so that they may enter and be absorbed into the blood stream. Any remaining undigested food travels into the small intestine, where it is broken down further. After the small intestine has removed all available nutrients from the feed, the remaining material is passed into the cecum and finally excreted from the body through the rectum or anus. The cecum of a horse contains many microorganisms needed for digestion of a large amount of plants materials they consume. It is an enlarged structure which allows fermentation and digestion of roughage (Figure- 4.9a). The remaining undigested material is finally excreted from the body through the rectum or anus.

The Poultry Digestive System

In chicken, food is taken in with the beak. A small bit of saliva and digestive enzymes are added as the food moves from the mouth into the esophagus. From the esophagus food moves to the crop, an expandable storage compartment located at the base of the chicken's neck, where it can remain for up to 12 hours. The food trickles from the crop into the bird's stomach where digestive enzymes are added to the mix and physical grinding of the food occurs. The stomach in chickens is subdivided into two parts, the proventriculus (glandular stomach) and the gizzard. The proventriculus is the organ producing acid and enzymes. The gizzard is the muscular stomach and pacemaker of gut motility. They are pivotal for digestion and gut health.

From the gizzard, food passes into the small intestine, where nutrients are absorbed. The residue then passes through the ceca, a blind sack along the lower intestinal tract, where bacteria help break down undigested food. From the ceca, food moves to the large intestine, which absorbs water and dries out indigestible foods. This remaining residue passes through the cloaca where the chicken's urine (the white in chicken droppings) mixes with the waste. Both exit the chicken at the vent, the external opening of the cloaca (Figure- 4.9b).

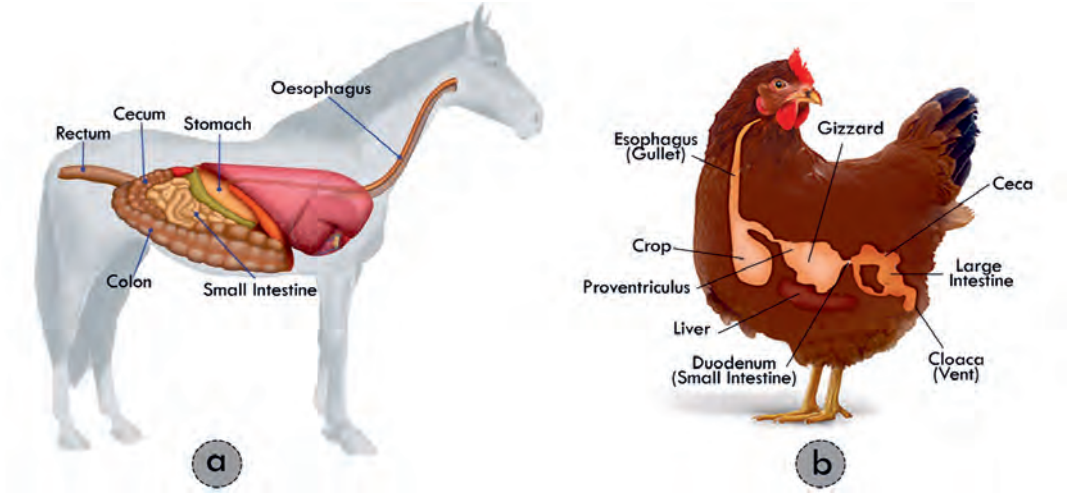

Figure 4.9.Digestive system of mono-gastric animals: a) Horse, b) Chicken

Activity 4.1.

Small group discussion

- Create a table showing the main features (e.g., stomach makeup, feed preference, digestion and absorption efficiency, food habit, rumination, etc.) of the digestive systems of ruminant and monogastric animals. Present your work to the whole class.

4.2. Importance of Animal Production

Brainstorming 4.2.

Work in pairs

1. What products of farm animals do you know in your area?
2. What farm animal products do your community members use on a regular basis?
3. What farm animal products are occasionally used in your home?

Animal production (also called animal husbandry) is the keeping of farm animals for human use. Farm animals have several roles in the farm ecosystem. They are primarily reared for the production of consumable foods. The pulling power of draught horses, donkeys, camels and oxen is the other form of services obtained from farm animals. Some by-products are also used for different purposes such as clothing, feed, fertilizer or medicine. Beyond these functions, farm animals also play important economic, cultural and social roles in the society.

► Food and nutrition supply

One essential purpose of keeping animals is food production and supply. Several animals convert high-fiber feeds into edible food that is consumed by humans. Many food products are derived from farm animals. More than thirty-four percent of global food protein supply comes from farm animals. Animal products are also rich sources of fats, minerals and vitamins. They are essential for a healthy and balanced diet.

Figure 4.10. Foods derived from farm animals

► **Livelihood and economy**

Animal production provides the livelihood for 65% of population in Ethiopia. Farm animals are an important source of income, and a way of capital accumulation and savings. Since 2018, the livestock sector has contributed 45 to 48% of the Agricultural Gross Domestic Product in Ethiopia. The sector also accounts for 16 to 19% of the total export earnings.

► **Work**

The two most important categories of animal work are traction and transport. Some animals can be used to carry out farm operations. Bullocks and camel draw working machinery like ploughs, harrow and ridge. Some animals are involved in crop husbandry (e.g., seeding with drills) and crop processing (e.g., threshing). Camels, donkeys and horses are used to transport people and goods in many parts of the developing world.

► **Clothing**

Animal by-products such as skin, wool and fur are used for the preparation of clothing. They can also be used for foot wear, bags and drum making. Feathers from poultry are used in the production of mattresses and pillows.

Figure 4.11. Leather products

► Raw materials

Skins and wool from goats and sheep are used as raw materials for various traditional household products in the cottage industry. Animal bones and hooves are used for adhesives. Fats are used for candles and soap making. Chemical or liquid extractions from the internal organs of animals can also be used in the pharmaceutical industries to manufacture hormones and other kinds of drugs.

► Livestock feed

Residues from slaughtered farm animals are used in the preparation of feed for mono-gastric animals. For example, bone meal, fish meal, blood meal and meat meal are good sources of protein and amino acids for optimal animal feeding.

► Socio-cultural roles

Livestock ownership, especially ownership of cattle, is an index of social wealth. A person's wealth, in a traditional society, is usually assessed by the herd size owned by the individual. Moreover, livestock are kept for various socio-economic reasons. Savings and investment, security and insurance, stability, and social functions are examples of socio-economic reasons for keeping livestock. One social function of keeping livestock is for the fulfilment of a set of rituals and social obligations. Funerals, ritual slaughter and bride wealth of families and communities are examples of social functions that can be fulfilled by slaughtering animals.

Activity 4.2.

Work independently (Class work)

Farm animals have a wide range of importance to a community. State some of their importance and values. Show your answers to your teacher.

4.3. Constraints in Animal Production and Their Mitigation Strategies

Ethiopia has huge potential for animal production. However, some constraints have held back animal productivity.

► Feed shortage

Inadequate feed supply, both in quantity and quality, is the major constraint affecting animal production in Ethiopia. The main feed resources are natural pastures and crop residues. These supply more than 90% of the annual feed. They have, however, poor feeding value in terms of crude protein (3 to 6%), energy value, minerals and digestibility.

There is also a high seasonal variation. Feed resources are exhausted quickly in the dry season. Animals are maintained with less feed than their usual requirement. This affects their productivity and reproductive potential. The use of agro-industrial by-products (e.g., wheat bran, oil seed cakes and molasses) as feed is very limited. This is because of unavailability, expensiveness and lack of awareness of their importance as animal feed.

Feed shortage in quantity can be mitigated through expanding commercial feed production (improved grasses, legumes and formulated feeds). The use of young and succulent grass (at 30% flowering stage), mixing mature grass with legumes, chopping matured grass and mixing it with molasses, etc. are some strategies in feed quality enhancement.

► Genetic factors

The animal production system in Ethiopia can be characterized as a traditional management system. This system uses local breeds. The local breeds are well-adapted to the local conditions. They are resistant to many tropical diseases. They can survive and are produce on low quality feed resources. Indigenous animals are also known for their quality product in terms of yolk color, milk fat and meat taste. However, indigenous animals are usually considered poor in their productivity. Proper feeding, selecting those with good production, crossing with exotic breeds, etc. are recommended for successful genetic improvement.

► Animal diseases and parasites

Disease is one major constraint in animal production. There are a lot of animal diseases in all agro-ecologies. Examples of such diseases are Anthrax, Blackleg, Contagious bovine pleuropneumonia and Newcastle

diseases. These diseases affect the efficiency of animal productivity. Diseases also hamper export market development. Internal and external parasites are additional burdens of the sector. Proper feeding, vaccination and isolation of sick animals can be used as prevention mechanisms. Equally effective methods of preventing disease are treating sick animals, proper cleaning and management of the animals and their housing.

► Traditional production system

Many farmers in Ethiopia use a traditional production system and have no knowledge of modern animal production. Draft animals are the major focus in mixed farming (i.e., farming both animals and crops on the same farm). Similarly, milk is the main focus in pastoral farming (keeping or grazing of animals). This means meat production is considered as by-product. Pastoral farmers consider their livestock as a means of capital accumulation. Livestock are sold if the need arises or when a shortage of feed and water occurs. This is due to the absence of entrepreneurial awareness. Recurrent capacity building, demonstrating the modern way of farming, availing credit facility and strong extension system are possible means of enhancing knowledge of modern animal production.

► Socio-economic constraints

Socio-economic constraints are a lack of services and facilities that are vital for livestock development. Weak extension services, shortage of appropriate technologies and poor infrastructure are some examples of such constraints.

There is a huge scarcity in electric power supply. Electricity is used to preserve perishable items such as meat, milk, drugs and vaccines. The scarcity in transport facilities hampers the flow of livestock and their products. A lack of credit and saving services is another challenge.

Farmers have little or no access to training on modern animal rearing practices. There is also inadequate flow of market information. Examples of social constraint is that it is a taboo to eat goats' meat in some areas. Similarly, fish is not eaten in some parts of the country. Products of cross breed animals like egg, meat, milk, etc. are also not preferred for food in certain areas in the society.

Activity 4.3.

Discuss in small groups.

What factors affect animal production in your area? Can you suggest some possible solutions? Report the result of your group discussion to the whole class.

4.4. Animal Production Systems

Brainstorming 4.3.

Work in pairs

List the characteristics of animal production system/s practiced in your community. Consider the type of feed provided, breeds kept, number of animals kept, land size, etc. Is the system traditional or modern? Share your work with the rest of the class.

There are different types of livestock farming systems that are differentiated by the production processes that take place in each of them. They are generally classified as extensive, semi-intensive and intensive systems. Figure 4.12 shows such classifications in a more visual format.

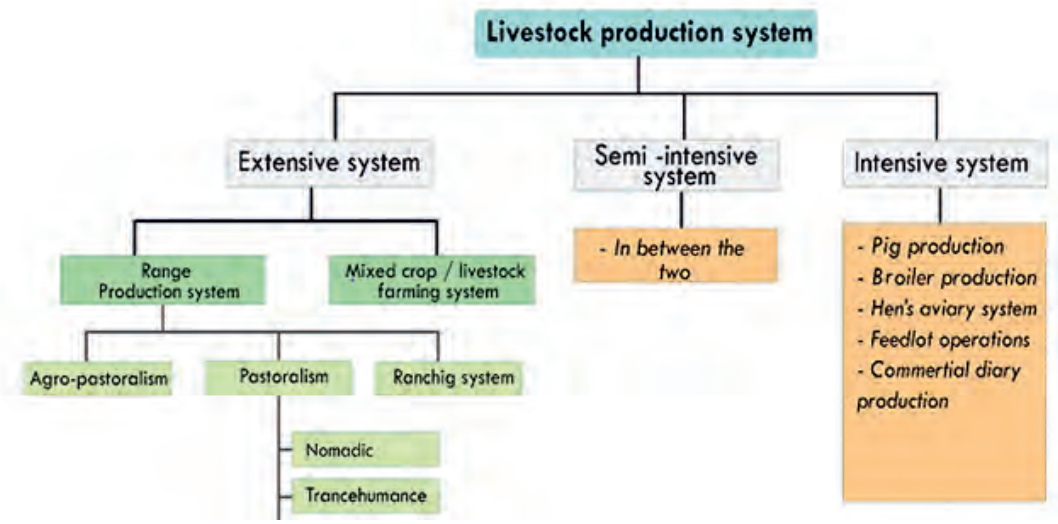

Figure 4.12. Schematic classification of livestock production systems

4.4.1. Extensive Production System

Extensive farming system is an animal production system that uses small inputs of labour, fertilizers and capital relative to the land area being used.

In livestock, extensive farming commonly refers to cattle, sheep and goat farming in areas with low agricultural productivity. Livestock types are the locally known ones. The feed depends on the condition of the climate. There is a severe shortage of pasture and fodder during the dry season. Compared to intensive farming, productivity in extensive farming tends to be much lower, growth rate slower, and time to maturity much longer. However, the system requires less labour per unit area. There are different forms of extensive production system (See Figure 4.12.).

- **Pastoralism** is an extreme example of extensive farming where herders move their animals to get pastures from occasional rainfall. Pastoralism allows communities to feed themselves in areas that do not support other forms of agriculture. Pastoralism is a livelihood system and a way of life for millions of citizens in Ethiopia. Feed and water shortage, poor market outlet, disease and number oriented livestock production are the major problems in the pastoral production system. Pastoralists are of two types.
  - **Nomads** have no permanent home, but move from place to place with their herd and flocks in search of water and feed for their animals. Movement is usually without much long-term planning. This is mainly found in arid and semi-arid areas. The production system is largely based on increasing animal number.
  - **Transhumance** have a permanent home to which they return each year, but some take the flocks and herds away from their permanent settlement for some part of the year. It is characterised by the seasonal and recurring movement of livestock across regions. Seasonal grazing areas and routes for livestock movement are fixed. The aim of this system is to make use of often distant pasture during rainy season and what remain after harvest around farm houses.
- **Agro-pastoral system** is a system in which livestock are important components of the farming system. Crops are produced both for subsistence and market. Livestock are kept for draft, sale and generation of other primary products (milk, meat and eggs).
- **Ranching** is the practice of raising large number of animals on a

fenced land or has fixed boundaries. Ranching is another form of extensive system. There is relatively little labor input compared to the land and number of animals being farmed. Ranching is modern alternative to pastoralism. Ranchers commonly raise grazing animals such as cattle and sheep. They are raised for meat, dairy or wool. Function of livestock and products is to provide cash income and for making profit.

- **Mixed farming** is a system whereby both crops and livestock are raised on the same farm. In a mixed farming system, the farmer may keep cow for milk, goats and sheep for meat and wool, and grow food crops and hay to feed animals. Equines (horse, mule and donkey) are used for transport. While manure from the animal dungs serve as source of manure to improve the soil fertility. Natural pasture and crop residues (e.g., teff, barley and wheat straws) are the major feed resources. Mixed farming system is subsistence-oriented, which means that livestock/crop are produced for family consumption rather than for market.

4.4.2. Semi-intensive System

Semi-intensive system is a type of animal production system that lies between the extensive and intensive systems. The system is characterized by high input and high output relative to extensive production system. This systems is usually located around the periphery of large towns. They are commonly practiced by small scale producers. In a semi-intensive system, animals are reared for family consumption but the surplus can be sold for income generation. This system can easily be intensified.

4.4.3. Intensive System

Production systems in the intensive system are characterized by high inputs with high output. This is a modern farming system where livestock are raised at high stocking density with a relatively high inputs and operations. The production systems are market-oriented, which means that livestock is raised to be sold. The system often located near highly populated urban centers. The environment for the animals can be modified to suit all specialized breeds and production systems. The type of animals can be crossbred or exotic.

Feed type is grown forage which can be used in **cut and carry** system. Feeding industrial by-products and **balanced ration** is another common practice in intensive farming system. In intensive system, the animals feed is usually supplemented with proteins, minerals and vitamins. Examples of intensive farming are pig production, broiler production, feedlot operations, and commercial dairy production. Meat, milk and eggs are the main products of the farms.

Key terms:

Cut and carry system (also called zero grazing) is a feeding system where fresh grass is cut daily and fed to housed animals throughout the grazing season.

A balanced ration is the amount of feed that will supply the proper amount and proportions of nutrients needed for an animal to perform a specific purpose such as growth, maintenance, lactation or gestation.

Feedlot is a plot of land where livestock are kept in order to feed them intensively with the purpose of fattening for slaughter. Cattle, sheep, goats and camels are usually fattened for a period of 3 to 4 months for market.

Table 4.2. A comparison of intensive and extensive farming systems

Parameter	Intensive farming	Extensive farming
Input level	High labour and capital use	Low labor and capital input
Animal density	High animal population density compared to land size	Low animal population density to area/land available
Type of animals	Exotic or crossbred animals	Largely indigenous animals
Output level	Large output per land size	Small output per land size
Proximity to market	Generally closer to the market area	Largely distant from market area

Unit Summary

In this unit you have learnt that:

- cattle, sheep, goats, camels and chicken are some common farm animals in Ethiopia
- ruminant animal a digestive system comprised of a four-chambered stomach (rumen, reticulum, omasum and abomasum)
- pseudo-ruminants have a digestive system comprised of a three-chambered stomach (omasum, abomasum and reticulum) but lacks a rumen
- monogastric animals have a single compartment of stomach
- farm animals are reared for food or assist in farm work services as well as for economic and socio-cultural functions
- feed shortages, genetic factors, diseases and parasites, farmer's poor knowledge, lack of favorable infrastructure and water shortages are examples of the constraints facing animal production in Ethiopia
- animal production systems can be classified into extensive, semi-intensive and intensive systems
    - the extensive system is a traditional and subsistence system
    - the intensive system is modern and market-oriented
    - the semi-intensive system is somewhere in between the two

Review Exercise

Part I: Choose the best answer from the given alternatives.

1. Which of the following is not the component of a monogastric digestive system?
   A. Mouth
   B. Esophagus
   C. Large intestine
   D. Rumen
2. Among the following, which one is omnivorous animal?
   A. Chicken
   B. Cattle
   C. Sheep
   D. Horse
3. Which one of the following is not a socio-economic constraint of animal production?
   A. Poor infrastructure
   B. Diseases problems
   C. Weak extension service
   D. Shortage of appropriate technologies
4. Which one of the following is a feature of intensive livestock production system?
   A. Intensive system uses a large area of land.
   B. Animals are mostly local breeds in intensive system.
   C. Intensive system is market-oriented.
   D. Productivity per animal is low in intensive system.
5. Among the following forms of extensive production systems, which one involves relatively a better livestock management?
   A. Nomadism
   B. Agro-pastoralism
   C. Ranching
   D. Transhumance

Part II: Answer the following questions.

1. What are the functions of farm animals for the farming community and the country at large?
2. List the main constraints of animal production in Ethiopia.
3. Write a description of each of the following types of digestive systems: ruminant, pseudo-ruminant and monogastric. Give example of a farm animal for each type.

Unit 5 Animal Feeds and Feeding Practices

Contents	Learning Outcomes
5.1. Feed resources in Ethiopia 5.2. Classification of feed resources 5.3. Nutrient requirements of animals 5.4. Feed formulation practices 5.5. Feed conservation and compound feed manufacturing	At the end of this unit, you will be able to: ▪ identify types of animal feeds and available resources in their localities ▪ categorize the different feed resources into roughages and concentrates ▪ explain the nutrient requirements of farm animals ▪ describe functions and sources of basic nutrients ▪ analyze factors to be considered in feed formulation ▪ formulate a ration using the Pearson's square method of formulation ▪ demonstrate feed conservation in terms of hay and silage ▪ state the main stages of compound feed manufacturing

5.1. Feed Resources in Ethiopia

Brainstorming 5.1.

Discuss in pair-group

- What do you think the importance of feed in animal production is?
- What are the consequences of overfeeding animals and inadequate nutrition?
- List down the feed resources available in our country or your locality.

Animal nutrition is the science of feed preparation and feeding. Feed is the most important factor that determines animal performance and profitability in many cases. The largest operating cost in a livestock production enterprise is the feed cost. It varies from 50% to 80% depending on the operating area in animal production. Farmers must supply the right amount of feed to the animals. Overfeeding is wasteful and costly. Underfeeding will decrease animal performance and profitability. The feasibility of livestock enterprises always depends on proper animal feeding and nutrition.

Livestock feed resources available in Ethiopia are natural pastures, crop residues, improved forages and agro-industrial by-products. These are described below.

5.1.1. Natural Pasture

Natural pastures are naturally occurring grasses, shrubs and tree forages (edible portions of plants). In natural pasture, forages grow naturally on their own and are feed upon by farm animals. Natural pastures usually provide more than 60% of livestock feed. Grazing is the least expensive way to deliver feed to animals. Natural pasture is of good quality in the wet season and so animals have plenty to feed in order to maintain their productivity. Pasture usually diminishes in dry seasons.

Figure 5.1. Natural pasture

Some common management practices in pasture to ensure continuous supply of grasses and legumes to livestock include grazing land management, fertilizer application, oversowing legumes, etc. Application of fertilizers (e.g., urea and DAP) in the pasture ensures rapid and succulent growth of pasture because of increase in the fertility of the soil. Weeds, pests and diseases should be prevented to ensure rapid growth of pasture crops. The correct number of animals should be placed on a pasture to graze. Overgrazing does not ensure increased productivity of pasture.

5.1.2. Crop Residues

Crop residues are the remaining portion of the crops after harvesting the main crop for human consumption. Several forms of crop residues provide the majority (greater volume) of livestock feed. These include straws, stovers, cobs, hulls, chaffs, etc. Crop residues are generally low in crude protein, energy and micronutrients (vitamins and minerals). They are fibrous and of low palatability and digestibility. Supplementing them with improved forages (forage legumes and browse species), grains and other concentrates is often recommended to maximize animal productivity. Their quality can also be improved by physically (e.g., chopping) or chemical methods such as treating with ordinary urea fertilizer. Crop residues generally are not suitable for pig and poultry feeding.

Figure 5.2. Examples of crop residues: a) wheat stubble, b) millet straw, c) maize stover, d) barley straw, e) teff straw

5.1.3. Forage Crops

Forage crops are plants cultivated for their edible vegetative portions and used in fresh or preserved forms of feeding livestock. There are two basic types of forage crops. These are grasses and legumes. Grasses serve as the best and cheapest bulk feed for ruminants. Grasses produce more yield per unit area than legumes. Grasses are higher in fiber than legumes. Rhodes grass, Sudan grass and Elephant grass are some examples of grasses used as animal feed. Legumes contain protein, vitamins and minerals than grasses. Legumes are usually used as a cheap source of supplement when feeding crop residues and natural pastures, for improved productivity of animals. Examples of legumes used for feed are Alfalfa, Vetch and Sesbania sesban. The nutritive value and digestibility of forage crops generally declines as they mature. Cultivated forage crops can be cut and fed fresh or they can be conserved for the dry season. Farmers should be encouraged to produce improved forages in order to increase animal productivity.

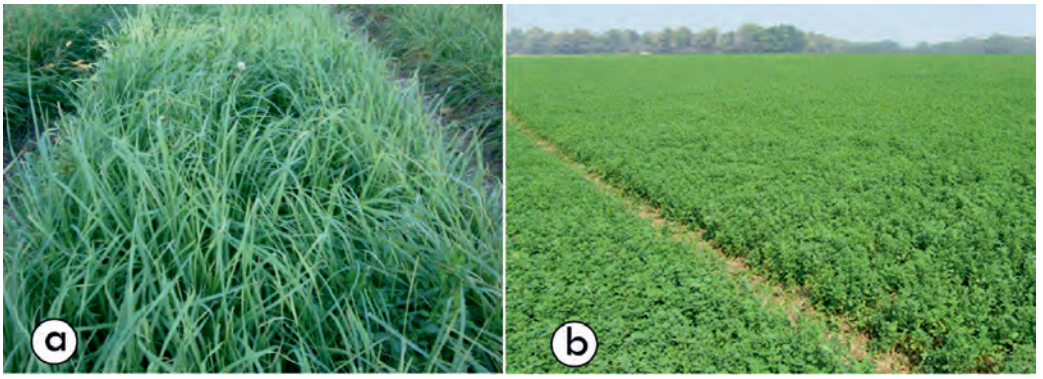

Figure 5.3. Forage crops a) Grass, b) Legume

Forage production can be an attractive business

Several new reforms have been implemented to encourage new business ideas in Ethiopia. Also, a lot of emphasis is being placed on animal farming. Forage production is a profitable business idea because feed shortage is a major challenge for animal farming in Ethiopia. This business has a good market demand throughout the year as well as growth potential. Hence forage production in a large plot can be profitable. However, proper planning and dedication are a must to build a successful venture. Several forage species can be cultivated. Farmers can choose any one or several of them. In this case, farmers must have a basic knowledge of agronomic practices along with the marketing network for selling. Grass-legume mixtures produce the best in terms of the yield and nutritional quality, and therefore the highest profit margins. Farmers can sell green forage, good quality hay as well as planting materials (seed, cutting, splits and seedlings) from their pasture land and improve their income. This venture is unusual in Ethiopia. A group of youth and women can join the venture with some support from the government, including land and regulated short-term loans.

5.1.4. Agro-industrial By-products

These feed resources are by-products obtained from various agro-industries. They usually supplement crop residues such as straw. The commonly used agro-industrial by-products are flour milling by-products, oil seed cakes, molasses and brewery by-products. They are rich either in energy or protein, compared to pastures and crop residues.

- **Flour milling by-products**: are generally very palatable and are readily consumed by all classes of farm animals. Wheat **bran**, wheat middling and rice bran are some examples of milling by-products used as animal feed. Brans are pleasant-tasting feed to animals. They are also **laxative** animal feed. They can be used to supplement low quality feeds such as crop residues. Brans are especially good sources of thiamine and niacin vitamins. They supply fair amounts of protein and energy. **Cereal middlings** and **rice polish** are lower in fiber and higher in energy than brans.

Key terms:

Bran is consists of the outer layers (cuticle, pericarp and seed coat) combined with small amounts of starchy endosperm of the kernel. It is one of the major agro-industrial by-products used in animal feeding. Examples are wheat bran, maize bran and rice bran.

Cereal middling are the product of the flour milling process that is not flour. Examples are wheat middling and maize middling.

Rice polish is a by-product of rice obtained in the milling operation of brushing the grain to polish the kernel.

Laxative is a feed which ferment quickly in the stomach and therefore stimulates elimination of the bowels (wastes).

- **Oilseed cakes or meals:** Oilseed cakes are the residues obtained after the extraction of oil from oilseeds. The oilseed cakes have high protein, carbohydrate, mineral and nitrogen contents. Soybean meal, noug seed cake, cotton seed cake, peanut cake and ground nut cake are examples of oil by-products used as animal feed.
- **Molasses:** is a by-product of sugar industry. Molasses is a good source of energy (54% TDN). It is low in protein (3%) and minerals. It is an appetizer and dust settler. This means that animals like the taste and it stops dry food from becoming dusty.
- **Brewery by-products:** The main by-products of breweries are spent grain and spent yeast. Brewer's spent grain contain good protein, fiber, and energy that can be used as animal feed. They are higher in fiber, protein, and minerals than are the initial grains. Brewer's spent yeast is also a cheap source of protein, minerals and vitamin B-complexes.

Figure 5.4. Agro-industrial by-products: a) oilseed cake, b) molasses, c) brewer's grain

Activity 5.1.

Answer these questions in small group.

1. List the feed resources available in your area.
2. Write the characteristics of grasses and legumes.
3. In your vicinity, find out more about the support available or groups that have built forage production venture. Assess their experience; the opportunities exist, as well as the challenges thy face.

*Share your work with the whole class.

5.2. Classification of Feed Resources

Brainstorming 5.2.

Classifying feed resources into roughages and concentrates

1. Have you ever heard about roughage feeds and concentrate feeds?
2. Can you classify the feed resources available in your area into roughages and concentrates? Which ones are roughages and which ones are concentrates? Discuss in small groups.

The feeds used in livestock feeding are broadly classified as roughages and concentrates. Figure 5.5. shows how various feeds are classified.

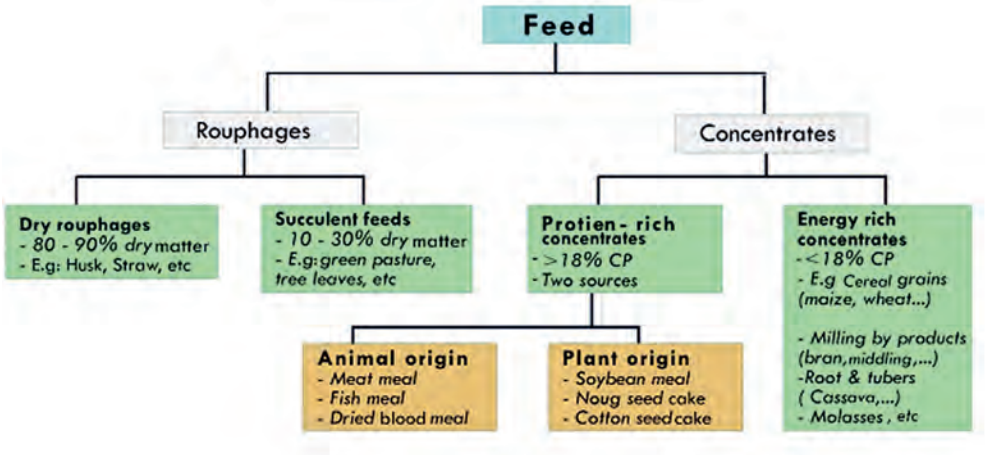

Figure 5.5. Classification of feed resources

5.2.1. Roughages

Roughages are bulky feeds. They are high in fibrous carbohydrates. The digestible energy content of roughages is low. The digestibility of their

nutrients is also low. Roughages are feed stuff which contain more than 18% crude fiber and less than 60% Total Digestible Nutrients (TDN). TDN is the sum of the digestible fiber, protein, lipid (fat), and carbohydrate components of an animal feedstuff. The high crude fiber content makes roughages less digestible than concentrates. Roughages are natural feed for herbivore animals. They constitute over 50% of the feedstuff fed to livestock.

There are two main forms of roughages: dry roughage and green or succulent roughage.

- Dry roughages include hay, straw, stover, husks and sugarcane bagasse. They contain about 80 to 90% of dry matter.
- Green, growing pastures provide roughage that has high water content and low dry matter (10 to 30%). This is called green or succulent roughage. Silage is produced from green roughage.

5.2.2. Concentrates

Concentrates are rich source of nutrients. They have a higher nutritive value than roughages. Concentrates have a high energy content. Their protein content varies from 2% to 80%. Concentrates contain less than 18% crude fibre and more than 60% TDN. They are highly digestible.

Concentrates are classified into energy-rich and protein-rich concentrates.

- **Energy-rich concentrates:** Energy-rich concentrates are an excellent source of energy. They are high in carbohydrate, medium in protein (<18% crude protein, CP) and low in fat content. These concentrates have low fiber and moisture content. All cereal grains, roots and tubers are examples of energy-rich concentrates. Agro-industrial by-products such as bran, middlings, and molasses are also types of energy-rich concentrates.

- **Protein-rich concentrates:** Protein-rich concentrates contain more than 18% CP. They can be derived from either plant or animal origins. Oil seed cakes and meals are the most common plant protein concentrates. Soybean meal and cottonseed cake are examples of protein-rich

concentrates. There are also animal source protein concentrates. Meat meal, dried blood meal and fish meal are examples of animal source protein concentrates.

Activity 5.2.

In small groups, group the following feeds into roughages and concentrates.

Draw a table that has two columns: for roughages and concentrates. Place the following feed ingredients in the correct columns: Maize grain, soybean meal, distillers' grains, bakery meal, maize gluten feed, hairy coat haulm, cottonseed cake, wheat middlings, hay, natural pasture, sorghum, cassava, silage, alfalfa, soybean hulls, maize stover, rice bran, fish meal, edible insects, wheat bran, molasses, mango kernel, maize bran, and teff straw.

5.3. Nutrient Requirements of Farm Animals

Brainstorming 5.3.

What did you learn about the following in your biology classes?

- Nutrients (Carbohydrates, fats, proteins, minerals, vitamins and water)
- Nutrient requirements

Feed consumed by animals gets digested and nutrients absorbed. The energy generated helps the animals to perform their activities well. Nutrients are elements, compounds or groups of compounds that are required and/or used for animal nourishment and performance. Carbohydrates, fats, proteins, minerals, vitamins and water are the basic animal nutrients. Nutrient requirement refers to the minimum amount of nutrients necessary to meet an animal's needs for maintenance (neither gain nor loss), growth, reproduction, lactation (milk production), work and good health.

Water constitutes more than one-half of the animals' body. It is vital for all processes such as digestion, blood circulation and waste elimination. Water is the medium in which all the nutrients are dissolved. It regulates body temperature. Fresh and clean water is important to animals. Farm animals need access to an adequate supply of fresh drinking water.

Carbohydrates are energy-rich organic compounds. They are the main source of energy in animal feed. The main source of carbohydrates in livestock feed are grains. These include wheat, maize and sorghum. Crop residues, molasses, forages and hay are also important sources of carbohydrates.

Fats in small amounts are important in the animal diet. Fats act as storehouses of energy. They also insulate the body. Normal roughages such as grazing pasture contain very little fat. Oilseeds cakes such as soybean meal or cottonseed cake are the main source of fats in livestock feeds. Feed concentrates such as oilseed cakes contain up to 10% fats and oils. The energy needed for growth and activity is basically derived from carbohydrates and fats, though proteins also supply some energy to the body.

Proteins are polymers that are formed through the combination of amino acid molecules. Protein is essential for animals' healthy growth, maintenance and reproduction. Amino acids are the building blocks of protein. They are essential for the formation of animal tissues. Protein can be of plant or animal origin. Plant proteins in livestock feed can come from oil seed cakes/meals, pulse and legumes. Fish meal, meat scraps, etc. are sources of animal protein for livestock. There is no storage of protein in the body. This makes it necessary to provide animals with the amount of protein needed each day. Excess protein is deaminated and converted into fat and is stored in the body as a source of energy.

Minerals are inorganic elements required in small amounts but are important components of the animal feed. They ensure normal and proper functions of the body. They help in the maintenance of good health, bones, teeth and tissues. They also regulate the body's chemical processes.

Minerals are subdivided into macro- and micro-elements based on the quantity required by the animal's metabolism. Macro minerals are required in larger amounts by the body. Examples are calcium (Ca), phosphorus (P), magnesium (Mg), potassium (K) and sodium (Na). Micro or trace minerals are required in small amounts. Copper (Cu), iodine (I), iron (Fe), manganese (Mn) and zink (Zn) are some examples of micro-minerals.

Although mineral intake accounts for a smaller proportion of the diet, any deficiency can lead to major metabolic disorders and their excess intake causes toxicity.

Vitamins are organic compounds required in small amounts. They contribute to functions like metabolism, growth and reproduction. Red blood cell maturation, digestion, bone and teeth formation also require vitamins. The body combats stress and prevents infection when a proper supply of vitamins is ensured. Vitamins can either be fat-soluble (vitamin A, D, E and K) or water-soluble (vitamin B and C). Water-soluble vitamins cannot be stored in the body and must be taken in daily. Table 5.1. summarizes the basic animal nutrients and their corresponding sources and deficiencies.

Table 5.1. The possible sources and signs of deficiencies of basic feed nutrients

Nutrients	Source	Signs of deficiency
Carbohydrates	Crop residues, straw, hay; Cereals (cracked maize, cooked wheat, teff, barley, sorghum, millet, bean, grass pea), milling by-products (cereal bran, flour, middling, short), sweet potato vine, sugar cane tops, molasses, *atela*, etc.	Reduced feed intake, low weight gain, prolonged fattening, drop in milk yield, etc.
Fats	Oil seed cakes/meals such as soybean meal; tallow, fish meal and oil, etc.	Poor skin and hair coat, inability to maintain a successful pregnancy, and potentially inadequate absorption of fat-soluble vitamins.
Protein	Leguminous plants (e.g., Sesbania sesban, Lucerne), oilseed cakes (noug seed cakes, cottonseed cake, linseed cake, soybean meal), poultry litter and urea.	Low weight gain, stunted growth, poor product quality, etc.

Nutrients	Source	Signs of deficiency
Vitamins	Vegetables, green fodders (alfalfa, grasses, green wheat, green sorghum, green maize), vitamin preparations, etc.	Rough and loose hair coat, coughing, nasal discharge, watery eyes, diarrhea, staggering gait, scaly skin, pneumonia, etc.
Minerals	Agro-industrial residues, bone meal, limestone, common salt, bole salt, mineral lick, etc.	Reduced fodder intake, low weight gain, chewing and suckling of wood and metal; stiff joints, weakened bones and teeth, impaired energy utilization, drop in milk production, etc.
Water	Water bodies, succulent feeds	Reduced feed intake, low weight gain and milk yield

Activity 5.3.

Library/Internet Search

Work with your partner on feed nutrients and their functions. Use your school library or Internet search and complete the boxes in the Table below.

Nutrient	Function	Sources
Carbohydrates		
Fats		
Protein		
Minerals		
Vitamins		
Water		

5.4. Feed Formulation Practices

Feed formulation is the process of quantifying the amounts of feed ingredients to be combined to form a single uniform mixture for a particular animal. The formulated feed should meet animals' nutrient requirements. Formulating a ration requires having information about the

cost and availability of ingredients, nutrient content of feed, and nutrient requirements of animals.

Key terms:
Ration the amount of feed given to an animal to meet its needs during a twenty-four hour period.
Balanced ration has all the nutrients the animal needs in the right proportion and amount**.**

5.4.1. Types of Rations

Generally, there are two types of rations: maintenance and the production rations.

Maintenance ration: The minimum quantity of feed required to maintain an animal is called a maintenance ration. Maintenance ration depends on the body mass and type of animal. When an animal receives maintenance ration, the body mass will remain constant. Roughly, half of the feed an animal takes is required for maintenance.

Production ration: In addition to the feed required for maintenance, certain nutrients are required for the production of products like milk, eggs and meat. The feed that is beyond the maintenance ration is used for production purposes. This additional feed is known as the production ration.

5.4.2. Characteristics of a Good Ration

Ration should

- satisfy the total dry matter requirement of an animal based on weight
- provide highly digestible nutrients, including enough minerals and vitamins
- be palatable to the target animal
- be fairly bulky, to satisfy hunger and expel undigested material
- be digestible - this can be improved by grinding, crushing, etc.
- be fresh and free from undesirable weeds and dust

5.4.3. Method of Balancing Ration

Farm animals must be fed a balanced diet in order for the animal to produce what the farmer requires (e.g., egg, meat and milk). Using the

basic information on preparation of a good ration, there are many ways to ensure a balanced diet. These include the Trial and Error method, the Pearson Square method, substitution formulation and computer-assisted formulation. The Pearson Square Method is the most well-known method of balancing animal diets.

The Pearson Square Method

The Pearson Square method is a common method of balancing a ration for all classes and types of livestock. The method is used to calculate the portion of two feeds needed to meet either the protein or energy requirements of an animal. To make this tool work, one of the feeds used must be higher in Metabolisable energy (ME) or CP than the desired level and the other feed must be below the desired level.

The following steps show how to calculate for CP using the Pearson Square method.

Step 1: Draw a square. Insert the % of CP desired in the final ration in the middle of the square.

Step 2: Place the name of the first feed and its % of CP in the upper left corner. Place the name of the second feed and its % of CP in the lower left corner.

Step 3: Subtract the desired % of CP (middle of the square) from the feed CP % (on the left of the square) across the diagonal and add the results to the right side of the square.

- top left – middle = bottom right
- bottom left – middle = top right

Note: disregard the negative or positive value of the numbers.

Step 4: Calculate the weight of each feed by adding the two figures on the right and then dividing each number on the right by this total and multiplying by the weight of feed required. The results of the calculation show the amount of each of the two feeds that should be combined to produce a balanced ration. Repeat for ME as required.

Example 1: A farmer has home-grown maize (CP = 9.5%) and purchases Soybean meal (SBM) as a protein supplement (CP = 42%). The desired CP for the feed is 16%. The farmer uses the Pearson Square method.

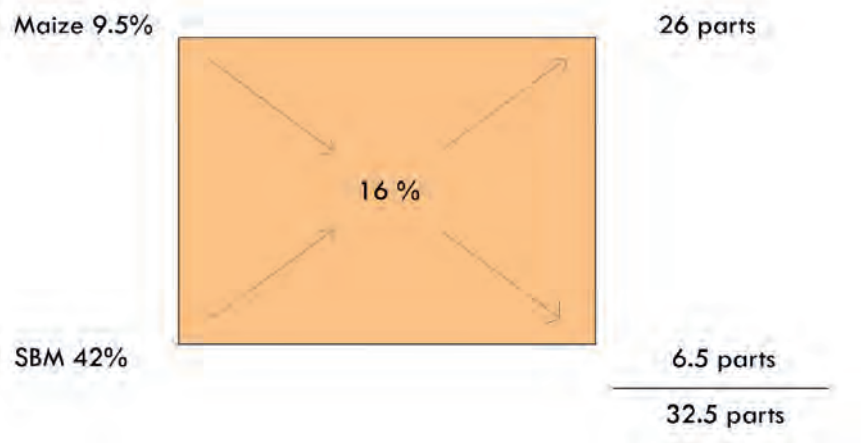

Figure 5.6. The Pearson Square Method

If the farmer aims at preparing 100 kg of the ration in the above proportion, how many kgs of maize and Soybean meal should be mixed?

- Maize: (26 ÷ 32.5) x 100 = **80.0 kg**
- SBM: (6.5 ÷ 32.5) x 100 = **20.0 kg**

Therefore, to formulate 100 kg of feed with 16% CP, the farmer should make up the feed using 80 kg maize and 20 kg soybean meal.

Excersise 5.1. Calculate a balanced ration for broilers using the Pearson Square method

Selam is a poultry farmer around Hawassa. She has maize grain and soybean meal to prepare a balanced ration for her broiler chickens. The maize has a CP of 10.5% and the soybean meal has a CP of 37.4%. Broilers need 23% CP for their starter phase of two weeks. How much of each feed should Selam use to prepare 2000 kgs of ration?

5.5. Feed Conservation and Compound Feed Manufacturing

5.5.1. Feed Conservation

Brainstorming 5.4.

Discuss in small groups.

Do you think feed supply is uniform throughout the year? If not, why? What do you think is feed conservation? Can you guess what feed conservation is?

Livestock must be fed all year round. Green or succulent feed is only available at certain times of the year. Forage production decreases during dry periods. Forage can be conserved to feed livestock during periods

of shortage. Conservation enhances animal productivity by overcoming seasonal nutritional deficits. The common methods of forage conservation are hay and silage making.

5.5.1.1. Hay making

Hay is forage harvested during the growing period and preserved by drying. The aim of hay making is to reduce the moisture contents of green crops from 70 - 90% to 15 - 20%. This process of reducing moisture is called curing. Curing is normally accomplished with energy provided by the sun and wind. It is a method to preserve grasses, legumes and fodders for feeding at a later stage.

Hay can be stored satisfactorily in a bale or tripod system (See Figure 5.7.). Various options exist for storing hay bales, be they small squares, large squares, rectangular bales, or round bales. The baling process makes the compact cubical bundles of the forages. This reduces the requirement of space in comparison to loose or chopped hay. The bales may be stored in open environment or in the barn. Tripod system a three-legged stand of hay. It helps to drain rainy water. The average height of this stand may be 2 to 3 meters.

Hay is the oldest and still the most important way of conserving feed. It can be made with little cost other than labor. Hay can be made with simple equipment. Hay is easy to transport and store. It can be fed with little or no wastage. Hay is often marketed as a cash crop, usually baled. Hay has also some shortcomings. It varies in nutrient content and palatability more than any feed. It is very dependent on the weather condition. Late crop harvest also affects hay quality because it decreases the nutrient content of the feed.

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Figure 5.7. Hay storage: a) baled, b) tripod system

5.5.1.2. Silage making

Silage is the preserved material produced by the controlled fermentation of green crops under anaerobic conditions. The process of silage making is also known as ensilage. The main purpose of silage making is to preserve succulent feeds for usage at times of scarcity. Very good silage can be made from grasses or grass-legume mixtures or fodders (e.g., maize and sorghum). Grasses should be harvested at head forming stage, while legumes at early blooming. Fodders at dough (milky) stage. The crop should be wilted, chopped and stored in a silo. The process takes 2 to 4 weeks for the best production and feed intake. The silage making process is shown in Figure-5.8 and describes in Table 5.2.

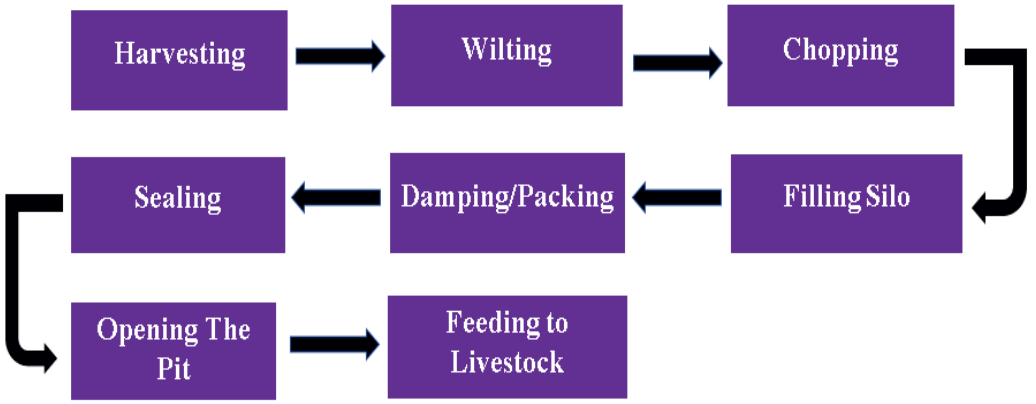


Figure 5.8. Schematic presentation of silage making process

Table 5.2. Step-wise checklist for making and feeding a good quality silage

Step	Checklist
Harvesting	▪ Assess the quantity of crop to be harvested ▪ Avoid bad weather at the time of harvest ▪ Check growth stage of the crop. Harvest at flowering stage: 35-40% DM (60-65% moisture).
Wilting (optional) and chopping	▪ Wilt the forage to 30% DM, avoid over wilting ▪ Chop to proper size (facilitate the packing process)
Additives use (optional)	▪ Add molasses, urea, salt, acids, limestone, etc. while filling silo pit. ▪ Add molasses for materials < 10% DM
Proper filling of silo/bag/pit	▪ Check the condition of silo. Silo should have impermeable walls and be designed to allow easy sealing. ▪ Check if the distribution of the plant material is uniform ▪ Complete it within the planned time for completion.
Dumping/ Packing	▪ Compress the forage as tightly as possible ▪ Pack the forage. Packing encourages fermentation and discourages spoilage
Packing and sealing	▪ Seal the silo tightly. What` happens at this stage? ▪ Carbohydrates (sugar) breaks down to organic acids ▪ Anaerobic fermentation converts organic materials to carbon dioxide and water, plus heat ▪ The organic acids (Lactic acid) reduce pH to 4 or lower. ▪ Aerobic bacteria die and anaerobic bacteria multiply rapidly ▪ The fermentation process takes 2-4 weeks for completion
Opening the pit/ silo	▪ Never open the whole pit at one time. Only one end of the narrow side should be opened. ▪ small opening prevents air entry and silage spoilage

Step	Checklist
Feeding to livestock	▪ Feed to ruminants only and do not feed when their rumen is empty. Do not feed cows that are in late pregnancy and calves that are less than 6 months old. Do not feed the sick, hungry and weak animals. ▪ Start bit by bit and gradually increase the quantity.

Procedure of silage making

1. Put on personal protective equipment and clothing.
2. Prepare materials for silage making (plastic sheet, spring balance, container, molasses fresh forage like alfalfa, grass, or cactus leaves, urea, maize, elephant grass and others), cut it and allow it to dry it for 2 days. Also gather some straw.
3. Making a silo (any structure for ensiling of feed material) can be above or below ground its size depends on number of animal, period of feeding, and quantity of feed or use plastic sheet.
4. Harvesting of crops at (30-35% of moisture content).
5. Chopping the crop (chopping make it easy to compact the silage and to remove the air).
6. Measure 1% molasses, 1-3 liter water and 1kg urea for 50- 70 kg silage.
7. Make absolution molasses and urea by water.
8. Mixing the solution and chopping forage.
9. Filling the silo, fill the material into the container layer by layer. Try to fill the silo continuously and seal it quickly. This will prevent air entrapment and speed up the fermentation process.
10. Cover the silo by using soil to control the entrance of air.
11. After 2-3 week feed for animals depend on their age, health condition, time of production (cannot feed for pregnant), and type of production.

Activity 5.4.

Form a small group, and demonstrate silage making in the field.

Apply the procedures described above and demonstrate silage making in the field. To do this, you need fresh feed materials, molasses, salt, scale, sickle, etc. When you finish, take the photograph of the silage and document it. Later, you may need to report your activity to your teacher.

5.5.2. Compound Feed Manufacturing

Manufacturing animal feed involves blending several raw feed ingredients of different physical, chemical and nutritional composition into a homogenous mixture. The mixture should meet the nutrient requirements of the target species. Cereals and agro-industrial by-products are the main ingredients of commercial feeds in Ethiopia. Compound feed may also contain salt, limestone and **premixes**. The manufacturing process involves several operations, as shown in Figure 5.9. The sequence of the operation and the size and sophistication of the equipment may vary with the output of the required feed. Quality control is essential at all stages of the operation.

Key term:

Premixes are complex mixtures of vitamins, minerals, trace elements and other feed additives. They are incorporated at small levels in a compound feed. Premixes are designed to provide a balanced contribution to the animal's needs.

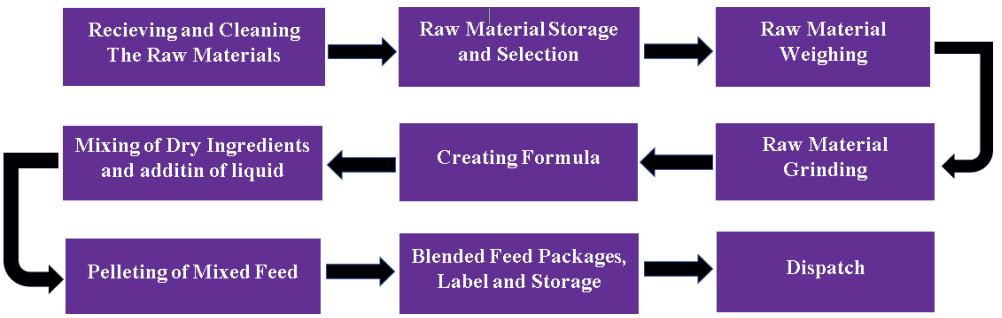


Figure 5.9. A flow chart that shows the main stages of compound feed production

Unit Summary

In this unit you have learnt that:

- nutrition plays an essential role in improving the performance of livestock
- natural pasture, crop residues, improved forages and industrial by-products are the main feed resources in Ethiopia
- feeds are classified into roughages and concentrates based on their nutritive value
  - roughage may be dry roughages, or succulents like silages and pastures
  - concentrates are classified into energy-rich and protein-rich, depending on their nutritional contents
- basic nutrients for animals are carbohydrates, fat, protein, minerals, vitamins, and water
  - they are required for maintenance, growth, reproduction, and good health
- ration formulation plays a significant role when there is a scarcity in the supply of feed
  - the Pearson Square method is a well-known method of balancing animal diets
- grasses and fodders can be preserved either as hay or as silage
  - the choice is determined by the weather conditions and availability fodders and grasses
- compound feed manufacturing aims to meet the nutrient requirements of the target species

Review Exercise

Part I: Choose the best answer from the given alternatives.

1. What is the most common feed resource in Ethiopia?
   A. Crop residue
   B. Natural pasture
   C. Improved forages
   D. Agro-industrial by-products
2. Which one of the following feeds is not agro-industrial by-product?
   A. Molasses
   B. Wheat bran
   C. Straw
   D. Soybean meal
3. A well-known method of balancing animal feeds is _____.
   A. Trial and Error method
   B. Pearson Square method
   C. Substitution formulation
   D. Computer-assisted formulation
4. Which of the following are micro-nutrients?
   A. Minerals and vitamins
   B. Water and vitamins
   C. Minerals and proteins
   D. Fats and carbohydrates
5. The science of feed preparation and feeding of farm animals is known as _____.
   A. Feed formulation
   B. Feedstuff
   C. Animal nutrition
   D. Feeding
6. Which one of the following feed resource is not a type of roughage?
   A. Hay
   B. Straw
   C. Molasses
   D. Silage
7. Which one of the following is not characteristics of roughage feeds?
   A. They are low in total digestible nutrient (TDN).
   B. They are bulky feeds.
   C. They contain more than 18% crude fiber.
   D. They are highly digestible.
8. Which one of the following is the shortcoming of hay?
   A. Hay making is dependent on the current weather condition.
   B. It can be fed with little or no wastage.
   C. Hay is difficult to transport and store.
   D. Hay making incurs high cost.

Part II: Answer the following questions.

1. Feeds are divided into two groups. Name the groups and give an example for each group.
2. A farmer has maize and fish meal available for compiling a balanced diet for the laying hens. Laying hens need 16% protein. The maize has a protein content of 10% and the fish meal has a protein content of 48%. Use the Pearson Square method to calculate how much of each feed the farmer should give to the hens per 100 kgs.
3. Summarize the main steps involved in the production of compound feed.

Unit 6 Animal Genetics and Breeding Practices

Contents	Learning Outcomes
6.1. Introduction to animal genetics and breeding 6.2. Breed improvement methods 6.3. Farm animal reproductive technologies 6.4. Animal identification and record keeping	At the end of this unit, you will be able to: ▪ define animal genetics and breeding practices ▪ explain breed improvement methods (breed introduction, selection and breeding) ▪ describe farm animal reproductive technologies (artificial insemination and embryo transfer) ▪ analyze the importance of animal identification and record keeping

6.1. Introduction to Animal Genetics and Breeding

Brainstorming 6.1

Genetics and Breeding

What did you learn about the following in your biology class?

- Animal genetics
- Animal breeding

Genetics is the study of heredity, which is the passing of genetic information and traits from parents to offspring. Genetics include the study of genes and their effects on living organisms. Genes are small sections of deoxyribonucleic acid (DNA) that are coded for specific traits. DNA is the molecule that contains the genetic code of organisms. DNA is inherited by offspring from their parents. Genes are found in chromosomes. Animal geneticists have identified elements within genes that can enhance animal growth, health, and the ability to utilize nutrients efficiently. These genetic advances can increase production and reduce environmental impacts. Animal genetics is one of the pillars of livestock development alongside animal health, animal nutrition and husbandry issues such as animal housing.

Animal breeding indicates the mating of selective animals for purpose of the enhancement of particular characteristics in subsequent generations. These characteristics are usually chosen with the aim of increasing production and profitability. Animal breeding ensures a continuous improvement of farm animals' generation after generation. Different animal traits are measured and the best animals are used as parent animals. In this way, breeders provide livestock farmers with a next generation of animals. Thus, animal breeding helps in accumulation of superior genes and elimination of the less desirable genes.

The objectives of animal breeding are to:

- increase animal yield or productivity
- improve the desirable quality of animal product
- produce disease-resistant animals

6.2. Breed Improvement Methods

To make livestock production profitable, productivity per animal (e.g., growth rate, milk yield and egg number) needs to be increased. Productivity of animals can be increased by better feeding, better health care and better management of the existing animals. However, genetic improvement also plays an important role. Genetic improvement is based on the principle that the products (such as milk, meat, and wool) and services (e.g., transport, draught power or cultural services) provided by animals are functions of their genes and their living environment.

There are three methods of genetic improvement applied in farm animals. These are breed introduction, selection and breeding.

6.2.1. Breed Introduction

Breed introduction is bringing high-quality breeds of livestock into the farm or a country. High-quality breeds of livestock have a high productive capacity and other desirable characteristics. The introduction of high-quality breeds of livestock can be from another farm or another country. Before introducing such animals from another farm/country, it is important to be sure that the breeds possess higher quality characteristics than the local ones. There are different breeds of farm animals around the world. These are the local breeds, exotic breeds and the cross breeds.

In Ethiopia, local breeds are usually small animals. They mature slowly and are poor producers. They are, however, adapted to the local environment and are resistant to diseases. Exotic breeds are breed that are not native to Ethiopia, and these are often larger animals. They also mature early. They are good producers but they may not adapt to the local environment and fall victim to various diseases. To overcome these issues, the exotic breeds can be mated with the local breeds. This may help to obtain cross-breeds which possess the most desirable qualities of both exotic and local breeds.

Advantages of breed introduction

- Characteristics which are not originally present in the local breeds are introduced

- Breed introduction enhances productivity
- Crossbreeds may perform better than local breed if adapted to the local environment

Disadvantages of introduction

- It may introduce new diseases and pests to the area
- Exotic breeds may struggle to adapt to the new area
- Exotic breeds may not reach full productivity in the new environment

6.2.2. Selection

Genetic improvement can be achieved by a proper selection. Selection is used as a tool for livestock improvement. Selection is the process of allowing genetically superior animals to be parents of future generations while culling others. Culling is the removal of animals which do not perform at the desired level, from the herd. The animals retained have certain desirable characteristics which make them more productive.

Animals with desirable characteristics are selected. Selected animals make up the breeding stock. The breeding stock should pass the good qualities to their offspring for better performance, e.g., higher milk production or growth to improve the herd. Selection process repeated for many generations increases chances of formation of desirable qualities in an animal. Selection increases occurrences of desirable genes and decreases that of the undesirable ones. There are two types of selection.

Natural selection: This is the process in which animals that are better adapted to their environment get a better chance of surviving and producing more offspring than those that fail to adapt themselves. The offspring of the adapted animals will be more adapted than their parents. Animals that are unable to adapt cannot survive or reproduce.

Artificial selection: farmers select and mate the best animals. This increases the health and productivity of animals. There are several methods of artificial selection.

- **Mass selection:** Animas are selected or rejected on the basis of their own performance in the field. Those with the desired characteristics are often from a large group, which is composed of large number of animals.

- **Progeny selection:** Animals are selected on the performance of their progeny or offspring. Mothers of the best performing offspring are retained while the mothers of offspring that do not perform well are culled (removed).

- **Family selection:** Animals are selected or rejected on the basis of the performance of their relatives or family. Family selection is usual when the family size is large or when the family have large number of members.

- **Pedigree selection:** Animals are selected or rejected on the basis of the performance of their ancestors.

Advantages of selection

- It ensures that only the best naturally available animal is selected
- Animals with desirable characteristics are selected.
- Animals from best breeds are bred for distribution.
- Animals with undesirable characteristics are detected and culled.
- Selection reduces the spread of diseases and parasites associated with breeding stocks.

Disadvantages of selection

- Selection is very costly in terms of time and money
- It requires expertise which may not be readily available
- It may bring about elimination or exclusion of some desirable traits of some parent stock
- No new desirable characteristics that do not occur in the existing stock are introduced

6.2.3. Breeding

Breeding involves the development of animals by transferring inherited qualities from parents to offspring. This is achieved through mating. There are different methods of breeding, which can be categorized as related or unrelated breeding systems.

In-breeding: This involves mating of more closely related animals than the average of the population from which they come, e.g., the mating of father to daughter, son to mother or brother to sister. In-breeding helps to produce inbred lines that can be used for cross breeding to produce hybrid vigour. However, it can produce offspring with undesirable characteristics because recessive genes show up. This is known as in-breeding depression.

Line-breeding: This involves the mating of distantly related animals, e.g., mating between cousins. It has the same disadvantages as in-breeding, but it takes a longer period for undesirable traits to appear (i.e., for in-breeding depression to occur). It is used to consolidate traits for a particular outstanding ancestor. Most of the high-quality commercial characters developed recently have been a result of line-breeding.

Out breeding: This is the mating of unrelated animals within the same breed. Out-breeding is the opposite of in-breeding. It produces offspring with a greater vigor and productivity.

Cross breeding: This is the mating of proven quality animals of same species but different breeds. This is because parental animals differ in gene composition. Cross-breeding results in breeds of animals with higher production capacity than any of the parents. This phenomenon is called heterosis or hybrid vigor. It brings about a greater rate of growth in an offspring. Cross-breeding produces individuals that can withstand climatic variation in the environment. It increases disease resistance in offspring. It also promotes higher yields of eggs, meat and milk in offspring.

The following mating types represent the two methods of breeding applied in livestock farm, with their advantages and disadvantages.

Breeding system	Related breeding	Unrelated breeding
Mating example	Afar ram X Afar ewe of ram's daughter (In-breeding)	Arsi cow X HF bull (Cross breeding)
Advantages	▪ Production of pure breeds or pure lines ▪ helps to concentrate and preserve specific qualities in an animal	▪ Promotes heterosis or hybrid vigor ▪ Development of new breeds ▪ Grows more rapidly and is more economical to rear ▪ Withstand environmental variations ▪ More resistance against diseases
Disadvantages	▪ Reduction in vigor and performance (i.e., drop in the productivity, slow growth rate, loss of fertility and poor resistance to diseases) ▪ It often gives rise to defective animals	▪ Operating costs are higher than those for local breeds ▪ If not systematic, sizing problems and associated delivery difficulties may occur

Activity 6.1.

Small group activity

In small groups, investigate the animal breeding carried out in your own locality. Research the success or difficulties that local farmers have encountered, and suggest ways that local farmers could improve their strategies in future.

*Present your work to the whole class.

6.3. Farm Animal Reproductive Technologies

Reproduction techniques are becoming more and more important and necessary for modern animal breeding. Reproduction techniques are used to make safe and efficient breeding possible.

Breeding programs can be improved and optimized through the use of reproductive techniques. Reproductive techniques allow the dissemination of genes of interest and increase the reproductive capacities of animals. Over the years, various biotechnology methods are used in improving the breeding stock of animals. Artificial insemination and embryo transfer are some examples of these biotechnology methods.

6.3.1. Artificial Insemination (AI)

Artificial insemination is the process of collecting sperm cells from male animals and depositing them into the reproductive tract of a female (vagina, cervix or uterus) by a method other than natural mating. It is the most important reproduction technology for genetic improvement in domestic animals. The semen is collected hygienically from superior males. The semen containing spermatozoa are carefully handled, diluted and stored in a freezer at a temperature of -196 ^{o}C in liquid nitrogen. The semen stays there until it is required for use. A liquid nitrogen tank is used for preserving and storing semen for an extended period of time.

Success in insemination timing is dependent upon a good heat detection program. Effective AI work needs accurate herd supervision and heat detection. Oestrus in females is identified by the following signs:

- loss of appetite
- constant vocalizations
- restlessness
- rubbing up against herd-mates
- lips of the vulva become redder and more moist than usual
- swelling around the vulva
- a thin mucous discharge from the vulva

- stop when mounted by other animals
- mount other animals

Artificial insemination of cattle involves several steps, and considerable skill and experience is required in order to perform AI successfully for large numbers of animals. The process begins with semen collection and storage for later use (Figure 6.1). The safe and best method of insemination in cattle is recto vaginal method of insemination. Insemination is carried out in a sheltered area to eliminate unfavorable conditions such as wind, dust and rain. Instruments must be sterile. Cow which is in heat is well controlled in crush. The inseminator will get ready by wearing a plastic apron, gumboots and gloves. The semen straw after thawing (keeping the semen straw in tepid water for a minute to convert the freezed semen into liquid and the sperms become motile) is loaded in a sterilized AI gum and is covered with a plastic sheath (Figure 6.1). The inseminator will insert the gloved left hand into the rectum after applying the soft soap or other lubricant on the glove and back racked the animal, and the hand is further inserted and will catch hold the cervix through rectal wall. The AI gum loaded with semen straw is passed.

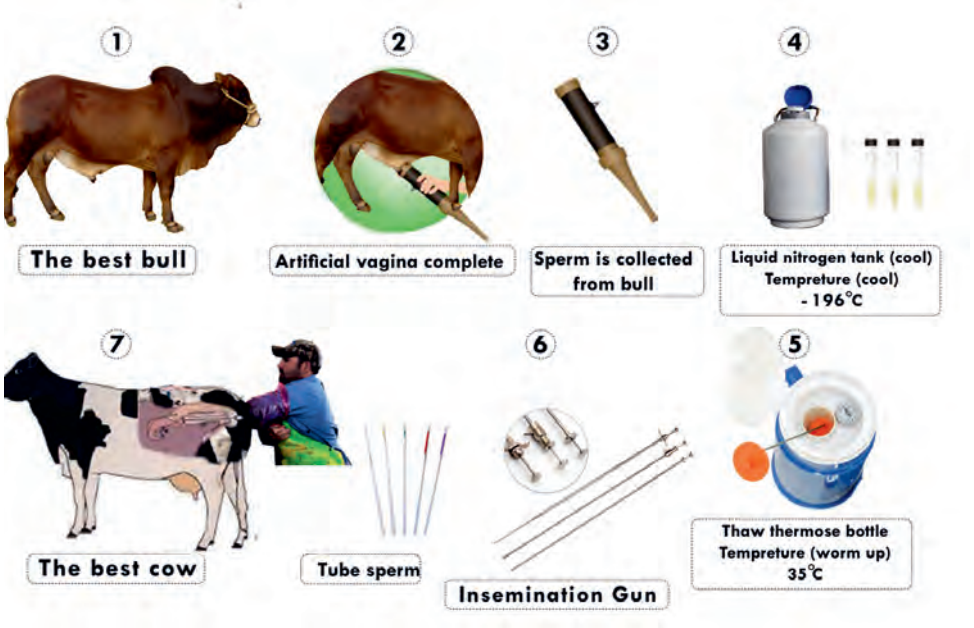


Figure 6.1. Steps in Artificial Insemination Process in Cattle

Advantages of Artificial Insemination (AI)

- Wider variety of superior males used
- Increase number of females that can be breed to a superior male
- Reduces spread of infectious diseases such as contagious abortion and vibriosis
- Don't have to keep a male animal on the farm. Mostly semen is brought from AI centers.
- It helps in maintaining the accurate breeding and parturition records.
- Old, heavy and injured males can be used.

Disadvantages/limitations of Artificial Insemination (AI)

- Requires well-trained operators.
- Requires specialist equipment and facilities.
- Requires more time than natural services.
- Improper cleaning of instruments and in sanitary conditions may lead to lower fertility.
- If the bull is not properly tested, the spreading of genital diseases will be increased.

6.3.2. Embryo Transfer (ET)

Embryo transfer is an artificial method of breeding whereby newly formed embryos prior to implantation are removed from a female animal (donor) and transferred into the reproductive tract of another female (recipient) of the same species. In embryo transfer, the donors are highly productive or are superior animals. The recipients are an inferior in productivity. Embryo transfer has proved to be a powerful technology in genetic improvement of farm animals. Embryo transfer is used to disseminate desirable genes from superior female animals and from various species (horses, cattle, sheep, goats, and pigs).

The embryo transfer process in cattle begins with cows receiving a hormone treatment to produce more than one ovulation (egg) at a time (Figure 6.2). The cows are then artificially inseminated with bulls also possessing

desirable genetics. Seven days later, a veterinarian recovers the embryos by using a catheter and recovery fluid. The fluid passes through a specialized filter, which catches the embryos. After recovering the embryos from both cows, they will be filtered into a lab and evaluated under a microscope. It is estimated that the process produces an average of six good embryos per cow. Any fertilized embryos captured in the process can be transferred into a surrogate cow, called a recipient, that will carry the pregnancy to term, or the embryos can be frozen to be used later.

Advantages of Embryo Transfer (ET)

- Allows a producer to quickly multiply the number of offspring of the top females
- Is an easier and more rapid exchange of genetic material between countries
- Involves no transport of live animals
- Reduces risks of disease transmission
- Enhances storage and expansion of rare genetic stock

Disadvantages of Embryo Transfer (ET)

- The technique requires a high cost.
- It requires skilled technicians.
- It may be time consuming.

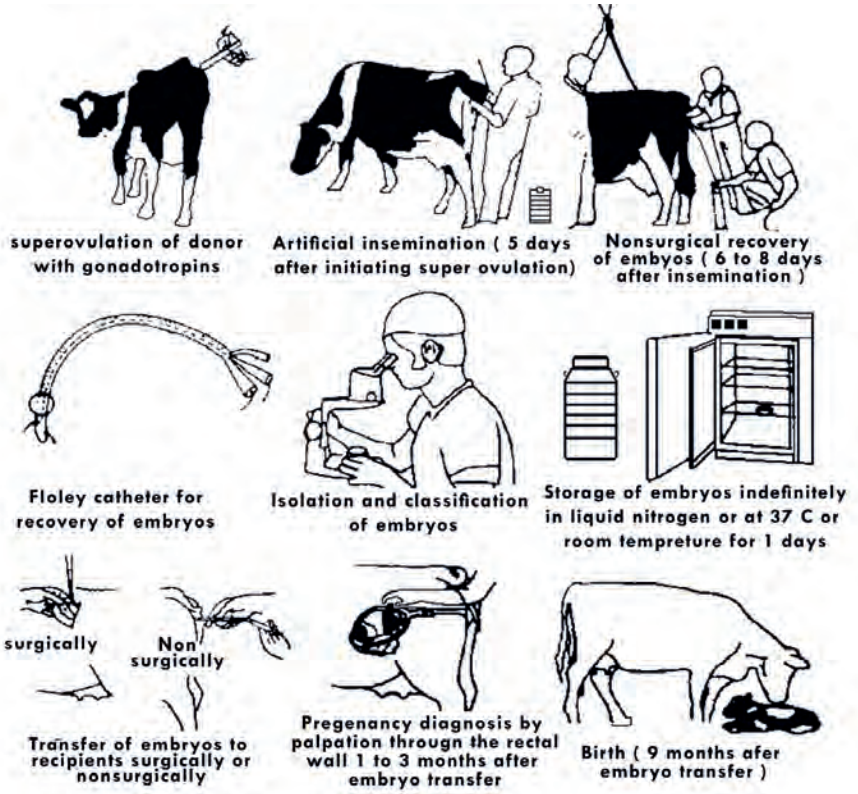


Figure 6.2. Procedure in Embryo Transfer in Cattle

Activity 6.2.

Group Works

Divide yourselves into small groups. Seven students in a group could be a good size. In your group, think about the two reproductive techniques (i.e., artificial insemination and embryo transfer) which are covered in this section. Take one reproductive technique each and prepare a talk on the advantages and disadvantages of the technique. Present your talk to your group. Take turns to do this. The presentations shouldn't exceed five minutes each. Nominate one student from the group to write the summary of the main points of the presentations. The group reporter will report the summary to the whole class.

6.4. Animal Identification and Record Keeping

Maintaining herd performance records is one of the best management tools for a successful genetic improvement program. Performance records help producers identify areas of weakness in the overall herd/flock performance. Information on animals' performance help a farmer to make informed decisions about flock management, the selection of new breeding stock and culling low performing animals. Tracking animals that have been treated with medication can be made easy through identification and record keeping. This means that keeping records of medical histories of individual animals can also be used when making culling decisions. Recording of phenotypic data (i.e., an individual's observable traits, such as height and color) is the major driving force for genetic progress. This genetic progress is very much dependent on the accuracy of the data.

Individual animal identification allows producers to keep records of an animal's parentage, birth date and production records. There are many identification systems. Permanent identifications include branding, ear tags, tattooing, ear notches or microchips. There are also some simple temporary methods to mark the animals. Tail marking with a pen and chalk, clipping their hair, or dying their fur are simple techniques to identify animals.

Activity 6.3.

Field Visit

In small groups, visit local farms (dairy, beef, sheep, goat, poultry, etc.) in your area.

1. List the methods of identification employed on the farm.
2. Why do you think these methods are preferred by farmers?
3. Find out what records are kept about the animals by the farmer.
   - Copy their record keeping formats or templates used, if any.
   - Discuss and share your findings with the rest of the class and submit the report to your teacher.

Unit Summary

In this unit you have learnt that:

- animal genetics is one of the pillars of livestock development alongside animal health, animal nutrition and husbandry issues such as housing
- the three processes of animal genetic improvement are breed introduction, selection and breeding
- cross breeding is the mating of animals of different breeds
  - the incentive for cross breeding is the exploitation of hybrid vigour (i.e., heterosis) as a result of which the performance of cross-breeds exceeds the average of the parental breeds
- artificial insemination (AI) and embryo transfer (ET) are examples of reproductive technologies
  - AI aims to exploit superior male
  - ET favors the rapid exploitation of superior females
- animal identification and trait recording are fundamental to all breeding programs
  - animals need to be appropriately identified
  - there are two basic types of identification: permanent and temporary

Review Exercise

Part I: Choose the best answer from the given alternatives.

1. The mating of proven quality animals from different breeds is known as _____.
   A. In-breeding
   B. Line-breeding
   C. Out breeding
   D. Cross breeding
2. Which one of the following is a temporary method of animal identification?
   A. Branding
   B. Tail marking
   C. Tattooing
   D. Ear notching
3. Which one of the following form of artificial selection involves selection or rejection of animals on the basis of their ancestor's performance?
   A. Pedigree selection
   B. Mass selection
   C. Progeny selection
   D. Family selection
4. One of the following is not among the objectives of animal breeding. Which one is it?
   A. To increase animal productivity
   B. To improve animal product quality
   C. To produce disease resistant animals
   D. To replace the indigenous breeds with the exogenous ones
5. Which of the following reproductive technique favors the rapid exploitation of superior females in the herd?
   A. Breed introduction
   B. Artificial insemination
   C. Embryo transfer
   D. Animal genetics

Part II: Answer the following questions.

1. Write the advantages and limitations of the two common reproductive techniques?
2. Explain the importance of record keeping in livestock farms.
3. Write the different methods of breed improvement used in farm animals with their advantages and disadvantages.

Unit 7 Farm Animals Housing

Contents	Learning Outcomes
7.1. Significance of farm animal house 7.2. Types of farm animal housing 7.3. Guidelines for site selection and house construction	At the end of this unit, you will be able to: ▪ explain the significance of farm animal house ▪ describe the different types of animal housing ▪ select sites for animal shelter and house construction ▪ construct model shelters and houses for animals

7.1. Significance of Animal Housing

Brainstorming 7.1

Purpose of housing

1. Have you ever seen any animal house? If 'Yes," houses of what kind of animals have you seen?
2. What do you think are the importance of the houses?

A good housing system has a significant role in profitable animal production. It is quite important to have proper housing system for animals to protect them from health problems and enable them to perform better. Good feeding and breeding will not result in a maximum production if farm animals are not kept in a good house. Housing should be constructed in such a way that it furnishes adequate comfort and protection from climatic stresses and potential diseases.

Provide some environmental controls: The purpose of keeping animals in a house is to improve the environment. Good housing allows the farmer to better control the inside environment. Farm animals respond to changes in environment (temperature, relative humidity, air movement, sun radiation and rain) through changing their behavior, and their productivity or reproduction efficiency also drop. For example, at high temperature feed intake of animals is reduced to regulate body temperature. This results in reduction in quantity and quality of milk, meat, egg, and wool production. Reproduction is also adversely affected by high temperature range. Protecting animals from all these environmental changes or conditions would help to achieve the desired production level throughout the year.

Control of diseases and external parasites: Diseases and parasites are among the profit liming factors in animal production especially in the developing countries. A well ventilated and dry house or shelter would help to prevent the buildup of pathogens. Good animal housing will facilitate the implementation of strict sanitary control measures while being easy to clean and disinfect to minimize animal mortality through elimination of external parasites like ticks, mite and lice.

Efficient use of feed and labor: Careful planning of buildings and

equipment arrangements will improve the efficiency of feeding and reduces feed wastage and labor cost. Efficient communication between feed stores and feeding points such as feed troughs could be made through well-designed house. It also makes easier other routine management activities such as watering, breeding, egg collection, milking, and cleaning. Well-designed house can also protect laborers from various environmental stresses, which has an economic implication.

Safeguard against predators: Another major reason to keep farm animals inside is to protect them from predators. All farm animals are prey animals.

7.2. Types of Farm Animal Housing

Different farm animals housing systems are available. Each housing system has its own advantages and disadvantages. Housing type should be chosen depending upon the type of animals, climate conditions, local tradition, availability of building materials and economics. For example, conventional barn system is not suitable to hot and humid climates. Loose housing system is more suitable to Ethiopian conditions.

7.2.1. Conventional barns or houses

in this housing system are kept in constructed houses. Animals are managed intensively and protected from adverse climatic conditions. The barns are constructed completely roofed. Their walls are complete with windows or ventilators at suitable places. The continual air flow keeps the area comfortable for animals. Animal and worker care for animals are less exposed to adverse weather conditions. Barns remain hygiene and disease prevalence is less. They are suitable in heavy rainfall and temperate climate.

Conventional barns for dairy cattle and deep litter poultry housing are examples of these housing type (Figure 7.1). In conventional barns, dairy cattle often kept tied in large stalls and cannot walk around the barn. The cows are provided with feed and water. They are also milked in the same barn. There is no need to have a separate milking parlour (i.e., a barn in which cows are milked at milking time). Tie stalls have largely been phased out due to animal welfare concerns. They are becoming less and less popular day-by-day.

Figure 7.1. Conventional barns: a) dairy cattle, b) beef cattle, c) deep litter poultry housing

A deep litter poultry or pig housing system is based on the repeated spreading of straw or sawdust material in indoor booths. An initial layer of litter is spread for the animals to use for bedding material and to defecate in, and as the litter is soiled, new layers of litter are continuously added by the farmer.

7.2.2. Loose housing

Loose housing are animal houses where the animals are allowed to move freely and have free access over the whole area of the building or pen. Loose housing systems provide more comfort and free movement for both workers and animals. Thus, it improves productivity and welfare. In loose housing, animals of equal line of production and similar age are usually kept in groups Group size depends on type of animal and size of farm. Self-feeding is practiced in loose housing system. Animals have freedom to walk around the free stalls at will. Animals feel comfortable. In loose housing, less bedding will be required and less manure will have to be removed. This type of housing is very suitable for tropical climate (most parts of Ethiopia). All types of livestock can be housed and managed under loose housing. The loose housings are cheaper to construct, easier to expand and flexible in utility.

Figure 7.2. Loose housing: a) Chicken, b) Beef cattle, c) Dairy cattle

7.2.3. Free range system

It is a system of housing by leaving stock animals in large area. The area is natural or cultivated pasture land with watering points and shelters. The farm headquarters is situated at the center. Free range system allows farm animals to run free in a large area throughout the year. There should be an attendant moving with animals to protect them from predators and thievery. The animals are less intensively managed than in modern farms. The farmer has less control over the animal's environment, but the animals get more exercise and more time to graze. This type of farming is suited to animals that are not handled daily, such as beef cattle and fattening sheep. Free-range systems enable farm animals' greater freedom to express their natural behaviour.

Figure 7.3. Free range systems: a) sheep, b) goats, c) chicken, d) beef cattle

Free range livestock production system is widely practiced in most parts of Ethiopia. Local chickens usually in mixed flock are allowed to an outdoor range area during daylight hours and they are housed in a shed at night time. Chicken are raised with little or no supplementation of prepared feed.

This limits their productivity. They are also attacked by predators. The same is true for sheep and goats. In range flock production systems, the farmer may allow his/her sheep/goats access to pasture during the day and keeps them a barn at night.

7.2.4. Modern farms

Depending on the weather condition the animals can be kept in full or half walled house in a separate pen/enclosure. Cut and carry or prepared feed is the main feed source. This system of housing or farming has been practiced on all common farm animals. The investment cost per animal is more when compared to the conventional operations. Productivity is better in this system. Battery cages like **enriched cages**, and **hens-aviary systems** for egg laying chicken are good examples of modern farms. Cage systems are the most efficient systems for egg production. However, some people are concerned about the **welfare** of the laying hens kept in cages.

Key terms:

Enriched cages are cages which are stacked on top of one another in row upon row, but they also provide limited facilities for nesting, perching and scratching.

Hens-aviary systems (so-called multi-tier system) the tiers are the most typical feature of the spacious character of the aviary and provide living space at several levels. The system allow hens to disperse across several levels.

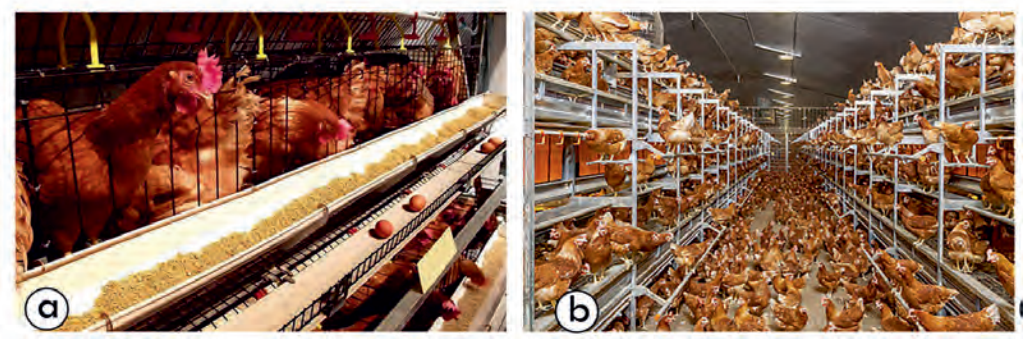


Figure 7.4. Modern housing of laying hens: a) enriched cages, b) hens-Aviary systems

Farm Animal Welfare Issues

Animal welfare is the well-being of non-human animals. An animal is in

a good state of welfare if it is healthy, comfortable, well-nourished, safe, able to express innate behavior, and if it is not suffering from unpleasant states such as pain, fear, and distress. Good animal welfare requires disease prevention and veterinary treatment, appropriate shelter, management, nutrition, humane handling, and humane slaughter. Protecting an animal's welfare means providing for its physical and mental needs. Ensuring animal welfare is a human responsibility

There are five freedoms of animal welfare. These are:

- Freedom from thirst and hunger
- Freedom from discomfort by providing adequate shelter
- Freedom from disease, pain, or injury
- Freedom from distress and fear
- Freedom to exhibit natural behaviors

Activity 7.1.

Field visit to describe farm animals housing

1. In a small group, visit animal production farms in your locality. Observe the features of the housing systems at the farms.
2. What kind of production system is the farmer using?
3. Discuss why the farmers prefer that system of housing over others.
4. Discuss in groups whether you think a different housing system might bring this farmer any advantages or disadvantages.

Compare the advantages and disadvantages of each system.

*Present your observations to the rest of the class. You may support your presentation with photos or audio-videos which are taken at your visit. Try to make your presentation brief - keep to five minutes if possible.

7.3. Guidelines for Site Selection and House Construction

7.3.1. Guidelines for Site Selection

When planning an entirely new farm, the choice of location for constructing the building is the first consideration. Location refers to the place where animal housing is placed in relation to soil structure, drainage, road access and proximity to other farm houses, etc. The following factors should be considered when selecting site for farm animal housing.

- **Topography and drainage:** Topography means the arrangement of the features of an area. The topography of the site should ideally be elevated but fairly level with no abrupt slopes. Farm animal houses should always be located in a well-drained area for effective drainage. The soil should be porous and the slope gentle so that drainage is efficient.

- **Feed, water and veterinary services:** A good source of clean water supply should be available cheaply and in plenty. A year-round supply of water is essential for the animals, sanitation, workers and residences and fire protection. The site should be located in areas where there are adequate veterinary services and where feed is available at a cheaper price.

- **Accessibility:** The site should be preferably located where good market outlet, power line (electric power source), and all weather road are available. There should be provision for easy electricity connection. Outages are more likely if the site is far removed from the electric substation. You need to have access to very good roads to ease the supply process. Inadequate road and transportation facilities creates problem to produce and market fresh farm produces (e.g., milk, meat, fish and egg).

- **Distance from residences:** Odorsare inherent in livestock operations, especially when manure is not managed properly. Prevailing wind direction in relationship to non-owned residences is important. The site should not be near hospital, school, residential areas, slaughter houses, factories, etc.

- **Guarantee health of animals:** The ssite should preferably not be located by the side of a national highway or main market load to reduce the risk of disease transmission. There should be enough space between farm houses to reduce the possibility of disease spreads
- **Size:** The area for the farm should be of adequate size while considering future expansion. Plan for expansion some years into the future; consider doubling the size anticipated at present. Avoid locating facilities near property lines, public-use areas, or other features that limit expansion.

7.3.2. Guidelines for Construction of Animal House

A good housing system provides adequate space for feeding and exercise and proper ventilation. Housing should be constructed in such a way that it offers a maximum comfort and protection from environmental stresses. The objective is to provide housing which is inexpensive to build and economical to operate and maintain. The house should at the same time be easy to clean and disinfect to minimize animal mortality. It should protect farm animals from drafts. The system of ventilation should be adequate to prevent dampness.

Careful planning of buildings is essential in developing an integrated and efficient layout for producing quality products such as milk. Due consideration must be given to building and equipment arrangements for efficient use of labor and feed (efficient communication). Inadequate and improper planning results in additional labour charges and increased costs in maintenance. The basic guidelines for construction of farm animal's house are detailed below.

Orientation: There are two types of orientation for animal houses. The East-West direction helps to avoid direct sunlight. Feed and water troughs could be placed under shade all times a day. In this orientation, feed consumption will increase and more manure will be dropped in the shade. In North-South orientation, the sun will strike every part of floor area under and on either side of the roof at some time of the day. This will keep the floor area dry. If paving is too costly, this orientation is preferred to keep the area dry.

Floor: The floor is an extremely important part of the building. The floor should be laid on solid and compact foundation. Foundation must be with stones but inner side must be smooth. Good sanitary control measures should be taken into account in the design of housing floor. An ideal floor for a livestock house is well drained and made of cement concrete. Flooring must facilitate hygienic feeding and effective removal of liquid and solid wastes. Floor should be made non-slippery so grooves and a roughened surface should be provided.

Walls: The walls should protect farm animals from draft. It should be hard and durable preferably made with cement concrete. The inside of the walls should have a smooth hard finish of cement, which will not allow any lodgment of dust and moisture. Avoid constructing any corners or projections on which animals could injure themselves. The walls of the house could also be made of any inexpensive local materials such as wood and bamboo. If wood is used, then the farmer should paint with wood preservative solution every 3 to 5 years. The walls may be solid or partially open depending on the local conditions and the type of animals. Side walls often include windows which can be covered with wire mesh for ventilation. This is especially true for chicken and pig houses. The width, which is shorter than the length side, has to be solid.

Roof: A well designed roof is quite important in reducing heat and cold stresses. It should be preferably made with galvanized iron-sheet for durability and comfort. Like the walls, the roof could also be made of any inexpensive local materials such as thatches. The roof needs to be high enough to release excess heat, moisture and pollutants. The roof should be sloped, overhang should be at least 60 cm to offer protection from sun and rain. Direct solar radiation increases the heat load on the animals. This in turn has an adverse effect on production and reproduction of the animals.

Ventilation: A is the entry and circulation of air freely. A smooth air movement will supply the animal with fresh air for breathing and to remove noxious and toxic gases (e.g., CO2 and NH3) from the house. Adequate ventilation system is a must in all farm animal houses to avoid dampness. The continual air flow helps to keep the area comfortable and prevent and control possible disease causing pathogens. The roof height should be

minimum of 3m high to allow sufficient air movement.

Activity 7.2.

Small group activity

1. In a small group, look at any plot of land in your school backyard, and select a suitable site for animal house for each type of animal and explain why.
2. Visit a livestock farm in groups if there is one close to your school.
   - Observe and explain how the wall, roof and floor are constructed.
   - Observe and describe the equipment used for feeding and drinking.
   - Indicate the positive and negative aspects of the farm design and its facilities.
3. Construct a model house for animals and explain what animal is designed for and what features are present and why. Also explain what materials would be used and why.

*Produce a project about site of housing, type of housing and house construction. You could write a report showing what you have found or do a presentation.

Unit Summary

In this unit you have learnt that:

- proper housing system keep farm animals protected from health problems
- good housing protect farm animals from adverse weather conditions and predators
- several types of housing are available for farm animals
  - the type of animal, production system, climate condition, local tradition, availability of building materials and economics are important considerations while selecting the type of housing system
- good animal welfare requires disease prevention and veterinary treatment, appropriate shelter, management, nutrition, humane handling, and humane slaughter
- a simple yard and bedded shed systems (loose housing) are entirely satisfactory in warm climates to protect animals from weather extremes
- enriched cages and hens-aviary systems for egg laying chickens are good examples of modern farms
- determinant factors that need to be considered in establishing animal farms or houses are topography, drainage, accessibility, distance from residences, and availability of services
- housing should be constructed in the way it can offer a maximum comfort and protection
  - floor should be made of concrete with proper gradient to facilitate drainage
  - walls should protect farm animals from drafts
  - roof needs to be high enough to release excess heat, moisture and pollutants
  - ventilation system should be adequate to prevent dampness
  - minimum investment should be put by utilizing the locally available materials for construction of roof, floor and walls without compromising the comfort of animals

Review Exercise

Part I: Choose the best answer from the given alternatives.

1. Which of these statements is not a characteristics of East-West orientation of farm animal housing?
   A. East-West orientation helps to avoid direct sunlight.
   B. East-West orientation helps to keep dry floor area.
   C. East-West orientation increases feed consumption.
   D. In East-West orientation, more manure will drop in the shade.
2. Which of the following are the purposes of farm animal housing?
   A. To safeguard animals from predators
   B. To control inside environment
   C. To prevent pathogen buildup
   D. All of the above
3. An ideal site for livestock house should be high and level with no abrupt slopes. This is best described as_____.
   A. Location
   B. Drainage
   C. Topography
   D. Accessibility
4. In which of the following housing system does animals confined together on a platform and tied at neck by stanchions or neck chains or ropes?.
   A. Conventional barn
   B. Loose housing
   C. Free range
   D. Open shade housing
5. All farm animals have the right to be housed with, or apart from, other animals. This form of freedom is categorized as _____.
   A. Freedom from discomfort
   B. Freedom from disease or injury
   C. Freedom from distress and fear
   D. Freedom to engage in natural behaviors

Part II: Answer the following questions.

1. List the factors that should be considered in site selection for livestock housing.
2. What are the different types of animal housing? Describe factors that should be considered by a farmer in selecting the type of housing

system for a particular area.

3. List the general guidelines when constructing farm animal houses.
4. Explain why adequate ventilation is important in farm animal housing.

Unit 8 Basic Animal Health and Disease Control

Contents	Learning Outcomes
8.1. Introduction to animal health and disease control 8.2. Major diseases of farm animals 8.3. Internal and external parasites of farm animals 8.4. Effects of diseases and parasites in animal production 8.5. Prevention and control of common farm animal diseases	At the end of this unit, you will be able to: ▪ explain the routes of transmission of pathogens ▪ identify the common symptoms of sick animals ▪ explain the major diseases of farm animals (viral, bacterial, protozoan, and parasitic) ▪ describe the two groups of parasites (internal and external) ▪ describe the effect of diseases and parasites in animal production ▪ explain the prevention and control of common farm animal diseases ▪ appreciate the role of indigenous knowledge in animal disease management

8.1. Introduction to Animal Health and Disease Control

Brainstorming 8.1.

Work independently.

1. Define animal health and diseases commonly known in your area.
2. List some signs of sick animals you know.
3. Do you think humans and animals have common diseases?

The best economic returns are realized when animals are kept in good health and disease problems are minimized. Health is the state of wellbeing of an animal. Any departure from the state of health is called disease. A healthy animal attains an acceptable level of production within the farming system in which it is maintained. Loss of appetite and weight, slow growth, reduction in production, reproduction loss and death of the animal are consequences of animal diseases.

8.1.1. Routes of Transmission of Pathogens

Pathogens are disease-causing microorganisms. Animals can be infected with pathogens through different ways. Direct contact with an infected animal or its tissues or fluids (e.g., blood, saliva, urine and droppings) is one of the ways. Ingestion of pathogens from contaminated feed, water and farm equipment (e.g., feed and water troughs) is another route of infection. Pathogens may be spread during mating or before birth through the placenta. Animals also can be infected through inhalation of droplets or dust containing pathogens or through vectors (living organisms, such as insects, carrying pathogens).

8.1.2. Symptoms of Sick Animals

A symptom is a sign or indication of the existence of a disease or other disorder. Sick animals can show a wide variety of symptoms, depending on the disease. These include loss of appetite, weight loss, coughing, being unable to rise, slow movement, lameness, and isolation from the herd or flock. A sick animal may stand with its head and neck down, or appear to have a tired or lazy look. They may have watery, bad-smelling or blood-stained faeces and urine. Other signs of ill health are discharges from

body openings, sunken eyes, raised hair coat, rough skin, dry muzzle and swelling in joints. There may be variation in body temperature, pulse rate and respiration rate. Disease may also lead to death.

Activity 8.1.

Form a group of 3-5 students, and visit the nearby veterinary clinic

- Observe the common symptoms of sick animals and health problems of farm animals in the clinic. Ask the veterinarian about the routes of transmission of pathogens.
- Ask the local vet about the most common diseases that occur in the local areas, and what treatments are offered.

*Share your field work with your class mates. Make your presentation interesting and lively as much as possible. You can support your presentation with relevant pictures and videos.

8.2. Major Diseases of Farm Animals

Diseases of farm animals are usually categorized as infectious and non-infectious. The infectious diseases are caused by pathogenic organisms such as **virus, bacteria** and **protozoa**. They are communicable from one animal to another animal or a human being. Examples are anthrax, foot and mouth disease (FMD) and Newcastle disease. Non-infectious diseases are neither caused by pathogens nor passed from one animal to another. Non-infectious diseases may be caused by hereditary factors or by the environment in which an animal lives. Examples are ketosis, rickets and poisoning.

Key terms:

Viruses are very small acellular structures, only visible with a powerful electron microscope, they multiply only within a living cell and can be transmitted from one organism to another.

Bacteria are microscopically small, single-celled organisms found worldwide in most habitats.

Protozoa are single celled organisms that live within the animal or on the animal. They are found worldwide in most habitats. Most protozoa do not cause infections, but a few do.

The major animal diseases in Ethiopia include foot and mouth disease (FMD), anthrax, tuberculosis and brucellosis. Contagious Bovine Pleuropneumonia (CBPP), mastitis, Newcastle disease, coccidiosis and trypanosomiasis are also common. The cause, host, transmission, symptoms and preventative/control measures for some diseases are described below.

Foot and Mouth Disease (FMD): This is a highly contagious, acute viral disease. It affects cattle, sheep, goats and pigs. Contact with infected urine, faeces, milk and nasal discharge are the main routes of transmission. This disease is characterized by formation of sores on feet, lips, tongue and cheek. Symptoms include fever, rough hair coat, salivation, foaming, inability to feed, weakness, lameness and death. Prevention and control measures are quarantine, vaccination, good sanitation and elimination of infected animals.

Contagious Bovine Pleuropneumonia (CBPP): This is a viral disease. It is a respiratory disease of cattle, goats, sheep and pigs. Its transmission is through contact with infected body fluids such as milk and urine. An infected animal will have a dry and painful cough, loss of appetite, difficulty in breathing and inflammation of the lungs. CBPP causes important productivity losses due to a high mortality (death) and morbidity (having a specific illness) rates. Prevention and control measures include vaccination, isolation and slaughtering of infected animals.

Brucellosis: This is an infectious bacterial disease. It is caused by the bacterium *Brucella* abortus. It is also known as contagious abortion disease. Brucella can infect cattle, goats, sheep, camels and pigs. The routes of transmission include direct contact with infected animals, tissue or fluids, and ingestion. The disease causes abortion and infertility. This results in a heavy economic loss. Symptoms include intermittent fever, reduced milk flow and enlarged testicles. Prevention is accomplished by good herd management. Dead animals should be burned or buried. Brucellosis also threatens the health of people if they eat infected (raw or unpasteurized) dairy products.

Anthrax: This infectious bacterial disease that afflicts ruminant animals. It

can also affect human. The causative agent is *Bacillus anthracis*. Animals usually get infected through contact with infected animals or materials and inhalation of spores. The disease is accompanied by high fever, convulsion, rapid breathing and sudden death. Prevention is possible through isolation of infected animals and disposal of the dead ones.

Newcastle disease (NCD): This is a well-known viral disease of poultry. Transmission can be airborne, or through contaminated vaccines and farm equipment such as feeders and drinkers. Birds may show signs of lack of appetite, respiratory difficulties, twisted neck, paralysis of the legs or wings, laying of soft shelled eggs, and watery greenish diarrhea. Culling of sick birds, quarantine and vaccination are recommended measures of prevention and control.

Taeniasis: This disease is also known as tapeworm infection disease. It affects cattle and pigs. Anaemia, vomiting and discomfort are symptoms of the infection. The common mode of transmission is through the soil during feeding. Regular de-worming and good sanitation are recommended control measures.

8.3. Internal and External Parasites of Farm Animals

A parasite is an organism that lives in or on another host organism to get its nourishment. Over 1,000 species of parasites affect domestic animals. Parasites can be broadly classified into internal and external, depending on where they live. Animal parasites cause loss of production and high mortality rate. This results in negative financial impacts on farmers. They may also cause or transmit diseases. Diseases that occur due to parasites are called parasitic diseases.

Internal parasites (Endoparasites) live in the blood or tissues of the animal's body. Tape worm, round worm, trypanosome and liver fluke are good examples of internal parasites. They often interfere with the animal's digestion and assimilation of food. They share the animal's food and cause diarrhea, anaemia and loss of condition. The consequence is often death, if there is no effective treatment. This leads to loss of production and income.

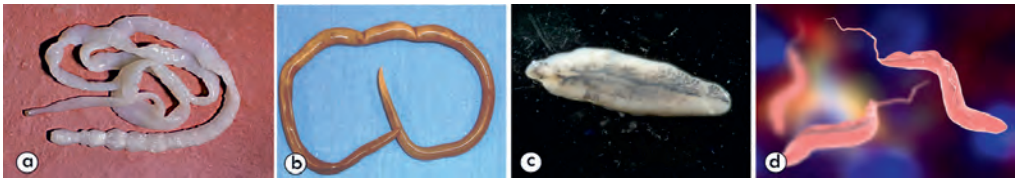


Figure 8.1. Internal parasites a) tape worm, b) round worm, c) liver fluke, d) trypanosome

External parasites (Ectoparasites) often annoy their hosts by biting, embedding, or irritating the skin. Good examples are ticks, flies, lice, and mites. They attack the blood, skin or hair of the host. They cause anemia, weight/condition loss, restlessness, skin irritation and skin destruction. External parasites may cause serious diseases (e.g., mange and scabies) or transmit diseases (e.g., red water and trypanomiasis). For example, the bite of a tsetse fly transmits trypanosomiasis. Mange is an infectious skin disease of animals caused by mites and results in hair loss, scabs, and itching. Scabies is a contagious skin disease marked by intense itching, inflammation and red papules. Red water is a disease characterized by the passage of reddish urine.

Figure 8.2. External parasites a) tick, b) mites, c) lice

8.4. Effects of Diseases and Parasites on Animal Production

Brainstorming 8.3.

Work in small group.

What do you think are the negative effects of diseases and parasites on: a) the animal, b) the farmer, c) the country?

Diseases and parasites are among the greatest constraints in animal production. Their effects may be expressed in different ways. Sick animals eventually fail to produce or reproduce to their ultimate capacity. Such loss

of productivity is loss for the farmer. The fate of sick animal may also be death (mortality). Both production loss and mortality are loss to a farmer.

Another effect of animal diseases and parasites is economic loss. These may arise in several forms. Reduction in productivity and mortality result in money loss. Farmer has less product to sell and/or has a reduced number of animals. External parasites attack the coat of animals. This degrades the market value of hide, skin and wool. Diseases and parasites limit the export of live animals and their products to other countries. Costs of control, prevention, diagnosis and treatment are also expensive. Consequently, disease and parasite outbreaks also affect food and job security. Any of these can results in an economic loss to the farmer as well as a nation.

An additional effect of animal diseases and parasites is the public health concern. Some animal diseases are transmittable to humans. Such diseases are called zoonotic. Transmission often occurs through the consumption of food products from infected animals. More than 150 such diseases are known. Examples are brucellosis, anthrax, salmonellosis and taeniasis.

Activity 8.2.

Work independently.

Name three examples for each category of disease/parasite and fill in the table below.

Infectious diseases	Non-infectious diseases	Parasitic diseases
Zoonotic diseases	**Internal parasites**	**External parasites**

8.5. Prevention and Control of Common Farm Animal Diseases

8.5.1. Prevention and Control of Diseases and Parasites

The control and prevention of diseases and parasites is an important activity in livestock rearing. Prevention refers to measures that are applied to prevent the occurrence of a disease. Control refers to measures applied to prevent transmission after the disease has occurred. The prevention and

control of diseases and parasites involves the following practices.

- **Proper hygiene or sanitation**: Hygiene or sanitation is an effective strategy for the control of infectious disease and parasite infestations. Washing feed and water troughs well is one helpful measure. Separating sick animals from the healthy ones is another. Dead animals should be either burned or buried.
- **Good management:** Animals that are provided with the essential nutrients can resist the effect of disease and parasite attacks. Keep animals' house well ventilated and dry. In pasture grazing, following rotational grazing and avoiding overcrowding is recommended.
- **Quarantine and isolation:** Purchase only healthy-looking animals from reputable farms. At arrival, quarantine the new animals, by keeping them away from the other animals for two weeks until you're sure they aren't sick. Isolate any sick animals to prevent illnesses from spreading.
- **Medication:** This is one of the most important measures in controlling farm animal diseases. Timely vaccination against diseases and quarantining diseased animals are important. The use of drugs in the form of powder, liquid or solids can be another option.
- **Spraying or dipping:** Spray animals with chemical solutions or dip them in the solutions. This controls external parasites like flies, lice, mites and ticks. Spraying pens and animals with veterinary chemicals helps to control external parasites. Dipping animals in water containing chemicals such as wettable powders is good for controlling ticks, mites and lice. Farmers are encouraged to dip or spray their animals regularly.
- **Deworming:** Deworming is giving appropriate drugs to expel internal parasites from animals. De-wormers include piperazine that controls roundworm. Internal parasites are also controlled with drugs, antibiotics or drenches.
- **Biosecurity:** is Biosecurity refers to measures taken to prevent the introduction and/or spread of harmful organisms to animals and plants. Controlling animal mixing, unnecessary personnel entry to

farms and using protective clothing are examples of bio-security measures.

8.5.2. Indigenous Knowledge in Livestock Disease Treatment

In Ethiopia, plant-based remedies are the most important and sometimes the only method of managing livestock diseases. It is an inexpensive alternative to science-based treatments. Farmers mostly acquire ethno-veterinary knowledge from their elders. Indigenous veterinary practices include mechanical, physical, pharmacological, surgical, rituals and managerial methods of treatment. Several medicinal plant species of veterinary importance are documented. Most medicinal plants are collected from the wild. The plant parts used for livestock health treatment may be leaf, root, rhizomes, bulb, bark, seed, stem, whole parts; alone or in combination.

The preparation methods of traditional medicine are concoction, squeezing, crushing or pounding. Concoction (mixing things together) is the major form of preparation of herbal medicines. Farmers are aware of toxicity and provide antioxidants. They can determine the dose using different household utensils. Farmers can also use their own hand. Ethno-veterinary medicines are administered to livestock in different ways. Oral route is the most common mechanism of application of traditional medicines.

A large number of livestock diseases and parasite syndromes are treated by traditional practitioners. Anthrax, black leg, ectoparasites and endoparasites are good examples of livestock disease and parasite syndromes treated using traditional medicines. Rabies, foot and mouth disease, bloat, and colic are other examples of animal diseases treated in this way. Besides plant-based medications, some animal fluids are used in traditional medicine. For example, the Somali pastoralists in Ethiopia immunize their animals against rinder-pest by employing a solution of urine, milk and faeces obtained from the animal with mild cases of rinderpest.

Activity 8.3.

Field Visit

In small groups, visit the farmers in your area and ask if they use indigenous knowledge in the treatment of disease on their farm.

- Find out how they acquired the knowledge.
- Ask the farmers the names of plants and plant parts used in the preparation of the remedy.
- Ask also about methods of preparation and how they determine the dose.
- Find out the routes of administration or applications of the medicine.
- Get information on the common types of diseases and parasites treated by traditional practitioners.
- Discuss the advantages/drawbacks of these traditional practices or techniques?
- How do you see the commitments that the local farmers make to treat their sick animals?

*Prepare a report and present it for classroom discussion.

Unit Summary

In this unit you have learnt that:

- a disease often results in death or production loss in herds/flocks
- common routes of transmission of pathogens are direct contact, ingestion, inhalation, uro-genital tract, placenta and vectors
- there are two types of diseases: infectious (pathogenic and transmittable) and non-infectious (non-transmittable)
- major animal diseases in Ethiopia include foot and mouth disease, anthrax, tuberculosis, brucellosis, contagious bovine pleuro pneumonia, Newcastle diseases and trypanosomiasis
- there are two types of parasites
  - external parasites: e. g., ticks, mites, flies and lice
  - internal parasites: e. g., roundworms, tapeworms, liver fluke and trypanosome
- effects of disease and parasites are morbidity, mortality, economic and zoonotic effects
- diseases and parasites can be prevented through changes in animal husbandry such as
  - proper hygiene, good management, medication and adapting bio-security measures
  - dipping or spraying and deworming of animals regularly
- traditional veterinary practices are cheap alternatives to scientific medications
  - different parts of plants are good source of medicines
  - oral administration is the most common method of application

Review Exercise

Part I: Choose the best answer from the given alternatives.

1. What name is given to the process of giving drugs to expel internal parasites of animals?
   A. Spraying
   B. Dipping
   C. Deworming
   D. Debeaking
2. Which one of the following is a parasitic disease?
   A. Mastitis
   B. Trypanosomiasis
   C. Coccidiosis
   D. Brucellosis
3. Which of the following method is the major form of preparation of herbal medicines in traditional way?
   A. Squeezing
   B. Crushing
   C. Pounding
   D. Concoction
4. Identify the false statement about non-infectious diseases.
   A. Non-infectious diseases are not caused by pathogens.
   B. Anthrax, FMD and Newcastle disease are examples of non-infectious diseases.
   C. Non-infectious diseases cannot be passed from animal to animal.
   D. Non-infectious diseases may be caused by hereditary factors or by the environment in which an animal lives.
5. Some types of animal diseases are communicable to humans. What are such diseases called?
   A. Infectious
   B. Pathogens
   C. Vectors
   D. Zoonoses
6. Which of the following is external parasite (ectoparasite) of farm animals?
   A. Tape worm
   B. Liver fluke
   C. Tick
   D. Round worm

Part II: Answer the following questions.

1. Define briefly health, disease, symptom, control and prevention.
2. List the general symptoms of sick animals.
3. Write the effect of diseases and parasites in animal production.
4. Write the different measures of prevention and control of diseases and parasites in farm animals

Unit 9 Dairy Cattle Production and Management

Contents	Learning Outcomes
9.1. Introduction to dairy cattle production and management 9.2. Dairy cattle breeds and their selection 9.3. Feeding management of dairy cattle 9.4. Milk production and processing 9.5. Dairy cattle housing management 9.6. Major diseases of dairy cattle and their control methods 9.7. Profitability in dairy business	At the end of this unit, you will be able to: ▪ describe different dairy cattle breeds and their selection criteria ▪ describe dairy cattle feeding management ▪ explain milk production and processing ▪ internalize the concept of lactation cycle in dairy production ▪ realize dairy cattle housing, sanitation and manure management ▪ list major diseases of dairy cattle and control methods in their localities ▪ calculate profitability in dairy business

9.1. Introduction to dairy cattle production and management

Brainstorming 9.1.

Pair work

In pairs, discuss what you already know about dairy cattle production or dairying.

*Share the summary of your discussion with other pairs of students sitting next to you.

Dairy type cattle are raised for milk production. Cattle of this type are excellent in converting feeds into high quality milk. Some categories of cattle are raised for both meat and milk production. These are called dual-purpose cattle. Other cattle have the properties of a typical dual-purpose cattle (i.e., milk and meat production). These cattle also have some features of working cattle such as strong bones, sound constitution, and quiet temperament. These are called multi-purpose cattle.

In this unit, you will learn about the dairy cattle types. Dairying or dairy cattle production is a branch of agriculture that encompasses the raising of dairy animals for the production of milk and milk products. Milk is the primary product of dairying. Before producing milk, a cow must first have a calf. Female calves of modern breeds reach sexual maturity at the age of seven or eight months and are then called heifers (i.e., before having their first calf or having only one calf). Heifers are usually mated when they are 15 to 18 months old. This age is said to be the age at first service. The gestation period typically lasts 265 to 300 days. Heifers tend to give birth to their first calves at the age of 2 to 2.5 years. They are typically bred again four to eight weeks after calving. Good dairy farming practice involves the production of safe and high quality milk from healthy animals. This involves different management practices such as breeding, feeding, housing, health care and record keeping.

9.2. Dairy Cattle Breeds and Their Selection

Brainstorming 9.2.

Discuss in small groups.

1. List down dairy cattle breeds common in your locality.
2. Do you think there are different breeds of dairy cattle in the community? If there are different breeds in the community, how can you tell one breed from the other breed?
3. In your opinion, how do farmers in your area select high yielding dairy animals?

*Report the summary of your main points to the whole class.

All domestic cattle of the world are in the scientific family *Bovidae*. Cattle are classified into two groups: *Bos indicus* and *Bos taurus*. Each group has its characteristics. The two groups are different in terms of conformation, fitness characters and production abilities.

Table 9.1. Characteristic of Indigenous (*Bos indicus*) and Exotic (*Bos taurus*) Cattle

Characteristics	*Bos indicus*	*Bos taurus*
Conformation	Much narrower body, longer legs, very prominent dewlap; humped	Wider body, shorter legs, less prominent dewlap; humpless
Environmental requirements	Adapted to tropical environment through natural selection (Africa and Asia)	Adapted to temperate environment through artificial selection (Europe and USA)
Management requirements	Adapted to tropical environment through natural selection (Africa and Asia)	Adapted to temperate environment through artificial selection (Europe and USA)
Production abilities	Delayed maturity, long calving interval, slow growth rate, short lactation, and low milk yield	Early maturing, short calving interval, fast growth, milked up to 305 days, and high milk yield

Representative breeds	Sahiwal, Red Sindhi, Tharparker (Pakistan), Gir, Kankrej, Hariana (India), Kenana, Butana (Sudan), Ethiopian cattle breeds	Holstein Friesian, Jersey, Brown Swiss, Guernsey, Ayrshire, Milking Shorthorn, Red Danish

9.2.1. Ethiopian cattle breeds

There are many local cattle breeds in Ethiopia. They vary in size and colour. All indigenous cattle are multi-purpose (i.e., milk, meat and draft). There are around 27 recognized cattle breeds of Ethiopian origin. They are usually named after their place of origin. Examples are the Horro, Fogera, Arsi, Barca, Sheko and Boran cattle. There is no specialized local cattle breed considered as dairy type.

Fogera cattle

The Fogera breed is found in the north-western part of the country around Fogera, Gondar. The common coat color is white with black spots or patches. Fogera are a small sized breed. They can produce about 915 litre of milk per lactation. The butter fat content is 5.8%..

Figure 9.1. Fogera cow

Barca/Begait cattle

Barca originated in the west part of Eritrea, but is abundant in Tigray and Gonder. Coat colour is variable, but two colours (pied) including black is common. It is considered to be a good milk cattle. Milk yield is about 682 litres per lactation under extensive management conditions. Milk production is enhanced when managed intensively.

Figure 9.2. Barca cow

Arsi-Bale cattle

This breed is predominantly found in the highlands of the central region of Arsi and Bale. The coat colour is variable. It has a small body size. The breed possesses a compact body conformation. Selected Arsi cows produce up to 516 litres per lactation. The milk contains a high butter fat percentage (5.4 to 5.8 %).

Figure 9.3. Arsi-Bale cow

Horro cattle

Horro cattle originated in the western part of Ethiopia, around Horro Guduru, Wollega. The dominant coat color is brown and sometimes slightly lighter on the flanks and between the hind legs. They are medium sized animals. They are mainly raised for meat and draft use. Selected Horro cows can produce up to 543 litre/lactation.

Figure 9.4. Horro cow

9.2.2. Exotic dairy cattle breeds

The major breeds of dairy cattle in the world include the Holstein-Friesian, Ayrshire, Brown Swiss, Guernsey and Jersey. All of these major dairy breeds are originated in Europe. They are outstanding milk producers. The most popular exotic cattle breeds in Ethiopia are Holstein Friesian and Jersey. Holstein Friesian are well known for their higher milk yield. Friesian teat size is often preferred by farmers for both hand and machine milking. Jersey is the most heat-tolerant of the exotic breeds and are good

pasture animals in harsh environments.

Holstein Friesian

Holstein Friesian (HF) originated in the Netherlands. They have a Black and White or Red and White color pattern. Friesians are large, angular animals. They require more feed than other dairy breeds. Friesians are outstanding milk producers. They can produce more than 6600 litres of milk per lactation. However, Holstein Friesian milk is low in terms of butterfat (average 3.6%) and protein (average 3.2%).

Figure 9.5. Holstein Friesian cow

Jersey

Jersey is originated in the Island of Jersey, in the United Kingdom. It is a small-sized breed, with light gray to a dark fawn coat color. Jersey are well known for their well-shaped udders, stronger udder attachments and ease of calving. Jersey milk is the richest when it comes to butterfat (average 5%) and protein (3.8%). They require less feed than HF breed. They are good foragers.

Figure 9.6. Jersey cow

9.2.3. Dairy Cattle Selection

Brainstorming 9.3.

Individual Work.

1. List down dairy cattle breeds you already know.
2. What type of dairy cows do people in your community keep?
3. What selection criteria do you think they use in selecting the breeds of their choice?
4. Do you think the breeds kept in the community give satisfying yields to the owners?

*Share your answers with some students sitting close to you.

9.2.3.1. Choice of breed

The selection of dairy breed depends upon several factors.

Climatic conditions: Select dairy cattle breeds that are hardy and tolerant of tropical environmental conditions. The farmer should choose the breed that is most popular in their community. This indicates that the breed is well suited to the conditions of that locality (ambient temperature, poor quality feeds, parasitic and disease situation). Cross-breed animals with exotic inheritance of about 50% are preferable to retain the adaptability, heat tolerance and disease resistance traits of local animals, in cross breeds.

Production objective: Get information on the type of dairy product, fresh milk or butter that has a good market in the region. If there is good market for cheese and butter, then should select a cow that produces more cream, such as a Jersey and local breeds. If there is good market for fresh milk, then the farmer should select high yielder dairy breeds such as Holstein Friesians.

Feeding system: If the farmer uses a system of growing forage and grazing, they should select dairy breeds of high grazing ability. If the farmer uses a system of growing forage and employing cut and carry system, a breed with less grazing ability would be suitable.

Age of maturity: There is at least 4 to 5 months difference in age of maturity among the major dairy breeds. Heifers of small-sized breeds such

as Jersey and Guernsey come to production soon after 24 months of age. Large-sized dairy breeds do not come to production until they reach 28 to 30 months of age. Thus, if the farmer wants to start milk production early, small-sized breeds are best. Local breeds are generally slow to reach maturity.

Cost: Price should be the last consideration within reasonable limits. Locally grown cattle of equal quality should be cheaper due to considerably lower transportation and incidental costs.

9.2.3.2. Choice of individual animals

When the breed has been decided upon, the problem of selecting individual animals for the dairy herd must be considered. Selection of the right kind of foundation animals with which to begin dairying is very important. The following points should be given much consideration in choosing the animals-which are to form the foundation of a new dairy herd.

Physical characteristics: Dairy Certain physical characteristics indicate whether the animal is high milk producer or not. Such characteristics are used to judge the production potential of the animals. One can judge desirable conformation by closely inspecting the animal in question.

The indicators of good productive dairy cattle include general appearance, dairy character, body capacity and mammary system. The high yielding dairy cows are usually not large, and are characterised by a lean, angular form and a well-developed mammary system. They should have wedge shaped body appearance (i.e., the front portion being less deep than the rear), bright eyes and a lean neck. The udder should be healthy and large enough to produce and store milk. All four quarters of the udder should be well demarcated with well-placed teats. The udder should be attached high to the abdomen to prevent teat injury.

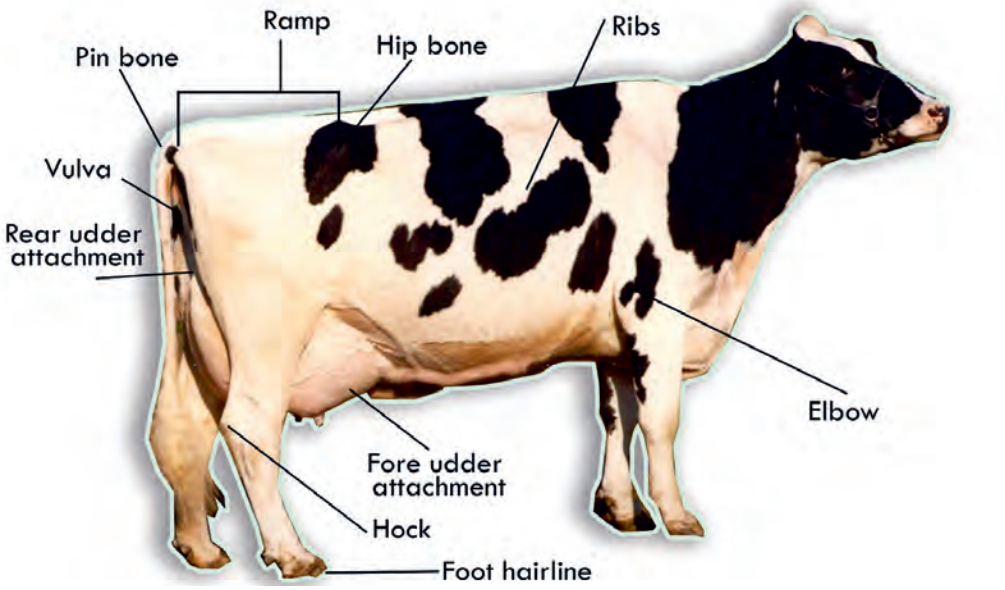


Figure 9.7. Physical characteristics of high yielding dairy cow

Performance records: Performance records are much more reliable for use in selection than visual appraisals. Performance records contain information on characteristics such as milk yield, milk composition, feeding efficiency, age at calving and condition at calving. The breeding ability of the sire or dam of prospective foundation females is another good guide in making a selection.

Free from diseases: : Important contagious reproductive diseases of breeding cattle are tuberculosis, brucellosis, leptospirosis, vibriosis and mastitis in females and trichomoniasis in bulls. The diseases can be minimized at the time of purchase by demanding negative results from high quality and timely tests.

Activity 9.1.

Class work

Imagine you are starting your own dairy farm.

1. Write a plan showing which breed you would select, and why.
2. List the important points you have considered to find suitable dairy cattle for your local area.

9.3. Feeding Management of Dairy Cattle

Brainstorming 9.4.

Individual Work

Write answers to the questions below. Your teacher will tell you what to do with the answers.

1. What cattle feed resources are available in your community?
2. Do you think the feed resource available is adequate to feed the cattle in the community?
3. If no adequate feed resource is available, what do you think the cattle owners should do?
4. Why do dairy cattle fed on roughage feeds such as crop residues and hay?

Supply of feed is a key factor on dairy farm. Dairy cattle feeding management is a very important farm management area for two reasons. First, nutrition plays a very important role in maintaining the health and productivity of dairy cattle. Second, feed alone constitutes 60 to 70% of the production cost of milk. This is why feeding management plays a vital role in farm economy. This management involves feeding a balanced diet and avoiding overfeeding.

Feed is of two types: roughage and concentrates. Roughage available on the farm includes grazing, hay, silage, and roots. Timothy, Clover and Alfalfa are the some kinds of green fodder to be given to dairy cattle. Concentrates are supplementary feeds and not a staple feed. Concentrates should contain high-energy feeds and protein supplements. The first four months of lactation will require a higher percentage of concentrates because production will be high during this time. Reducing concentrates for low-producing or cows in the late lactation period helps to reduce feed costs. In general, two-third of the daily dry matter requirement should be supplied from roughages. The remaining portion from concentrates.

Lactating dairy cows need energy, protein, fiber, vitamins, minerals and water. The nutrient requirement of lactating cows should be determined for maintenance as well as for milk production and to meet the fat percentage in milk and gestation. Maximizing dry matter (DM) intake provides more

nutrients to rumen microbes. This in turn provides more nutrients to the cow for milk production, milk composition, growth, reproduction and body condition. An efficient milking cow needs a daily dry matter intake equivalent to at least 3% of its body weight. For example, a 400 kg cow needs 400 kg × 3% = 12 kg DM/day. The higher producing cows will need more than 4% of their body weight as dry matter. For example, a high-producing (over 25 L/day) 450 kg cow needs 450 kg x 4% = 18 kg DM/day. Farmers can monitor the adequacy of daily dry matter intake of their lactating cows as presented in the following table.

Table 9.2. Indicators of adequate/inadequate daily dry matter intake

When there is enough dry matter in the diet	When there is not enough dry matter in the diet
▪ Milk yield and composition will be on target. ▪ Lush pasture allocation will not be fully eaten. ▪ Silage, grain or mixed feed will be left in troughs. ▪ Cows will not stand around 'waiting to be fed'. ▪ Body condition scores will be on target.	▪ Low milk yield and problems with composition will occur (mainly milk fat percentage will be variable). ▪ Cows will appear hungry; they shout and wait for feed. ▪ Cows will rush to fresh forage, to feed troughs, and into the dairy for grain. ▪ Cows will eat all feed allocated in paddocks and troughs. ▪ Body condition scores will be low.

Feeding management also involves providing abundant supplies of cool, clean, and pure water to optimize feed and nutrient use. Provision of clean drinking water is of great importance to lactating cows. No animal requires clean drinking water as much as a milk-producing animal does. To produce one litre of fresh milk, a cow requires five litres of clean and fresh water. This will vary with stress, weather conditions, heat, cold, disease, productive state, exercise, etc., as well as the water and salt content of the feed. Low quality or insufficient water greatly affect milk production. Water should be placed near feed sources and in milking parlor return

alleys. For water troughs, a minimum of 10 cm of length per cow at a height of 90 cm is recommended.

Activity 9.2.

Think-Pair-Share

Read these scenario and then answer the question that follow. A group of dairy farmers in Bishoftu town have 100 cross-breed dairy cows. They wanted to increase their profit and have a sustainable market. Unfortunately, they usually face a challenge of low milk production of their cows. This reduced their profit margin. In pair, suggest how the farmers might investigate the cause and propose a solution.

*Share your ideas with some students sitting close to you.

9.4. Milk Production and Processing

9.4.1. Milk Production

Dairy type cattle are primarily adapted to convert feed to a maximum of high quality milk. Milk is the primary product of dairying. Milk contains a variety of nutrients like calcium, iodine, potassium, phosphorous, fats, vitamins B2 and B12. Milk is important for food security. It influences both income and nutrition.

There are two types of milking systems. These are hand milking and machine milking. The choice of system depends on the level of operation, economic efficiency and number of cows to be milked. Select a calm and quiet place for milking cows.

Some important considerations involved in milking

- **Milking frequency:** Milking can be done twice or three times a day. But the interval must be regular. A sudden change in the time of milking affects the total yield.
- **Milking interval:** Interval between milking affects both quantity and composition of milk. The ideal interval is 12 hours.
- **Milking duration:** The ideal milking duration is 5 to 6 minutes for machines and 7 minutes for hand milking.
- **Milking order**: A suggested order is:
  1. first calf heifers free of mastitis
  2. older cows free of mastitis
  3. cows with history of mastitis but not showing the symptoms
  4. cows with quarters producing abnormal milk

*Newly introduced animals should be milked separately until their status is determined. Keeping the suggested milking order will help to prevent cross-infection during milking operation.

Activity 9.3.

In small groups, visit a dairy farm in your school or nearby area.

- Observe carefully the milking situation employed and individual cow's milk yield records. Which breed/s of dairy cattle is/are used? Which type of milking system is practiced? Is that hand milking or machine milking? How many times are they milking each day? At what time is the milking scheduled? How many litres of milk is harvested per day?
- Write a short report and present it in class on the strengths and weaknesses you observed. Do you have anything to recommend?

Concept of lactation cycle in dairy production

The lactation cycle is the period between one calving and the next. Mostly, cows calve every twelve months, as they must calve in order to be able to produce milk. The cycle is split into four phases; the early, mid lactation,

late lactation and the dry period. A normal lactation length for a dairy cow usually lasts around 10 months (305 days). The remaining two months are known as the "drying off" period. Colostrum is the first milk produced by the cow after calving. Milk yield will rise during the first months after calving, followed by a long period of continuous decline.

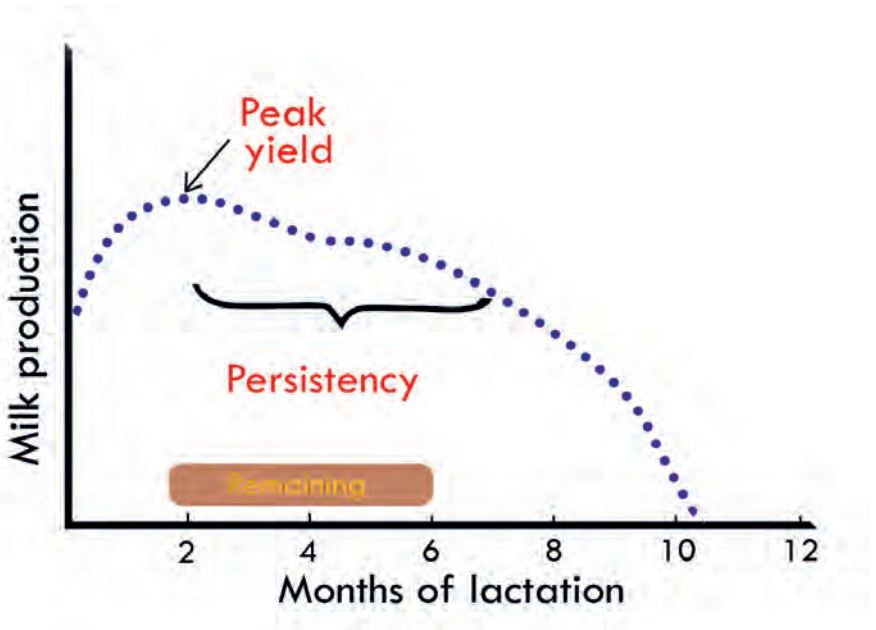


Figure 9.8. Lactation curve

The shape of the lactation curve will differ for each individual and also the breed of the animal. Feeding and management will also influence the shape of the lactation curve and have a significant impact on the total amount of milk produced. Peak yield is the point where the cow reaches the highest milk production level during the entire lactation. Normally the peak is reached four to ten weeks after calving. Milk yield remains high for a while and then gradually declines in the later stage of lactation.

The dry period is the most important phase of a dairy cow's lactation cycle. The dry period normally ranges from 55 to 60 days. This is meant for preparing the cow for the next calving or lactation. Therefore, any abnormalities during the dry period will have a negative effect on the cow's health and milk production after calving.

Cows should be encouraged to maximize their intake during early lactation. Cows should reach maximum dry matter intake no later than 10 weeks

after calving. At this point, cows should be eating at least 4% of their body weight. The cow should be fed a ration that will maintain peak production as long as possible.

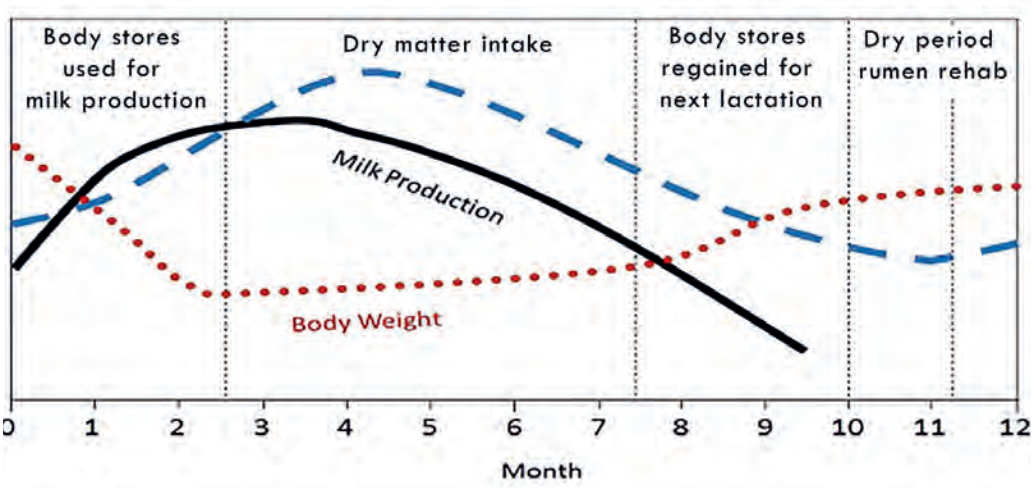


Figure 9.9. Changes in body weight, dry matter intake and milk production over a single lactation period

Activity 9.4.

Answer the following data response questions based on the above Figure.

Look carefully at Figure 9.9. In a small group, discuss the relationship between dry matter intake, milk yield and body condition scores of lactating dairy cows. What type of feeding management do you recommend at each stage? Discuss the profitability of a dairy farm in relation to lactation stage? Hint: use internet resources or discuss with your teacher.

9.4.2. Milk Processing

Milk is a valuable nutritious food. However, milk is an excellent medium for the growth of microorganisms. This results in spoilage and food-borne illness to consumers. The shelf life of milk can be extended for several days through techniques such as cooling or fermentation or processing. Cooling is the most common choice for maintaining the original quality of milk for consumption and processing. Milk should be cooled immediately after milking, and be kept as cold as possible. The best temperature to

keep the milk is 4 °C (or below). Cooling can be achieved by a mechanical refrigeration or cooling tanks.

Milk processing converts raw milk into high-value dairy products such as pasteurized liquid milk, cream, yoghurt, cheese, butter and ghee. Hygiene at all stages of milk collection and processing is very important. Milk can be transported in milk cans or bulk tankers from collection to a processing center. There are several reasons for milk processing. Basically milk is processed to increase shelf life and palatability of milk products. Processing reduces bulkiness (i.e., can reduce the space taken up by milk). This allows producers to access distant markets and satisfy consumer demands. It also creates employment opportunities.

Pasteurized milk

Pasteurized milk is dairy milk that is heated to a high temperature and cooled using a simple heating process to destroy any harmful bacteria and micro-organisms. This also extends the shelf life. Supermarket milk is always pasteurized. During pasteurization, milk is heated to between 63 and 65°C for 20 to 30 minutes or 72 to 75°C for 15 to 30 seconds. The simplest equipment required is an open boiling pan over a fire. Pasteurized milk has a shelf life of 2 to 3 days, and up to 12 days if kept at 4 °, depending on the environmental conditions.

Cream

Cream is a dairy product composed of the higher-butterfat. When milk is left to stand for some time, the lighter fat globules rises to the top. This top layer of fat is called cream, whereas the remaining milk is known as skim milk. The whole fresh milk might be separated into cream and skim milk. Separation can be achieved using a manual or powered centrifuge separator. There are different types of cream, each with different fat concentrations. Single or light cream contains 18% milk fat whereas double or heavy cream normally contains 48% milk fat. Cream is a luxury item and may be used in coffee, as a filling in cakes, or as an ingredient in ice cream. Fermented cream can also be processed into butter and butter milk.

Fermented milk

Fermentedmilk products are created when milk ferments with specific kinds of bacteria and sometimes yeast. The acidity prevents the growth of micro-organisms, and the fermentation preserves the milk for a long time. Yogurt is the best-known fermented dairy product. Yoghurt is produced by adding a mixed culture of *lactobacillus bulgaricus* and *streptococcus thermophilus* (in a ratio of 1:1). This is to convert lactose (i.e., milk sugar) to lactic acid.

Milk is normally heated at 70 °C for 15 to 20 minutes, using an open boiling pan, or a steam jacketed pan. The milk is cooled to 30 to 40 °C and then the culture is added. The product is left at a temperature of 32 to 47 °C for approximately five hours for the fermentation process to be completed, and then immediately cooled to 4 °C.

Cheese

Cheese is a concentrated form of milk-fat and milk-protein. Cheese can be produced from whole milk, sour milk, skim milk and butter milk. The cheapest way is production from butter milk or skim milk. Cheese is produced with the objective to prolong the shelf life of product, reduce spoilage, reduce the load and increase palatability. Despite variations due to several factors, cheese has all milk contents, and basically is composed of concentrated milk fat, casein, salts, lactose, and to some extent, albumin.

In making cheese, milk is coagulated by direct acidification, by lactic acid produced by bacteria, by adding rennet, or a combination of acidification and addition of rennet. After that, coagulant is heated at about 50 ^{o}C for at least 20 minutes. The solid left is referred to as cheese, while fluid left over is whey. Hard cheeses have most of the whey drained out and are pressed. Soft cheeses contain some of the whey and are not always pressed. Cheese can be stored for a long time at 5 to 10 ^{o}C.

Cottage cheese processing

Sample: whole fresh/sour milk and skim milk

Apparatus/equipment: pH meter, muslin close (cheese sieve), weighing balance, salt, plastic pails, molder with presser and scooper.

Reagent: with the absence of rennet or starter culture (lemon juice or lactic acids, acetic acid or acid whey).

Procedures

1. Put on personal protective equipment and clothing.
2. Take whole milk and boil it for about 83 - 85 ^{o}C for 20 minutes.
3. Add 30 ml of lemon juice through diluting with equal amount of pure water.
4. Stirring gently for 3 minutes continuously after adding lemon juice.
5. Stop heat treatment and allow curd to settle for 15minites.
6. Remove out the cheese or curd by scoop and filter by sieve (Filtering).
7. Add 40g of salt/kg of cheese and mix it thoroughly, if necessary.
8. Fill the packs/ moulds and press by cheese presser and allow it overnight.
9. Remove out the cheese from molder and store in to appropriate place.
10. Clean and store properly all the equipment and apparatus used.

Butter

Butter is a semi-solid product, made by churning fresh or fermented cream. It contains approximately 80 to 85% milk fat, 15 to 16% water and 2% solid-non-fat (SNF). It may be yellow or white in color. It has a bland flavour and a slightly salty taste. Butter is a valuable product that has a high demand and is used as an ingredient in other food processing.

Butter making

Sample: Sour whole milk and sweet cream

Apparatus/equipment: pH meter, thermometer, electrical churner, weighing balance, salt, plastic pails.

Procedures

1. Put on personal protective equipment and clothing.
2. Clean the inside of a churner by iodized water or salted water.
3. Operate the churner before rinsing out and remove out through their out let.
4. Take the prepared sour whole milk and sweet cream.
5. Dilute fermented cream with pure water to make less viscous.
6. Adjust the churning temperature of the milk with in arrange of 14 -17 ^{o}C.
7. Make sure the out let of churner is tightly closed.
8. Pour the milk/ cream in the churner; it should not be filled to half of its volumetric capacity of the churner.
9. Close the opening of the churn tightly.
10. Switch on the churner in order to allow agitation.
11. Open the churn within 30 seconds interval for 10 minutes in order to remove the gas.
12. Continues agitation until butter grains are formed.
13. Drain the skim milk in plastic pail through their out let.
14. Wash the butter by cold water having a temperature lower than butter temperature by 2 -3 ^{o}C and drain the water.
15. Take the butter from the churn and soak or knead in cold water.
16. Add 16g salt /kg of butter and mix it thoroughly, if necessary.
17. Determine the volume and fat content of the buttermilk, moisture content of the butter
18. Clean and store properly all the equipment and apparatus used.

Ghee

Ghee, also known as 'clarified butter oil', can be prepared from butter by direct heating to 110 to120 °C. Milk or cream is churned into butter and then the water is evaporated at a constant rate of boiling. Ghee can be stored more easily than butter in the absence of refrigeration. Ghee is almost entirely butterfat. It has no or low moisture and SNF contents, which inhibits bacterial growth.

Summary of industrial method of milk processing

1. Put on personal protective equipment and clothing.
2. Assemble and clean all the necessary materials required for milk processing.
3. Prepare whole milk.
4. Separate the whole milk in to cream and skim milk by cream separator (centrifugal/ gravitational way).
5. Churn the cream by churner to get butter milk and butter (concentrated fat, 85%).
6. Heat the butter to get ghee (melted butter, 89% fat).
7. Heat the skim milk at 50 °C for 20 minutes to get whey and cottage cheese.
8. Clean all the materials after completion of processing.

Activity 9.5.

Demonstrate milk processing in small groups.

Milk is usually processed into pasteurized liquid milk, cream, yoghurt, cheese, butter and ghee. Your teacher will divide the class into six groups. Each group should make one of these milk products and report back to the whole class. Where possible, each group can investigate the rate of fresh, pasteurised, sterilised and spoiled milk.

- Ask your school/teacher to arrange simple tools such as thermometer, cream separator, churner, pasteurizer, curd knife, cheesecloth, butter muslin, cheese molds, cheese press, etc. needed for milk processing.

9.5. Dairy Cattle Housing Management

Brainstorming 9.5.

Individual Work.

Write a few points you can remember from Unit 7 about the 'Significance of animal housing and their types'.

Dairy cattle may be successfully housed under a wide variety of conditions, ranging from close confinement to having few restrictions except at milking time. However, two types of dairy houses are, in general, used commonly. These are the loose housing and the conventional barn (See Unit 7 for details). The type of housing depends on the climate, local tradition and availability of building supplies. Loose housing with milking parlor is ideal for tropical regions like Ethiopia.

Whatever the type of housing, careful planning of buildings is essential in developing an integrated and efficient layout for producing quality milk. Housing should be an appropriate size for cows. This will allow them to stand or lie down easily. Respiratory infections and injuries can also be greatly reduced by the provision of adequate housing. Buildings must provide proper ventilation to reduce the spread of disease. The air in the barn should always be fresh, pure and free of dust and dirt. Good drainage is essential. Floor should be of rough concrete finish with 1.5% slope towards drain. Floor should not be slippery.

Table 9.3. The floor and trough space requirement of dairy cattle

Type of animal	Floor space per animal (m^2)		Trough length per animal (cm)
	Covered area	Open area	
None-pregnant cows	6-9	24-30	51-61
Young stock	4.5-6	15-18	38-51
Pregnant cows	30-36.5	55-61	61-76
Bulls	36.5-42.5	61-76	61-76

Sanitation and manure management in dairy farm

Maintaining good sanitation or good hygiene is a key element in maximizing quantity and quality of milk. This helps to minimize contamination caused by the entry of pathogens and bacteria from unhygienic milking procedures,

equipment, milk contact surfaces, handlers, storage or packaging conditions. Ongoing pen sanitation is an absolute necessity in preventing many of the infections that can debilitate dairy herds, both for calves and cows. Sanitation routines in dairy farm include regular cleaning of floors, bedding, walls and feeding surfaces. Modern sanitation equipment, when used with properly diluted chemicals on a regular basis, is key in preventing infections such as mastitis, ringworm, mange, foot rot and enteric diseases (i.e., cause intestinal illness) such as E. coli and Salmonella. Similarly, the presence of flies and other insects in the farm area disturb the animals and also spread deadly diseases such as bovine Babesiosis and Theileriosis to dairy cattle.

Manure is a valuable resource on the farm as a great source of nutrients for crop production. It can help to improve soil health. Dairy cattle produce a lot of manure. Each day each cow (large breed) produces 20 to 30 kg faeces and 10 to14 kg urine plus shed effluent from washing down floors. When not managed properly, the manure problem is associated with a number of issues, such as the community concern about pollution (smell, as well as contamination of groundwater and water courses). This is because manure contain Nitrogen, Phosphorous and Carbon.

The most common method of manure management is storage in pit and spreading. A manure pit should be dug, large enough to hold the shed's manure produced over 2 or 3 days. House floors should be designed for efficient drainage with wide channels for easy urine and faeces removal. A channel should be dug leading from the house floor to the pit and lined with concrete. This permits dairy farmers for manure collection, storage and application as a natural fertilizer for crops. This effective management of manure will allow farmers to grow their own feed for their cows. They spread manure over their forage fields before a crop is planted or practice composting to apply to their crops or sell to local nurseries. Manure can also be used for biogas production.

Activity 9.6.

Dairy farm visit

In small groups, visit a dairy cattle farm in your locality and identify the type of housing found there. Ask the owners of the farm why they chose that specific housing type for that area. How much of the housing on the farm is a reflection of indigenous knowledge? To what extent do you think the housing system fits the criteria you know about dairy cattle housing? Look at the way a farmer deals with manure. Report your finding to the whole class.

9.6. Major Disease of Dairy Cattle and Their Control Methods

Brainstorming 9.6.

Individual Work

Write down short answers to the questions below. Check your answers against the relevant section in Unit 8. Do this quickly.

1. List down three of the animal diseases you studied in Unit 8.
2. Do you remember the causes of the animal diseases? Write them down.
3. Do you remember their effects on the animals? Mention few examples.
4. Do you know how to prevent or control the animal diseases?
5. Do you know how to prevent or control the animal diseases?

Good feeding and breeding will not result in a maximum production if dairy cows are not kept in good health. The best economic returns are realized when disease problems are kept to a minimum. Diseases such as foot and mouth disease (FMD), blackleg, anthrax, brucellosis, chronic respiratory disease (CRD) and contagious bovine pleuropneumonia (CBPP) heavily affect dairy cattle. There are also various internal parasites like liver fluke and schistosomiasis. External parasites include ticks, flee and tsetse flies. Some diseases of nutritional disorders include bloat, diarrhea, acidosis, ketosis and milk fever. Dystocia, retention of placenta and vaginal prolapses are among the most common reproductive diseases of dairy cattle. Many diseases can be prevented through good herd management, proper nutrition, housing and vaccinations. Table 9.4 presents a summary of common diseases of dairy cattle with their symptoms, routes of transmissions and

prevention and control measures.

Table 9.4. A summary of diseases of dairy cattle

Name and type of disease	Symptoms	Transmission	Prevention and control measures
Chronic Respiratory Disease: Viral	Swollen face, nasal discharge and difficulty in breathing	Through contaminate feeds, water and beddings	Vaccination, good sanitation and good ventilation
Bovine tuberculosis (TB): Bacterial	Dry coughs with blood stained sputum, emaciation and death	Inhaling droplets (aerosol) that contain the bacteria, orally by contaminated feed	Vaccination
Blackleg: Bacterial	Lameness, depression, loss of appetite and a hot painful swelling on a limb which crackles when pressed	Ingestion of bacterial spores while grazing	Vaccination
Mastitis: Bacterial	Uneasiness during milking, traces of blood in milk, swollen udder and pains around udder	Through contaminated feed and water, injury on the udder and teat, dirty environment	Disinfection of hands before milking, good sanitation, avoid overcrowding, and use of antibiotics
Trypanosomiasis: Protozoan	Drowsiness, severe anaemia, loss of weight and death	Through tsetse fly (Glossina species)	Use of insecticides and good sanitation measure

Note: *Details of Foot and Mouth Disease (FMD), Contagious Bovine Pleuropneumonia (CBPP), Brucellosis, Anthrax, and Taeniasis are covered in Unit 8 under major diseases of farm animals.*

Activity 9.7.

Class work (Individual activity)

1. Write the major diseases and parasites of dairy cattle in Ethiopia.
2. Write a day in the life of a dairy farmer, detailing all the steps which the farmer would take during an average day to prevent disease.

9.7. Profitability in Dairy Business

Milk production, processing and marketing have profitable margins in Ethiopia. Demand for dairy products is expected to rise with a growing economy and an increasing number of urban middle class consumers. This makes the dairy sector an interesting sector for investors and developers. It also creates employment opportunities, especially for the young.

The main purpose of dairy farm is to earn income from milk sales. Not all the return from sales of milk is a profit. There are a lot of farm expenses such as feed, supplements, medication, labor and other expenses. Therefore, profit is calculated as income minus expenses. The following hypothetical example will illustrate the calculation of profitability in a dairy operation in Ethiopia.

A dairy farm profit analysis (Indicative only)

A farmer has 10 cross breed dairy cows and each producing about 12 liters of milk per day on average. This means the farmer will get 120 liters of milk per day. This is equal to approximately 3600 liters per month.

- In most of the towns, a liter of milk is sold at 50 birr on average.
- At this price, if the farmer sold all his/her milk he/she would receive 6000 birr per day, approximately 180, 000 birr per month.
- Estimated monthly farm expenses (i.e., the cost of feeds, supplements, medications, labor and other expenses) = 125, 250 birr
- Net profit per month: 180,000-125,250 birr = 54, 750 birr per month

Profit margins can be maximized if farmers employ good management practices at farm level. Some key indicators of such practices include farm forage production management, feed and nutrition management, fertility

management, hygienic milk production and marketing, etc. For example, forage production management ensures year round forage supply for the farm, and covering more feed from on farm forage production. In any dairy farm, major expenditure is on feed (nearly 60 to 70%). A constant supply of good quality grasses and legumes will help a farmer to reduce feed costs. Green forage helps in producing more milk and saves the cost of feeding for the owner. This contributes to better profitability.

Unit Summary

In this unit you have learnt that:

- dairy cattle production is the practice of keeping cattle for production of milk and milk products
- dairy type cattle breeds are triangular in characteristics
- they have well-developed mammary system
- selecting high-yielding and resistant breeds that fit the environment is recommended
- the breed that fits the local environment should have such characteristics as disease resistance, adaptability, and feeding capability on poor quality feeds
- high producing dairy cow should be fed on a large volume of nutrient daily to sustain the milk production at that level
- milk processing is an important mechanism in the preservation of food constituents as sources of nutrients and cash for many people in the world
  - milk processing converts liquid milk into high-value and concentrated dairy products: pasteurized liquid milk, cream, yoghurt, butter, cheese and ghee
- proper dairy cattle housing must provide a comfortable, well-drained and dry lying area
- sanitation and manure management is one of the most essential elements in any dairy farm
- the best economic returns are realized when health problems are kept to the minimum
- links between improved management practices and improved productivity are clear
- this is the solid foundation of profitable farming

Review Exercise

Part I: Choose the best answer from the given alternatives.

1. Which one of the following exotic dairy cattle breed is the highest milk producer?
   A. Holstein Friesian
   B. Ayrshire
   C. Fogera
   D. Jersey
2. One of the following is not a basis in choosing a breed. Which one is it?
   A. Adaptability
   B. Feeding system
   C. Production objective
   D. Attractive appearance of cattle
3. The highest fat content is found in which one of the following dairy product?
   A. Butter
   B. Cream
   C. Ghee
   D. Cheese
4. One of the following is a reproductive disease of dairy cattle. Which one is it?
   A. Mastitis
   B. Dystocia
   C. Anthrax
   D. Rickets
5. What temperature should milk to be cooled to after milking?
   A. $\leq 4°C$
   B. $>10°C$
   C. 37°C
   D. 14°C

Part II: Answer the following questions.

1. List five local cattle breeds of Ethiopia.
2. Write the characteristics of high yielding dairy cows.
3. What is the term for the span of time that a cow is giving milk?

Unit 10 Introduction to Natural Resources

Contents	Learning Outcomes
10.1. Definition and importance of natural resources 10.2. Major types of natural resources 10.3. Degradation of natural resources	At the end of this unit, you will be able to: ▪ define natural resources ▪ describe natural resources in their areas ▪ classify natural resources into renewable and non-renewable resources ▪ explain the importance of natural resources ▪ describe the causes of natural resource degradations ▪ explain the consequences of natural resource degradation

10.1. Definition and Importance of Natural Resources

Brainstorming 10.1.

Individual work.

1. What are natural resources?
2. What are the uses of natural resources?
3. What major natural resources do you know in your surrounding?
4. Can you classify natural resources according to some criteria of your own?
5. What is natural resource degradation? Causes and consequences of natural resources degradation?

* See your answers again after this lesson.

Definition

Natural resources are objects or materials, creatures or energy found in nature which can be used by humans. Hence, natural resources cannot be produced by humans, but they are used by humans. Natural resources are either renewable or non-renewable. Renewable resources are capable of regenerating themselves after use. Forests, soils, water, biodiversity, atmospheric air are examples. Non-renewable resources are resources that cannot regenerate themselves after being used once. Examples include oil, coal and minerals that occur in the natural environment.

Importance

Natural resources provide both direct and indirect benefits to humans. Some benefits are current benefits while others are only visible in the future. Most of our food and drink are directly or indirectly derived from natural resources. Natural resources are the sources of our clothes and shelters. Our survival, as a species, is dependent on the availability of natural resources. Economic growth and development of a nation is highly determined by the magnitude and quality of the management of natural resources available in the country.

10.2. Major Types of Natural Resources

The supply of natural resources and the services we get from them is fixed by nature. Generally, natural resources can be classified into several

categories. Such classification helps to identify and effectively execute sustainable managements of the resources to improve the quality of life for both current and future generations. Forests, soils, and water are natural resources closely associated with agriculture and will be the focus of this unit.

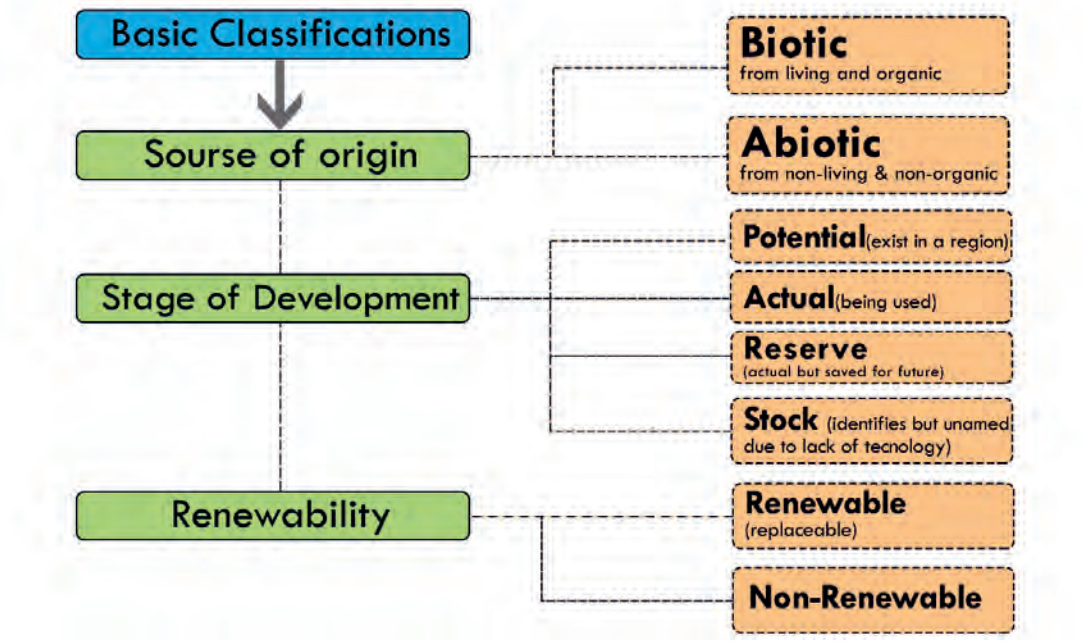


Figure 10.1. Classification of natural resources

10.2.1. Forests

Forests contain various plants or trees which stand very close to each other. In a forest, the leaves of tall trees form a continuous canopy. This significantly reduces the amount and quality of light that reaches the ground level and influences other climatic variables in the forest ecosystem. This in turn determines the number and types of different groups of plants, animals and microorganisms that live in the forest.

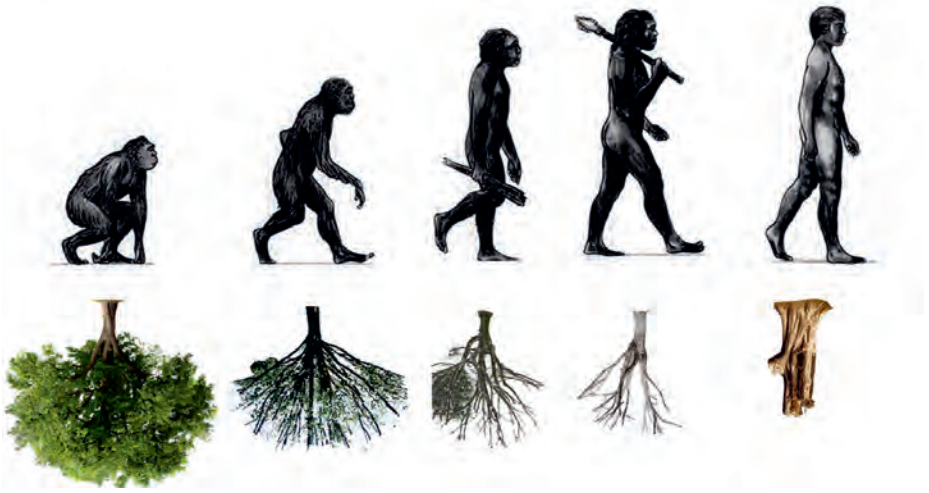


Figure 10.2. The evolution of man and forest

Importance of Trees in the Environment

Trees provide us with a wide range of products and services. These include firewood, fruits, medicines, timber and food. They are sources of construction materials. Trees provide us with shade and protect us from a strong wind. Trees also have aesthetic and spiritual value. They are also important habitats for various wild animals and are sources of various non-timber products including honey. Trees are also vital in improving soil fertility through their roots. They add organic matter to the soil through leaves falling on the soil. Trees also protect the soil from erosion and prevent flooding. Trees absorb carbon dioxide and water and produce oxygen through photosynthesis, keeping more carbon in their biomass and reducing its release to the atmosphere.

10.2.2. Soils

Soil is a mixture of mineral and organic particles of varying sizes. Soils are formed by the weathering processes that take place on the surface of rocks. The weathering process breaks the rocks into smaller particles called soil parent materials. Air and water enter rock cracks and result in the formation of chemical substances. Bacteria and plants then colonize these rock fragments, which gradually transform into soils. When plants die, the bacteria enhance their decay and improve the fertility of the soil. These processes gradually result in the formation of soils in the environment.

Importance of Soils in the Environment

Soils contain a mixture of mineral and organic materials in different proportions. For example, typical mineral soils contain about 5% organic material, 45% minerals, 25% water and 25% air. This serves as a source of essential nutrients for plant growth. Soils also contain water and air in the spaces between particles known as pore spaces. Soils, particularly the top layer, support plant growth including food and forage crops. They provide water, oxygen and different nutrients required for plant growth.

Soils serve as a habitat for millions of soil organisms including earth worms, bacteria, fungi and other microscopic organisms. Soils are a major storehouse of carbon. They reduce the release of carbon dioxide by storing carbon. The concentration of carbon dioxide in the air causes climate change. So, storage of carbon in soils contributes to minimize harmful effects of climate change. The nature of soils is one of the major factors that determine crop productivity in an area. Soil properties that affect crop yields include the soil's nutrient content, organic matter content, and soil reaction (acidity, alkalinity). Also, depth of top soil, soluble salt accumulation (salinity) and diversity of soil organisms affect crop yields. Change in these soil properties over time can lead to either improvement or degradation of the soil. High crop yields can be obtained only if all our activities can markedly contribute to the improvement of soil properties.

10.2.3. Water

Water is required by all living organisms. Water covers 70% of the earth's crust. Of the total water available globally, approximately 97% is found in the oceans and seas. Of the remaining, approximately 2% is fresh water and 1% is found as frozen in **ice caps** and **glaciers**.

Key terms:

Ice caps: mass of ice that covers a large area

Glaciers: a huge mass of ice that slowly moves over land

Any body of water aboveground including lakes, rivers, streams and ponds, is called surface water. Surface water is used for many purposes. Water is used in agriculture and industry. Fish and wild life need water for survival. Water is used for electricity generation. Surface water is also used for recreational and domestic purposes.

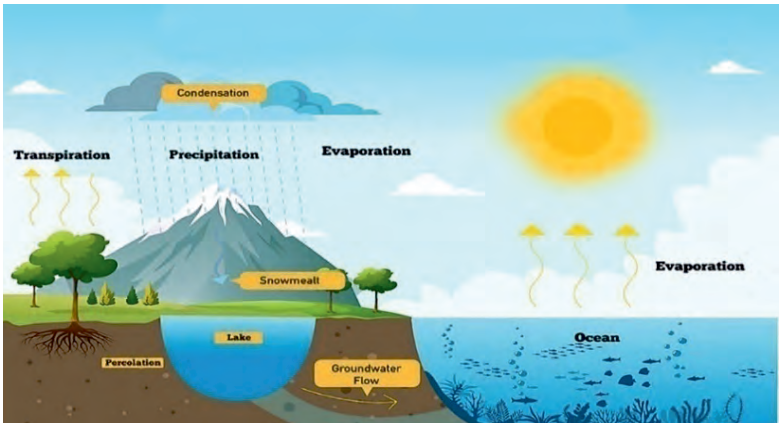


Figure 10.3. A simplified version of the global water cycle

Ethiopia is endowed with a substantial amount of water resources and often referred to as 'the water tower of Africa'. The country has eight **river basins** and one lake basin as shown in Table 10.1.

Table 10.1. The sources and flow directions of the major river/lake basins of Ethiopia

No.	Basin	Type	Source	Flow direction	Terminal
1	Abbay	River	Sekela, west Gojam	West	Sudan border
2	Awash	River	Ginchi	North-east	Border lakes
3	Baro-Akobo	River	Illubabor	West	Sudan border
4	Genale-Dawa	River	Bale	East	Somali border
5	Mereb	River	Zalanbessa	West	Eritrean border
6	Omo-Gibe	River	Ambo	South	Rudolph lake
7	Tekeze	River	Lasta/Gidan	West	''Chew bahir''
8	Wabishebele	River	Bale mountains	East	Somali border
9	Rift valley Lakes	Lake	Arsi mountain	South	Sudan border

Source: A. M. Melese et al. (eds.), Nile River Basin, DOI 10.1007/978-3-

Key term:

River basin: the portion of land drained by a river and its tributaries

Ethiopia has a substantial amount of groundwater resources. The country has a huge potential for expansion of small, medium and large scale irrigation. This can greatly improve agricultural productivity and food security. There is also an encouraging potential to develop hydropower that meets the growing energy demand in the country.

Activity 10.1.

Review of available natural resources

1. review natural resources available in the area and how they are used by the local community.
2. What benefits do the natural resources give?
3. Are there any problems with local natural resources - are any natural resources being adversely affected by human actions?

Share the summary of your discussion with the whole class.

10.3. Degradation of Natural Resources

Brainstorming 10.2.

Discuss in small groups.

Discuss the following questions in groups of 3 or 4 students. Report the summary of your group's discussion to the whole class.

1. How do you describe natural resource degradation?
2. What are the causes and impacts of natural resource degradation?
3. Give examples of natural resources and how they become degraded.

Natural resource degradation is any change or disturbance of the environment that causes deterioration, destruction or depletion of resources such as soil, trees, water or air. This can result in the destruction of ecosystems and extinction of wildlife.

10.3.1. Soil Degradation: Causes and Consequences

Soil degradation: is a long term decrease in the productivity of soils. Degradation of soils reduces their capacity to support healthy crop growth. There are three major forms of soil degradation. These are: water and wind erosion, chemical degradation including soil acidification, soil salinization and soil pollution by toxic chemicals and soil physical degradation which includes soil compaction.

Soil erosion refers to the washing away of surface or top soils by the natural physical forces of water and wind. Soil erosion is mainly caused by water in the highlands where average annual rainfall is high, and by wind in the lowlands where vegetation cover is low. Soil erosion is a natural process, but human activities accelerate it. These activities include: the removal of vegetation, high intensity of tillage, overgrazing, mining and construction activities. Soil erosion removes valuable top soil, which is the most productive part of soils for agriculture. The loss of this productive top soil results in lower yields as essential nutrients that plants require for growth are washed away, and increased production costs. Moreover, the eroded soils may end up in water bodies including lakes rivers and streams and may result in pollution of water. Soil erosion also increases sediment accumulation in dams which reduces power generation from hydro dams.

Soil chemical degradation includes the loss of essential plant nutrients, soil acidification, soil salinization and soil fertility decline. The major causes of soil chemical degradation include human activities such as deforestation, agricultural mismanagement and industrial pollution. Soil acidification is a common form of chemical soil degradation in highland areas in Ethiopia, where average annual rainfall is high. It is caused by removal of basic nutrient ions such as potassium, calcium, magnesium and sodium from top soils by water (called leaching) or in crop harvest and improper use of acid forming mineral fertilizers. These factors gradually make the soil pH value to decrease below a value of 7 and acidity develops. Acid soils are not suitable for plant growth or for activities of numerous soil organisms. For most crops, the most suitable soil pH is between 6.5 and 7.2. When pH values go below this range, it is not ideal for crop growth and is results in reduced agricultural productivity. Approximately, 40% of Ethiopian soils

are affected by different levels of soil acidity.

Soil salinization refers to excessive accumulation of soluble salts in surface soils. This results from the use of salt-rich irrigation and insufficient drainage. Soil salinization is common in lowland areas where the amount of annual rainfall is low. When salt-rich irrigation water is used in these areas, due to high temperature in these environments, evapotranspiration (evaporation and transpiration) is high. So, when the water evaporates, dissolved salts remain behind and accumulate in the soil surface and cause salinization of soils. As shown in figure 10.4, accumulated soluble salts are visible as a white thin layer on soil surfaces. When soluble salt accumulation is high in soils, water may move from plant roots back to the soil resulting in dehydration of plants causing yield decline or death of the plants. Soil salinization also restricts cropping options for farmers because only few crop species grow well in saline soils. Soil salinization problems are particularly common in the Ethiopian rift valley region.

Figure 10.4. Degradation of soil by excess accumulation of soluble salts on the surface

Soil physical degradation is the deterioration of the natural composition and structure of the soil. It often results in compacted soils with poor structure, which means that the soil particles are so closely packed together. Soil physical degradation can be caused by erosion of soils by water and wind, intensive (repeated) tillage practices (both oxen and heavy agricultural machinery), overgrazing and loss of cultivated land due to urban expansion. In physically degraded soils, there will be reduced root growth, reduced water and air movement in soils, reduced uptake of nutrients from soils by plants and reduced microbial activities. Also, physical soil degradation causes reduced water storage capacity of the soil and can result in increased flooding. These factors result in reduced plant growth and hence reduced yields.

Activity 10.2.

Work in small groups.

- In a small group, make an observation of the surroundings of your school and find out whether there are signs of soil erosion, physical or chemical soil degradation. List your observation of the different forms of soil degradation and explain how the different forms of soil degradation affect you individually, your family or the community in general.
- Share your group's findings with the whole class.

10.3.2. Water Pollution: Causes and Consequences

Water pollution refers to the presence of unacceptable levels of harmful substances or chemicals in water. Pollution spoils the quality of water. Water resources can be polluted in different ways. For example, industries use acid and alkaline chemicals in their industrial processes. Waste water produced in such industries, if not treated, pollutes water in the environment. If waste water is acidic, adding base will neutralize the acid and brings its pH value to around 7 before discharging it to the environment. Most rivers and lakes have pH values ranging from 6 to 8. If this natural range changes, aquatic organisms may not survive because these organisms have specific requirement of pH range. Water resources can also be polluted by organic wastes generated by living organisms. This includes wastes from human, animal, agriculture and food processing. If these organic wastes reach water bodies, they can kill aquatic animals like fish.

Phosphorus and nitrogen used as fertilizers in crop production are inorganic substances. We use metals extensively in our daily lives. Kitchen tools, paints, fuels, etc., are made of metals. Metals can enter water bodies by erosion or other ways. If the concentration of metals in water is higher than acceptable levels, the water can be toxic to aquatic organisms. Water can also be polluted by toxic substances like chlorine. Chlorine is used in production of disinfectants. Disinfectants are chemicals used to kill harmful bacteria and viruses. These chemicals also kill useful organisms like fish. Many organic substances like gasoline, oil, diesel and the pesticide 2-4D

are toxic pollutants that can cause health problems to humans as well as aquatic organisms.

Solid particles such as sands, silts, clays and fragments of plants can enter water bodies. Too much solid in water reduces visibility and causes problems for fish and other aquatic organisms. Solids that settle at the bottom of water bodies can harm organisms that live at the bottom of water bodies. The presence of too much solid in water makes treating the water difficult and expensive.

Microscopic organisms like bacteria and viruses can also cause water pollution and reduce its usability for different purposes. Bacteria and viruses can enter water bodies through direct damping of wastes into the water bodies or flood water from areas with high concentration of animals. These microscopic organisms can harm aquatic organisms. Water polluted by bacteria and viruses, if consumed for drinking purposes, can cause diseases in humans as well as in livestock.

Figure 10.5. Water polluted by oil or gasoline is highly toxic for aquatic organisms

10.3.3. Forest and Wildlife Degradation: Causes and Consequences

Forest is a vital natural resource with multiple benefits to humans and the environment. They provide various services. Firewood is obtained from forests. Forests are sources of construction materials, fruits, medicines, timber and food for animals. Forests also reduce the release of carbon to the atmosphere by storing carbon in their biomass. They are habitat for wildlife.

Scientific data shows that approximately over 50% of the tropical forests have been degraded since 1960's.

Different processes are responsible for forest degradation. This includes increasing forest fires and diseases, logging and climate change with high temperature and variable weather conditions. Logging refers to a situation in which forests are cleared for firewood, timber or to obtain additional land for crop cultivation. Fires are often used to clear the forest in order to use the land for agriculture.

The loss of trees or the forest can contribute to climate change, expansion of **desertification** and soil erosion. These again result in reduced food production both for humans and for livestock.

Key terms:
Desertification is a situation in which vegetation in drylands, arid and semi-arid areas such as grasslands or shrub lands decreases and eventually disappears
Arid/Semi-arid areas are areas that receive less than 25 mm rainfall per year (arid) or less 50 mm annual rainfall (Semi-arid).

Wildlife degradation: refers to a reduction in population size and types of wildlife species. Depending on the level of habitat destruction and wildlife degradation, species are classified as endangered and threatened. An endangered species is at risk of extinction or disappearance throughout its range of habitats. Human activities that destroy the natural habitats of wildlife have accelerated the rate of extinction of both plant and animal species. Threatened wildlife species are those species that can become endangered in the near future.

There are a number of causes of wildlife degradation. The major causes are expansion of agriculture, environmental pollution, loss of habitat, loss of mobility and limitation of expansion of vegetation. Introduction of non-native species, international trade of items like animal fur, animal bones and horns (i.e., ivory), and medicinal plants are also important causes of degradation of wildlife species.

Degradation of wildlife species results in the total loss of wildlife resources. A healthy forest has diverse tree species whereas a deforested area has

sparse vegetation and low species diversity. We all need to work hard to protect wildlife species against any form of degradation.

Figure 10.6. a) Thick vegetation and b) Sparse vegetation

Activity 10.3.

Individual work

1. Research individually on
   a. forest resources of Ethiopia. (i.e., information on coverage, location and types of tree species), whether the forest coverage in the country is increasing or decreasing and why
2. Talk to local people in your locality and find out about changes to forest and wildlife which they have witnessed during their life time and possible reasons why the changes happened.

Note: Information can be obtained from any pertinent office in your area. The Internet (if available) and your school library can also be useful sources of information.

Discuss your findings with your classmates

10.3.4. Causes and Consequences Air Pollution

The thin layer of air that surrounds the earth is called the atmosphere. The atmosphere is composed of nitrogen gas (78%) and oxygen (21%). Other gases constitute only 1% of the atmosphere. This means 99% of the atmosphere is made of nitrogen and oxygen gases. The remaining 1% is composed of water vapor in clouds, carbon dioxide and other minor gases.

We say the air is polluted when there is an abnormally high concentration of harmful and poisonous substances or chemicals in the atmosphere. When air moves across the earth's surface, it picks up dust from the land,

pollen and spores from plants and other particles. These particles reduce the cleanness of the air. In addition, human activities release smoke, dust and gases into the atmosphere. These also reduce the cleanness of the atmosphere.

Air pollution can be caused by the presence in high concentration of solid particles (particulate materials) of harmful gases. Gases emitted from cars, chemicals from industries, dust, agriculture and construction activities pollute the air. Other causes include soot and smoke from biomass burning and pollen and spores from plants. Pollen and spores from plants can be suspended in air and cause air pollution. Ozone is a gas that, when present in the atmosphere, can be toxic for plants and animals.

When we breathe in polluted air, toxic substances can enter our body and cause serious health problems. Health problems caused by air pollution, including respiratory problems, heart diseases and lung cancer, reduce the quality of human life and life expectancy. Air pollution also harms livestock and plants by reducing their health and productivity.

10.3.5. Environmental Impact of Mineral Exploitation

Mineral resources like gold, bronze, iron ore, aluminum, etc., contribute to the growth of national economy in many countries. Mining provides raw materials for different types of industries, and hence, is vital for the growth of the industry sector. Despite the benefits, mineral exploitation also has the potential to cause serious environmental problems.

During the mining process, surface excavation is often carried out to expose the mineral material. Dust particles from the excavation process can pollute the air. After excavation, rocks are crushed to smaller sizes, and the minerals are separated. Leftover materials are disposed or dumped as wastes. These wastes pollute soils and water in the area. The separation processes usually use water and chemicals. The chemicals, especially heavy metals and naturally occurring radionuclides (radiation emitting elements like uranium), can pollute water resources. Air pollution from mining can result in serious human and animal health problems. Water and soil pollution from mineral exploitation can harm soil, aquatic organisms and humans when the polluted water is used for domestic uses.

Activity 10.4.

Answer the following questions in a small group.

1. Are there mineral resources in your area? If 'Yes', name some of them. How does the extraction process affect the communities in your area?
2. List the locations of the major mineral resources in the country.
3. Explain how mineral resources in the country are exploited.
4. What consequences of the extraction of mineral resources on the environment do you know? (Consider the effects of both the traditional and modern mineral extraction methods used in the country.)

Note: Consult relevant offices in your area for information. You can also browse the Internet, if available. Your school library is another useful source of information

Unit Summary

In this unit you have learnt that:

- natural resources include materials, creatures or energy that are not produced but used by humans
- the supply of natural resources, particularly those that are non-renewable, is fixed and unless we use them wisely, our survival and the survival of the coming generations will be questionable.
- forests, soils, and water are natural resources closely associated with agriculture, and their use and management determines agricultural productivity
- Ethiopia is endowed with wide ranging water resources including surface and ground waters. This has a huge opportunity for developing and expanding irrigated agriculture and hydropower development
- soils are vital natural resources that are primarily used as a medium of plant growth. Soil degradation reduces the capacity of soil to produce crops. It makes achieving food security difficult.
- water pollution by different substances reduces its usability for various purposes including agriculture, industry and domestic uses.
- forest degradation reduces tree population as well as diversity and therefore services like wood and timber production, carbon storage, soil protection and provision of habitat for organisms that we obtain from forests will be highly reduced
- habitat destruction and environmental pollution result in degradation of wildlife resources reducing their population and diversity which reduces the ecological roles, aesthetic, recreational and scientific values of wildlife resources
- different solids and gases from human activities like agriculture and industrial processes can pollute the air and that has a negative impact on animal and human health
- mineral exploitation is vital in the development of a given country, but the extraction processes can generate toxic substances which pollute soils, water and air. These can harm the ecosystems, aquatic animals, the soil and human health

Review Exercise

Part I: Choose the best answer from the given alternatives.

1. Natural resources that are capable of renewing themselves or regenerate are known as_____.
   A. Non-exhaustible natural resources
   B. Renewable natural resources
   C. non-recyclable natural resources
   D. A and B
2. One of the following natural resources is non-renewable. Which one is it?
   A. Water
   B. Coal
   C. Natural gas
   D. B and C
3. Soils can mitigate climate change because they_____.
   A. store plant nutrients
   B. store carbon
   C. purify water
   D. A and C
4. What is the maximum population level for which a given resource can satisfy the food and shelter requirement called?
   A. Efficient resource use
   B. Carrying capacity
   C. Optimum resource use
   D. A and C
5. The principle of using natural resources in a way that enables us to have and continue to have the resources for our current needs as well as the needs of the future generations is called_____.
   A. Efficient use
   B. Sustainable use
   C. Economical use
   D. Multiple use
6. Soil degradation can be caused by which of the following processes?
   A. Soil erosion
   B. Soil acidification
   C. Soil compaction
   D. All
7. Degradation of forests does not result in_____.
   A. Increase in biomass production
   B. Reduction in species composition
   C. Reduction in microbial diversity
   D. Increased soil erosion

8. Which of the following is an indicator of wildlife degradation?
   A. Decline in population of animals
   B. Increase in the number of species
   C. Improved ecosystem production
   D. All
9. Water pollution is usually caused by which of the following?
   A. Pesticides
   B. Chemical used in industrial processes
   C. Fertlizers
   D. All
10. Which of the following is the major cause of forest degradation in Ethiopia?
   A. Expansion of agricultural land
   B. The need for pure water
   C. Tourism
   D. All

Part II: Answer the following questions.

1. Ethiopia is often called the Water Tower of the Horn of Africa. Explain why.
2. Do you think crop production is affected by soil properties? How?
3. What are the major economic and environmental benefits of forests?
4. What is sustainable natural resource management? Why is resource management required?
5. Describe the relationships between forest, soil and water resources.
6. What are the major consequences of soil degradation? How does soil degradation affect crop production?
7. When is air polluted? What are its causes? How does it affect the environment?
8. What are the major harmful environmental impacts of mineral extraction?

9. What are the possible solutions for the degradations of soil, wildlife, and pollutions of water and air? Suggest some of the ways of fixing the problems
10. Describe the relationship between mineral exploitation, soil degradation and water pollution.

Unit 11 Management of Natural Resources

Contents	Learning Outcomes
11.1. Concepts of natural resource use 11.2. Soil management 11.3. Agricultural water management 11.4. Forest and wildlife management 11.5. Environmental management 11.6. Types of indigenous knowledge's applicable in natural resources management practices	At the end of this unit, you will be able to: ▪ explain the major concepts in the use of natural resources ▪ explain the objectives of soil management and the practices used ▪ describe agricultural water management ▪ elaborate the importance of forest and wildlife management ▪ explain environmental management ▪ identify types of indigenous knowledge related to natural resources management practices ▪ value the importance of managing natural resources

11.1. Concepts of Natural Resource Use

Many of the natural resources (particularly the non-renewable ones) that exist in different regions are available in only limited or finite quantities. For example, the amount of coal, natural gas or mineral ores that exist globally is finite. Failure to wisely use natural resources results in their depletion in a short time. Lessening the amount of natural resources available in our surrounding markedly affects the fate of future generation. A proper management of natural resources ensures its sustainability. The terminologies and concepts commonly used in natural resources management are described below.

Carrying capacity

Carrying capacity refers to the maximum population level for which a given resource can satisfy the food and shelter requirement. For example, if a hectare of grassland can produce sufficient food for 100 sheep that is the carrying capacity of the grassland. Keeping 150 or more sheep on this grassland is far beyond the carrying capacity of the land.

When population exceeds a given ecosystem's carrying capacity, coupled with starvation leading to the emergence of diseases and predators that will eventually reduce the population. Farming has increased the carrying capacity of the world by increasing the amount of food that can be produced on the land. Intensive crop and livestock production has increased the carrying capacity of the land. In the process, the capacity of resource to pass onto the next generation and provide services to fulfill human needs can be highly damaged.

Sustainable use

Sustainable use: refers to natural resource use that creates and maintains a condition in which humans use resources to fulfill their social, economic and other requirements. Sustainability enables us to have and continue to have water, soils, forests, minerals and other resources to protect human health and the environment without interruption. In other words, it is sets of processes and techniques to handle resources to satisfy the needs and demands of the current generation without affecting the needs and demands of the future generations.

11.2. Soil Management

Brainstorming 11.1.

Answer the following questions individually.

1. What is soil management?
2. Why is managing the soil important?
3. Write some indigenous soil management practices used in your locality.

The way we manage the soils determines how exposed they are to soil erosion and other soil degradation processes. Soil erosion is a major soil degradation process. It reduces the productivity of soils. When soils are repeatedly cultivated, soil particles become pressed together. When soil particles are highly pressed together (compaction), rainwater does not enter the soil. Instead, a runoff which often causes soil erosion is created. When soils are bare, when they are without any crops, grasses or other types of vegetation, they can be easily washed away by rainwater or wind. Complete removal of plants during harvest or using fire during land preparation leaves the soil empty, without any cover and also causes nutrient depletion and a decline in soil fertility.

The magnitude of soil erosion effect on soil productivity is determined by how we manage our soils to reduce losses by soil erosion. Different management practices are used to reduce the effects of soil degradation on crop productivity.

Soil management practices to control soil degradation

Agronomic measures like mulching, mixed cropping and contour cultivation or strip cropping are usually soil management practices used in annual crops production. The objective in using these practices is to protect the exposure of soils to water or wind erosion - i.e., covering the soil by vegetation protects soil erosion. The vegetation cover does not have to be only living plants. Dry crop residues or various forms of mulch can also effectively protect soil from erosion. The plant cover or mulch absorbs the energy from raindrops and prevents loosening and removal of soil particles by erosion.

Mulching refers to spreading organic materials like crop residues or inorganic materials like plastic on the soil surface. These cover the soil and prevent direct exposure of the soil to raindrops and run off water. When rain directly drops on bare soil, it loosens the soil and causes the soil particles to be washed away easily. The mulch absorbs the energy of raindrops and run off water. This reduces the eroding capacity of the raindrops and run off water.

Figure 11.1. Mulching crop residue on farm

When crops are grown in mixture, they provide better coverage for the soil. This reduces more soil erosion than does mono cropping. Maize is grown mixed with beans in many maize producing areas in Ethiopia. Growing beans mixed with maize protects the soil well. The maize canopy protects the soil against raindrops and the beans provide additional canopy coverage.

Contour cropping**:** refers to planting long lines of plots with different crops along the contour to control soil erosion. In Contour cropping, crops with different canopy nature (growth habit) are usually used. Having different plant strips reduces sediments transported down the slope. Contour cropping reduces the speed of runoff water.

Figure 11.2. Contour cropping of maize and chili peppers

This usually results in reduced soil erosion.

Contour cultivation is cultivation of the soil opposite the slope direction. This reduces the speed of runoff water. Hence, it reduces the transport of the soil particles down the slope.

Improving the soil organic matter content or improving soil fertility is another soil management practice used to control or reduce soil nutrient depletion. Including legume crops in cereal crop plantings, applying manure, compost or other organic fertilizers improve soil fertility. Adding inorganic fertilizers also increases soil fertility but, the increase in the crop types in a farm increases the amount of organic matter added to the soil. When organic matter content of soils is increased, soils have better resistance to soil erosion and structural deterioration. Therefore, an increase in organic matter content of soils increases the fertility level of the soils and improves plant growth and better plant growth means better canopy coverage for the soil, resulting in reduced soil erosion.

Liming is the practice of adding calcium and magnesium-rich materials such as limestone to the soil in order to increase the pH value and reduce soil acidity. The calcium and magnesium added to the soil have the capacity to replace acidic nutrients from soils and increase the pH value (reduce soil acidity). When soil acidity is reduced, plants start to absorb essential nutrients from the soil and crop yield starts to increase, depending on the crop type. Traditionally, farmers in areas with acidic soil also add wood ash to the soil, which has the capacity to reduce soil acidity to some extent. In addition to addition of lime and wood ash to increase soil pH (reduce soil acidity), planting of acid tolerant crops is an alternative soil acidity management option. Such crops give reasonable yields in acidic soils and include crops such as rice, cowpea, cassava and mango.

Management of saline soils includes the removal of accumulated soluble salts from surface soils by washing (leaching) with good quality water. Also, addition of organic fertilizers such as compost and animal manure can improve the physical properties of salt affected soils and hence their productivity. Plants differ in their sensitivity to soil salinity and some plants perform reasonably well in saline soil. Crops such as sorghum, barley and wheat are relatively salt-tolerant while crops such as rice are sensitive.

11.3. Agricultural Water Management

Brainstorming 11.2.

Answer the following questions individually

- What is agricultural water management?
- How is water management related with agricultural production?
- List some agricultural water management practices you know.

Agriculture is the major sector that uses water resources. In developing countries agriculture is mainly based on water received from rainfall. Water received from the rain can be lost in different ways. For example, evaporation, **transpiration**, runoff and **deep percolation** are ways rain water can be lost. In areas where rainfall is the only source of water for growing plants, plants often face water shortage during critical growth stages. This problem is observed particularly in semi-arid areas. The total rainfall is low and rainfall patterns are unpredictable semi-arid areas. In such areas, it is important to reduce water loss through conserving water received from rainfall.

Key terms:

Transpiration: occurs when plants absorb liquid water from the soil and release water vapor into the atmosphere through their leaves.

Deep percolation: the movement of water downward through the soil below the depth which plant roots cannot reach

Different water management practices are used in agriculture to improve water availability for plant growth. One method is the use of contour cultivation in slopping areas. When soils in the slopping areas are cultivated opposite the slope, water running down the slope will be slowed down. This raises the likelihood of water entering the soils. Water available in the soils can be used to grow plants. Some common water management practices used in agriculture are presented below.

Rain water conservation

In arid and semi-arid areas, water received from rainfall can be saved using water harvesting techniques. Soil pit can be prepared with plastic sheets lining to store rainwater on the farm as shown in figure 11.3. The stored

water can be used when crops face water shortage. Excess water collected from roof tops of houses can be used for various purposes, including irrigation in droughts of short duration. This reduces carbon loss to the atmosphere and improves carbon stock and sequestration.

Figure 11.3. Rain water harvesting in Eastern Ethiopia (taken from Tolossa et al., Cogent Food & Agriculture (2020), 6: 1724354)

Reducing evaporative loss of water

One of the major ways water is lost from soils is through evaporation of water. Water loss through evaporation is particularly high when soils are either bare, with no vegetation cover or when the coverage is low. Such losses can be reduced by spreading organic materials on the surface of the soils (mulching). Leaving some biomass standing during crop harvest can also reduce soil loss.

Soil conservation

Practices that are used to conserve agricultural soils also improve water conservation. These practices include contour farming, contour bunding, bench terrace on steep slopes and storing runoff water. For example, bench terrace in Konso (figure 11.4) is used to reduce flooding and soil erosion and contributes to soil conservation. These activities reduce the speed of runoff water. They allow the water to enter the soil. This reduces water loss and makes the water available for growing crops.

In dry areas, crops that tolerate drought can be used. There are crops that give adequate yield with low water requirement and low transpiration.

Selection of appropriate crops for dry areas is an important water management method.

If irrigation is used, water losses linked to the efficiency of the irrigation method that is used should be minimized as much as possible. The amount of water used, the frequency of use and the irrigation time should be adjusted to properties of the soil, crop types and climatic conditions.

Figure 11.4. Bench terrace in Konso

11.4. Forest and Wildlife Management

Brainstorming 11.3.

Answer the following questions individually. Compare your answers with your partner's.

1. How do you understand forest and wildlife management?
2. Why is managing forest and wildlife important?
3. How are forest and wildlife in your locality managed?

Maintaining and improving the forest cover:

- increases the amount of carbon that the trees can store in their aboveground biomass and roots,
- reduces carbon emission to the atmosphere,
- protects soils against erosion and provides habitat for wildlife

Forest management practices are a range of human interventions including:

- planting of trees (afforestation) and replanting of depleted forests
- planning carefully ways to harvest and transport timber
- increasing forest cover through planting trees in areas where there are no forests

- adapting techniques to prevent wild forest fires

Forest management practices are needed to:

- provide fuel wood to meet demands sustainably
- allow for more productive use of forest vegetation
- create employment and income for rural communities
- contribute to biodiversity conservation
- reduce deforestation and desert expansion
- minimize vulnerability to climate change
- reduce carbon emission

Wildlife destruction usually occurs due to the destruction of their natural habitats. Protection of wildlife and their habitats is an integral part of management and conservation of wildlife resources. For example, humans allow their domestic animals to graze in national parks in Ethiopian. This violates the principal objective of wildlife management - protection of the habitats of wildlife including grasslands, forests, grazing lands. Walia Ibex and Ethiopian Wolf (figure 11.5) are among the most endangered endemic wild animals in Ethiopia mainly due to habitat destruction. Therefore, reducing agricultural encroachment into wildlife habitats, prevention of introduction of invasive plant species, creating buffer zone between settlements and wildlife habitats and controlling population growth are all integral parts of wildlife management.

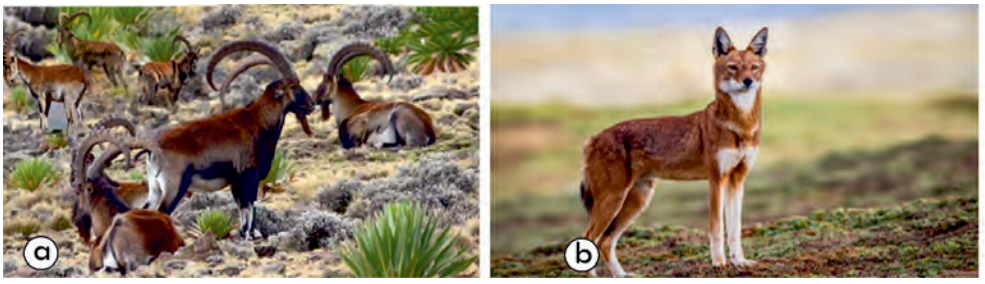


Figure 11.5. a) Walia Ibex and b) Ethiopian Wolf

11.5. Environmental Management

Brainstorming 11.4.

Answer the following questions before reading the notes that follow.

- What is environment? What do you know about its management?
- What practices are included in environmental management?

Environment

Environment refers to the climatic, biological and chemical conditions that may affect the growth and welfare of organisms.

- Humans interact with the environment in various ways.
- Humans should use the environmental resources in ways that do not harm the future use of the resources
- Practices that support such human interactions with the environment are called environmental management practices.

The main objectives of environmental management are to ensure the protection of human health and wellbeing, and conservation and preservation of all life forms and their habitats. The major goal of environmental management is to prevent the release of harmful chemicals into the environment.

The aims of environmental management are to:

- prevent air pollution and have acceptable air quality through improving management of agricultural wastes such as manure
- minimize water pollution to meet water quality standards by reducing erosion from agricultural areas which could pollute water
- reduce health and environmental risks of agricultural pesticides by proper use
- introduce sound solid waste management practice (reducing pollution from solid wastes such as animal manure)
- identify core processes of major outputs in agriculture and their environmental impacts
- ensure that farmers meet the requirements of the environmental regulations.

11.6. Indigenous Knowledge Applicable in Natural Resources Management

Brainstorming 11.5.

Discuss the following questions with your classmates.

1. What is indigenous knowledge?
2. Which indigenous knowledge practices related to natural resource management are used in your surroundings?
3. What are the practices in natural resource management in your area?

Ethiopia is a land of diverse altitudes and climates. The land is covered by various types of natural vegetation. Indigenous knowledge contributes to forest conservation..

Farmers in north Shewa apply indigenous soil and water conservation practices to respond to land degradation in their area.

These practices include:

- constructing a wide water way (40 to 50 cm wide) between adjacent farms to control runoff coming from upper slopes.
- Constructing a medium-sized traditional ditch that dissects the farm and connects two wide water ways. This reduces runoff speed by diverting excess water.
- constructing a single line of stones across the farm on slopes of up to 2%. This reduces runoff speed and retains soils (sediments) from the runoff water
- planting some tree species on the edge of the farm which protect the soil from erosion.
- using local vegetative barriers that filter out sediments from runoff waters and reduce runoff speed
- combining traditional stone bunds and vegetation ➔ grasses or perennial species with stone bunds can be used to control soil erosion on steep slopes

Similarly, the community in northwestern Ethiopia (Gumuz) use indigenous knowledge of natural resource management. The area has fertile soils.

Gumuz land has enormous vegetation with diverse plant and animal species. There are also abundant mineral resources such gold in the area. The livelihood of the community is highly based on natural resources. That is the Gumuz community members have special relationship with their land and the environment.

Through observation and experience the Gumuz have developed indigenous knowledge system for management of their natural resources. Their indigenous knowledge about management of natural resources is associated with their traditional belief systems. These beliefs include:

- vital natural resources are sacred
- natural resources are indigenous gift, blessing and creation of *Yamba* (God)
- Yamba (God) provided the Gumuz community with knowledge of proper use, management and the responsibility to pass on to future generation
- natural resources are perceived as ancestral heritage
- ownership of natural resources is vested upon the whole community ➔ so, they cannot be privately possessed or controlled by single members of the community.

This indigenous Gumuz knowledge of natural resource management constitutes mostly norms, values, ethics and taboos that have been institutionalized as customary laws and conventions within the community. The elders enforce these institutions.

Activity 11.1.

Work in small groups.

In small groups, collect information on water and forest resources available in your surroundings.

1. List the water and forest resources found in the area and the types of management in use to ensure the sustainability of the resources.
2. Study the information you collected and comment on the community's natural resource management practices. How could they be improved?
3. Consider the extent to which indigenous knowledge is used in the community's natural resource management practices. Do you think there is too much or too little use of indigenous knowledge in the community's management practices?

*Pertinent offices and the elderly farmers in the area could be helpful sources of information.

*Submit written answers to your teacher

Unit Summary

In this unit you have learnt that:

- soil management aims at reducing soil degradation and maintaining/ improving productive capacity of soils
- agronomic measures like mulching, contour cultivation, contour farming, crop rotation, mixed cropping and increasing the organic matter content of soils are examples of soil management practices
- agriculture is the major sector using water resources and these resources have to be managed in a way that sustains productivity
- major agricultural water management practices include rain water conservation, reducing evaporative loss of water and soil increasing conservation practices
- forest management practices should ensure sustainable supply of firewood for communities, reduce deforestation, conserve biodiversity, reduce risk of desertification and storage of organic carbon
- wildlife management aims at protecting natural habitats from destruction through reducing human encroachment into natural habitats including grasslands, forests and grazing lands
- environmental management aims at protecting human health and welfare and other organisms through the prevention of air, water and soil pollution and implementation of sound waste management strategies
- different indigenous knowledge practices play a vital role in the management of natural resources like soil, water, vegetation and wildlife.

Review Exercise

Part I: Choose the best answer from the given alternatives.

1. Which of the following is a form of soil degradation?
   A. Soil erosion
   B. Soil compaction
   C. Soil acidity
   D. All
2. Which of the following practices is used to reduce soil degradation?
   A. Mulching
   B. Mixed cropping
   C. A and B
   D. Mono cropping
3. Agricultural water management involves_____.
   A. Conserving rain water
   B. Soil conservation
   C. Both A and B
   D. Total crop residue removal from farm
4. Effective forest management does not result in_____.
   A. Wildlife degradation
   B. Reduced wildlife degradation
   C. Increased carbon storage in trees
   D. Reduced soil erosion
5. Which of the following is an endangered wild animal in Ethiopia?
   A. Walia Ibex
   B. Ethiopian Wolf
   C. A and B
   D. Gelada Baboon

Part II: Answer the following questions.

1. Why is agricultural water management needed?
2. How is water managed in agriculture in your locality?
3. How is forest management related to wildlife management?
4. What is the principal objective of soil management?
5. What do you think is the major problem in wildlife management in Ethiopia? How can it be improved?
6. Give two examples of indigenous knowledge practices used in natural resource management.

7. Describe the relationship between soil, forest and wildlife management by giving examples of how they interact with each other
8. How do you understand the relationship between environmental management and climate change?

Unit 12 Concepts of Biodiversity

Contents	Learning Outcomes
12.1. What is biodiversity? 12.2. The scope of biodiversity 12.3. Values and services of biodiversity 12.4. Threats to biodiversity 12.5. Biodiversity conservation and its status in Ethiopia	At the end of this unit, you will be able to: ▪ define biodiversity ▪ explain values and services of biodiversity ▪ identify threats to biodiversity ▪ explain measure that should be taken in biodiversity conservation ▪ justify the needs for conservation of biodiversity

12.1. What is Biodiversity?

Brainstorming 12.1.

Think individually about these questions. You can share your ideas with your partners.

1. What is biodiversity?
2. What are the components of biodiversity?

Biodiversity refers to the range of all forms of life on earth, including plants, animals, humans, bacteria and other organisms. It includes the different species, sub-species and communities that exist in a given habitat like a rainforest or grassland. Biodiversity has different components. Some are listed below:

- the number of species (i.e., plants, animals and other organisms) or
- the genetic diversity of different species found in an area,
- the population of each species (plants, animals and other organisms), and
- the diversity of habitats and landscapes of the species (forests, grasslands and others) in an area.

The biodiversity of an area shows how rich an area is in terms of the total number of species present and their populations and habitats. For example, Ethiopia is a country of high geographic and climatic diversity. This has resulted in high diversity of plant and animal species inhabiting the different agro ecologies. The country possesses a large number of plant and animal species that are not found elsewhere. These plants and animals are called endemic plants/animals. The way biodiversity of a given area is managed determines whether or not there is a healthy development of individual species and ecosystems.

12.2. The Scope of Biodiversity

Biodiversity deals with the diversity of:

- plant species including crop genetic resources and forest genetic resources

- animal species including farm animal genetic resources and wildlife genetic resources

Microbial genetic resources the assessment of biodiversity can be made at different scales. The scales vary from specific sites or regions. Country or global level scales can also be considered. The scale of assessment of biodiversity depends on the objective of the evaluation. For example, if one needs to know the level of biodiversity of a forest area, or a water resource, they evaluate the biodiversity in that specific forest or water body. On the other hand, if the assessment of general national biodiversity status is desired, assessment has to be made at a country level. This constitutes assessment of biodiversity in all kinds of habitats and the different species of plants, animals and other organisms.

12.3. Values and Services of Biodiversity

Brainstorming 12.2.

Answer the following questions. Compare your answers to your classmate's.

1. What do you think are the major benefits of biodiversity?
2. Which of the values and the services provided by biodiversity are closely associated with our day-to-day life?

Biodiversity provides a large number of values and services for humans and the environment. For example, it provides products and services in:

- food production (e.g., cropping, livestock, food from wild plants and animals)
- firewood, fiber and construction materials from various plant species,
- medicinal resources (e.g., various plant and animal species are important sources of medicines)

Regulatory services

- climate regulation - soil and forests store a large amount of carbon, preventing its release to the atmosphere, hence contributing to climate regulation
- disease and pest control - some natural predators control some

disease causing pests

- pollination - different organisms including bees and other insects assist in the dispersal of seeds and plant reproduction
- purification of drinking water and air - organisms decompose (detoxify) toxic substances that can pollute water and air and this contribute to water and air purification
- soil erosion control by forests
- waste decomposition - various organisms in the environment decompose wastes and enhance nutrient cycling and prevent accumulation of wastes

Cultural services

- recreation, sports, hunting
- source of foreign currency
- education and research

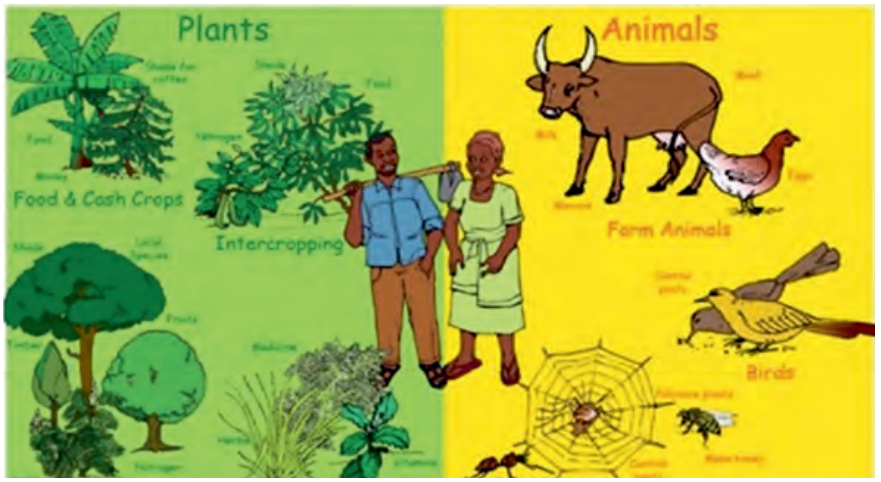


Figure 12.1. Plant and animal biodiversity

12.4. Threats to Biodiversity

Brainstorming 12.3.

Think about these questions independently and compare your thoughts with your classmate's

1. What are the major threats to biodiversity in Ethiopia?
2. What could be the consequences of biodiversity losses?

Biodiversity faces threats from different sources.

Land use change

The conversion of forests, grasslands and woodlands to cultivated land results in the destruction of the natural habitats of various plant and animal species. This conversion is called land use change and is usually done to expand cultivated land for crop production. Land use change results in the loss of several plant and animal species.

Unsustainable use of resources

Unsustainable use of resources refers to overexploitation of resources including overgrazing, hunting and harvesting of biological resources. Overgrazing exposes soils to erosion, and this, can result in the loss of plant and animal species. Together with the species, ecosystem services can also be lost. Uncontrolled fishing, overuse of water resources and overharvesting of tree species are further examples of unsustainable resource use. Overharvesting of timber production has threatened the tree species Hagenia abyssinica in Ethiopia. Over pumping of water from lakes and wetlands results in the loss of species and habitats (e.g., Lake Haramaya disappeared for many years due to over exploitation, and only starting to come back as a result of restorative efforts).

Invasive species

Some invasive species compete against local species for resources and habitats. This causes loss of biodiversity and ecosystem services. Parthenium weed (Parthenium hysterophorus), the shrub Prosopis juliflora L. and water hyacinth (Eichornia crossipes L., ‘’Emboch’’) are good examples of invasive species that threaten biodiversity in Ethiopia.

Parthenium weed invades forage and croplands. This causes yield losses. Prosopis has invaded rangelands in the Awash Valley, in Afar and Somali regions. It has caused losses of forage species in the areas. Water hyacinth has become a major threat to the Awash river basin and Lake Tana. By establishing dense canopy, water hyacinth limits boat traffic and recreation, it shades native aquatic plant species, preventing their growth and negatively affecting aquatic animals that feed on these plants. It also reduces oxygen availability and can result in reduced fish production.

Water hyacinth also reduces the volume of water in lakes and eventually can threaten the existence of lakes.

Figure 12.2. Water hyacinth in water resources in Ethiopia

Climate change

Due to climate change, the average maximum as well as the minimum temperatures have increased in Ethiopia. There has also been a change in the rainfall distribution pattern in the country. This has shortened the crop growing season in many areas. A substantial decrease has also been observed in crop varieties that require long growing seasons. Change in rainfall pattern, early coming of the rain or its late coming, usually affects yields of some crops. Climate change and its effects will be discussed in the next unit.

Environmental Pollution

Pollution in the Ethiopian context is usually related to improper management of both solid and liquid wastes. Solid and liquid wastes often contain toxic substances. These toxic substances enter water resources, forests or soils. Water resources, forests or soils are habitats for various organisms. Their pollution by toxic substances can be highly harmful to living organisms in these habitats.

The pollution of habitats destroys the natural habitats of various species of plants, animals and other organisms. This in turn leads to the reduction in the number of species, and in the population of different organisms. A total loss of some species could even be the consequence of pollution of habitats.

Irrigation of croplands with runoff water that contains dissolved pesticides

and fertilizers can affect soil and aquatic organisms. Eroded soils that contain high nitrogen and phosphorus pollute water resources. This harms aquatic animals like fish and could result in their extinction.

Population growth

The increase in the population of a country results in an increase in the demand for food and other basic services. Unchecked population growth results in the expansion of agricultural lands and overexploitation of resources. Using marginal and unsuitable lands for production can also be an undesirable consequence of uncontrolled population growth.

12.5. Biodiversity Conservation and its Status in Ethiopia

Brainstorming 12.4.

Discuss the following questions in pairs or in small groups.

1. What is biodiversity conservation? Why is it necessary?
2. What is the status of biodiversity conservation in Ethiopia? And its future trend?

Biodiversity conservation refers to the planned management of biodiversity in a particular ecosystem to prevent overexploitation, pollution, destruction and to ensure biodiversity is maintained.

The major objectives in biodiversity conservation are to maintain:

- a sustainable use of species and the ecosystem
- life supporting systems
- essential ecological processes

The need for conservation of biodiversity

Human activities like habitat destruction, introduction of invasive species and harvesting of species has caused huge losses of biodiversity. The presence of diversity in species of plants and animals enables researchers to develop improved varieties of plants and animals for human use. Diverse plant species could be important for food production and as raw materials for making different medicines. Biodiversity also provides various regulatory and cultural services.

In the Ethiopian context, approximately 85% of the population lives in

rural areas. The livelihood of most of this population, directly or indirectly, depends on natural resources. Therefore, conservation is vital for the livelihood of the population.

Biodiversity conservation in Ethiopia

Ethiopia has diverse **ecosystems** located in different altitudes. These ecosystems contain diverse biological resources including plant genetic resources which include:

- field crops,
- horticultural crops (such as fruits and vegetables),
- wild plants
- medicinal plants (wild plants used for treating human diseases)
- forests,
- rangelands and forage plants

Ethiopia has rich animal genetic resources and wildlife genetic resources. Animal genetic resources include farm animal genetic resources (e.g., indigenous breeds of cattle and other domestic animals). As examples of animal genetic resources, there are about 29 mammal types and 18 bird species that are endemic to Ethiopia.

Activity 12.1.

Work in small groups.

- In a group of 3 to 5 students, select two national parks and get information on some of the plant and animal species in the parks.
- Find out about the status of the plant and animal species (i.e., are they abundant, endangered or threatened?).
- You may consult wildlife experts or development agencies for information if they are available in your area. If these are not available, consult related literature in your school library or search the internet.
- Share your findings with the other groups in the class.

Threats to biodiversity in Ethiopia

Forest resources in the country are seriously threatened by deforestation, habitat destruction and poor regeneration. Expansion of invasive species, clearing forest for agriculture, forest fires and illegal tree harvest are other examples of threats to biodiversity in Ethiopia. This has threatened many species of trees in the country including medicinal plants.

Overgrazing and over-browsing of shrubby vegetation, invasive species and conversion of grazing lands to cultivated lands are major threats to forage resources of the country. Efforts are being made to reduce the problems. Clearing invasive species, selecting and multiplying locally adapted forage species, enclosing degraded rangelands and banning open grazing are some examples of the effort made to reduce the threats.

Various wild animals are threatened by the expansion of agriculture and grazing areas near wildlife habitats. Deforestation and habitat destruction also threaten wild animals. Similarly, overgrazing and overharvesting (fish) are harmful to wild animals. Unbalanced water use and siltation of water resources are yet other forms of habitat degradation. There are many endangered species of wild animals in the country. Below are some examples.

- Walia Ibex (*Capra walie*)
- Mountain Nyala (*Tragelaphus buxtoni*)
- Ethiopian Wolf (*Canis simensis*)

Figure 12.3. Walia Ibex

Different efforts are already in place in different regions to reduce the destruction of forest resources. The efforts involve local communities in the management of the forest resources. In some places, forests were closed to reduce human interference. There are various protected areas in

the country to reduce the risk of wildlife biodiversity losses in the country. These are:

- National and regional parks,
- Wildlife sanctuaries,
- Wildlife reserves,
- Botanical gardens and herbariums,
- Controlled hunting centers

In general, biodiversity conservation is important to reduce the losses of vital plants, animals and microbial resources for the sustainability of agriculture, forestry, wildlife and other similar sectors.

Activity 12.2.

Work in small groups.

In a group of 3 - 5 students, find out about what the status of plant and animal biodiversity was like 30 or 40 years ago in your community.

- Ask elder people in your community about trends in animal and plant biodiversity in the area. What changes have taken place in their life time?
- What should be done to maximize biodiversity conservation? Report your group's findings to the whole class.

* Share your points with other groups in the class.

Unit Summary

In this unit you have learnt that:

- biodiversity refers to a wide range of life forms including plant and animal species and other organisms
- biodiversity includes plant and animal genetic resources, microbial genetic resources and habitat diversity
- biodiversity has various roles to play in human life.
- there are various threats to biodiversity. Habitat destruction, overexploitation, invasive species, climate change, pollution and population growth are among the threats.
- to counter these threats and exploit the values and services provided by biodiversity resources, biodiversity conservation is very important.

Review Exercise

Part I: Choose the best answer from the given alternatives.

1. The major objectives of biodiversity conservation include_____.
   A. Sustainable use of species/ecosystems
   B. Functioning of ecological process
   C. Both A and B
   D. None
2. Which of the following is a regulatory service provided by biodiversity?
   A. Pollination
   B. Soil erosion control by forests
   C. Waste decomposition
   D. All of these
3. In Ethiopia, the major threats to biodiversity include_____.
   A. Habitat destruction
   B. Invasive species
   C. Deforestation
   D. All of these
4. Which of the following wild animals is a threatened species due to habitat destruction?
   A. Ethiopian Wolf
   B. Walia Ibex
   C. Both A and B
   D. There are no threatened species
5. Biodiversity refers to a range of different species of_____.
   A. Plants
   B. Animals
   C. Microorganisms
   D. All of these

Part II: Answer the following questions.

1. What are the major components of biodiversity?
2. Name biodiversity resources found in your localities. How useful are they in your daily life?
3. What types of services and values do we obtain from biodiversity? Give examples of how these services and values affect humans.

4. Describe the major threats to biodiversity resources. Give examples of the major threats to the major types of biodiversity resources in Ethiopia.
5. What are invasive species? How do they affect biodiversity? Give examples of such species in Ethiopia. What do you think is the contribution of biodiversity to the national economy?

Unit 13 Climate Change Adaptation and Mitigation

Contents	Learning Outcomes
13.1. Definition of climate change and its variability 13.2. Climate change and its effects 13.3. Climate change mitigation strategies 13.4. An overview of climate change adaptation strategies of Ethiopia 13.5. Indigenous knowledge in climate change mitigation strategies	At the end of this unit, you will be able to: ▪ describe what climate change and variability are and their consequences ▪ clarify the effects of climate change ▪ describe climate change mitigation strategies ▪ explain climate change adaptation strategies of Ethiopia ▪ explain Climate Smart Agriculture ▪ understand the community's perception of climate change ▪ mention indigenous knowledge used in climate change mitigation practices

13.1. Definitions of Climate Change and Variability

Brainstorming 13.1.

Think the answers to the following questions. Compare your thoughts to your classmate's thoughts.

1. What is climate change? And climate variability?
2. Can you mention examples of climate change and climate variability?

Climate change refers to a long term (e.g. decades) change in temperatures and the patterns of the weather.

In climate change, extreme weather events like unusual floods in some areas, droughts that stay for long periods, wildfires, unusual snowfalls, intense hurricanes and warming of the earth can become more common. Climate variability refers to the short term (days, weeks or months) variability in the climate. Climate variability does not cause fundamental changes in the ecosystem. Organisms can adapt to the changes, as the changes in climate variability are not long-term. For example, some years can have below average rainfall while others have average or above the average rainfall.

Climate change leads to fundamental changes in the ecosystem. Below are some examples.

- A decrease in crop and animal productivity
- Animals and plant species may be threatened and even become extinct
- Changes in water availability
- Changes in storm patters and frequencies
- Increased flooding of coastal areas
- Changes in rainfall amount and patterns
- Increased frequency of drought
- Drying of surface water resources
- Increased soil erosion
- Increase in desertification

The major cause of climate change is the production and release of gases called **greenhouse gases** to the atmosphere from different sources. Greenhouse gases are gases that trap heat in the atmosphere and cause

global warming. The major greenhouse gases are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). The accumulation of these gases in the atmosphere causes climate change. In addition to global warming, climate change also causes depletion of the ozone layer and exposes the earth to harmful radiation that can cause skin cancer in humans.

Human activities like agriculture, forest clearing, forest burning, and **fossil fuel** burning release these gases into the atmosphere. Natural processes can also produce the gases. It is generally agreed that climate change is mainly caused by human activities.

Key terms:

Greenhouse gases are gases that can absorb heat radiation emitted from the earth's surface and reradiate it to the earth, causing global warming by trapping heat that should be released out of the atmosphere into space.
Fossil fuels are fuels formed from fossilized plants and animals. Coal, oil and natural gas are some examples.

As shown in Figure 13.1. below, when the concentration of greenhouse gases increases in the atmosphere, heat is trapped, and this results in global warming

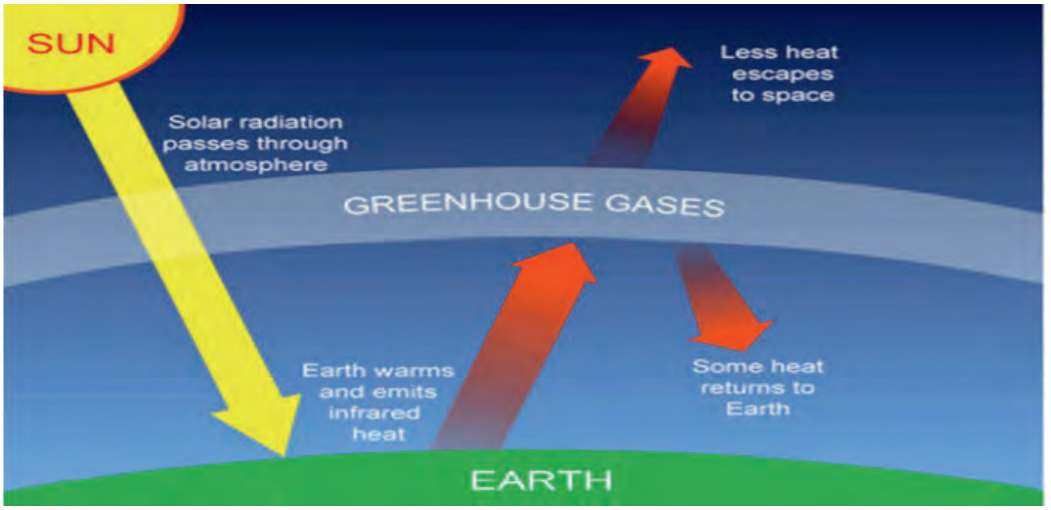


Figure 13.1. The impact of concentration of greenhouse gases in the atmosphere

13.2. Climate Change and Its Effects

Brainstorming 13.2.

Discuss the following points in a group.

1. Effects of climate change
2. How effects of climate change relate to daily life

Climate change causes changes in rainfall amounts and patterns. Climate change causes an increase in global temperatures and the melting of icecaps and glaciers. Rise in the sea level and droughts that cause an increase in evaporation are consequences of climate change.

Effects of climate change on agriculture

In areas where agriculture is mainly dependent on rainfall, a decrease in rainfall, due to climate change, reduces water availability. An increase in temperature, due to climate change, also increases water losses from soils and surface water resources. In both cases, there will be water shortage for growing crops and for animals and human consumption.

In some areas, climate change can also cause increased rainfall. The increase in rainfall may result in increased soil erosion. When soils are eroded, nutrients that plants use for growth will be washed away with the soils. This reduces nutrient availability for field crops and forages. The consequence will be a decrease in crop yields and animal productivity. Reduction in crop and livestock productivity is particularly harmful to societies that are dependent on agriculture for their livelihoods. Increased rainfall can also lead to damages of croplands and household properties.

In addition to reducing crop and livestock productivity, global warming could increase the incidence of some crop and animal diseases. This results in the reduction of crop and livestock yields. Global warming and decreased water availability also cause a marked decrease in crop and livestock productivities. Climate change also affects animal production through reduced forage yields, heat stress from increased temperature, water shortage and increased incidence of existing and new diseases and parasites causing reduced animal growth and productivity.

Ethiopian agriculture is mainly small scale with very low use of production enhancing technologies including improved seeds/breeds, fertilizers, pesticides, irrigation and agricultural machineries. Therefore, crop and animal productivity is low compared to the potential. These characteristics of Ethiopian agriculture make it highly vulnerable to the effects of climate change. For example, more than 90% of crop production in the country is rainfed, with very low production under irrigation. Climate change is expected to reduce rainwater and increase temperature. These will further reduce crop yields. Animal production will also be negatively affected by climate change. Therefore, a strategy is needed in agriculture to reduce climate change effects and improve agricultural production to meet the increasing demand for food production.

Effects of climate change on forestry

Global warming and reduced water availability causes reduced vegetation growth, reduced productivity and loss of some tree species. This reduces the capacity of the forest to absorb carbon through photosynthesis. Degradation of the environment in the form of deforestation, soil erosion and disappearance of wildlife enhances desertification in arid and semi-arid areas. Generally, climate change results in reduced capacity of the forest to regulate the climate through carbon storage. The forest is a habitat for various organisms - plants, animals and microbes. Any loss of the forest or species in it causes loss of plant and animal biodiversity.

Effects on sea level

An increase in global temperature – i.e., global warming - has already caused melting of polar ice caps. This causes sea level to rise and coastal communities become more vulnerable to flooding. Flooding destroys communities and can damage the overall ecosystems.

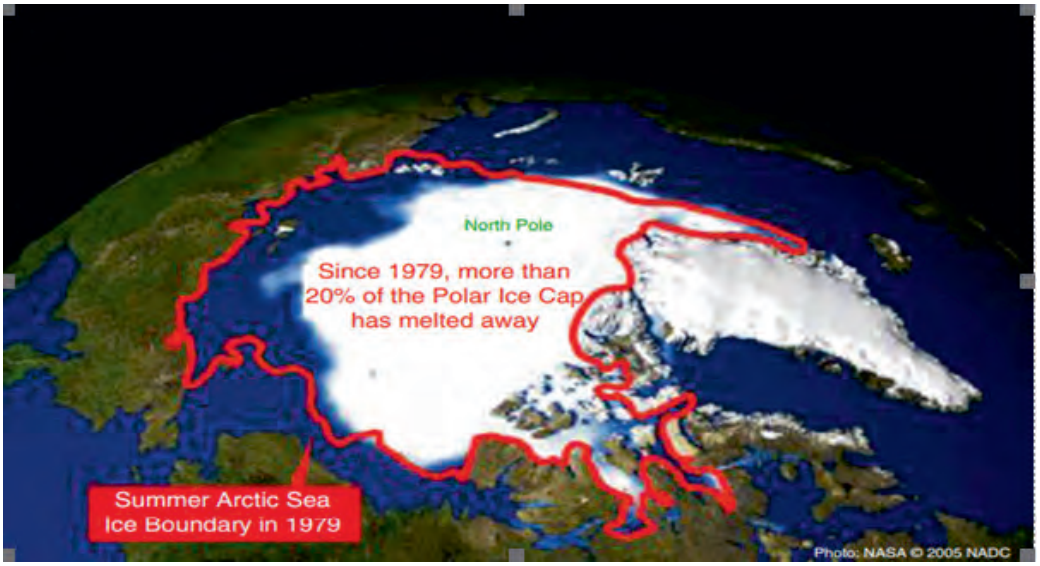


Figure 13.2. Reduction in polar ice caps due to global warming

Ocean acidification

Oceans absorb about 30% of carbon dioxide released to the atmosphere. The amount of carbon dioxide released to the atmosphere due to human activities is increasing. This increase can lead to a similar increase in the amount of carbon dioxide absorbed by oceans. When carbon dioxide is dissolved in water, it produces carbonic acid. When the amount of carbon dioxide dissolved in oceans increases, the oceans become more and more acidic. This is harmful to organisms that live in the oceans

13.3. Strategies of Mitigating Climate Change

Brainstorming 13.3.

Answer these questions individually.

1. What are climate change mitigation? And the mitigation strategies?
2. Why is mitigating climate change needed?

Climate change mitigation refers to the activities implemented to either reduce or remove the emissions of greenhouse gases to the atmosphere. These practices reduce or remove greenhouse gas emissions in two ways:

1. reducing greenhouse gas emissions
2. enhancing removal of greenhouse gases by **carbon sinks**

Key term:
Carbon sinks: Any processes, activities or mechanisms that remove greenhouse gases from the atmosphere

13.3.1 Reducing greenhouse gas emissions from sources

Energy

Fossil fuel burning has long been a source of energy in industries. The practice has been the largest source of human-induced carbon dioxide emission to the atmosphere. Today, however, there is a growing need to shift to renewable energy sources like solar energy, wind energy and hydropower in order to reduce carbon emission.

Deforestation

Clearing of forests results in the release of stored carbon into the atmosphere. Forests are usually cleared to get additional agricultural land, firewood and timber. These practices release massive amounts of carbon to the atmosphere as carbon dioxide. This contributes to global warming. The reduction of deforestation is an important way of reducing carbon emission from forests.

13.3.2. Enhancing carbon sinks

Afforestation

Forests store a large amount of carbon, through photosynthesis, in their biomass, forest floor and in soils. Forests play a vital role by removing carbon dioxide from the atmosphere. This helps to mitigate climate changes. Afforestation means planting new forests and this enhances the carbon storage capacity (sink capacity) and helps to mitigate climate change.

13.3.3. Improved soil management

Like forests, soils also store a large amount of carbon. About 2 times more carbon is stored in the soil, compared to the total amount in the atmosphere. So, conservation and management of soils through implementing best practices enhances the carbon storage capacity of soils. This means that a

high proportion of the carbon removed from atmosphere by plants remains in soils through implementing soil conservation practices. The practices include crop rotation, mixed cropping, reduced soil tillage, mulching and use of terraces and other physical soil conservation structures.

13.4. Climate Change Adaptation Strategies in Ethiopia

Brainstorming 13.4.

Answer the following questions in pairs.

1. What is climate adaptation?
2. What is Climate Smart Agriculture?
3. Give examples of climate adaptation practices used in your locality.

Climate Change Adaptation

Climate change adaptation refers to the adjustments that farmers and other communities make in response to actual or expected climate change. In order to cope with the impacts of climate change, farmers need to modify their ways of doing crop production and animal rearing. Farmers need to implement appropriate climate change adaptation practices to reduce the harmful effects of the changing climate.

The most common climate change adaptation practices include:

- Changing crop rotation and involving more drought adapted crops in the cropping pattern
- Intercropping, mixing legumes and cereals reduces soil erosion and reduces water loss by evaporation
- Changing the crop type to crops that are better adapted to drought conditions, crops with lower water demand
- Changing the crop calendar with changes in the climate which means planting early or late following the onset of rainfall
- Using perennials like fruit crops mixed with legumes and cereals protects the soil from erosion and reduces water loss
- Using animal breeds which are better adapted to increased temperatures, water stress and possessing better feed conversion

efficiency

- Grazing land enclosures to reduce land degradation and increase animal forage production and reduce incidence of animal diseases
- Utilization of locally available, non-conventional or unusual feed resources including agro-industrial by-products

Farmers make adjustments in their farming systems when they face or expect climate change. Below are some of the common climate adaptation strategies used by farmers in Ethiopia.

Expansion of perennial crops

This includes planting crops like *enset* and tree species that better tolerate the effects of climate change. When field crops fail due to climate change, the farmer may have food from *enset* plants or sell the tree products and purchase food. The use of these perennials reduces the risk of total yield loss.

Income diversification

Instead of depending totally on agriculture, farmers participate in off farm activities like trading, paid labor work and other activities. These reduce the chance of total income loss for the household, particularly during climate change.

Change in crop varieties

Certain crop varieties are more adapted to moisture shortage conditions than others. During moisture shortage years, farmers select crop varieties that are drought tolerant. These crop varieties can tolerate the drought conditions through short maturity period or efficient use of the available water. Through using these crop varieties, farmers reduce the risk of total yield loss.

Mixed cropping

Sometimes, more than one crop species is planted on the same farmland. This helps to use the soil resource efficiently and, during climate change,

reduces the risk of total crop loss. In mixed cropping, crops have different tolerance to drought conditions. If one crop species fails to give yield, the other crop in the mixture provides some crop yield for the farmers.

Figure 13.3. Mixed cropping of Maize with lablab (cereal with forage legume)

Selecting or breeding more suitable animals

An increased temperature and drought as a result of climate change would reduce animal productivity and will increase the susceptibility of animals to parasites and diseases. But the extent of the impacts depends on the animal breed. So, replacing low producing animals with fewer highly productive, disease resistant and breeds adapted to the local climate conditions and feeds is important to improve animal productivity in a changing climate.

Improving management practices

Globally animal production is the major source of methane (CH4) emission which causes global warming. Improving the management of animal manure for example through using it for biogas production has the potential to reduce greenhouse gas emission from the sector. Additionally, improving animal nutrition can reduce methane emission from the animal production sector. Implementing cut and carry system for animal feeding and limiting free grazing are also important strategies to reduce emission of greenhouse gases from animal production.

Climate Smart Agriculture (CSA)

Climate Smart Agriculture (CSA) is an integrated approach where crop production, animal production and natural resources are managed to address the changing climate. Climate Smart Agriculture has three aims. These are:

a. increase sustainable productivity
b. reduce vulnerability to climate related risks and improve capacity to adapt to climate change
c. reduce greenhouse gas emissions from agricultural production

In order to reduce the negative impacts of climate change, agricultural practices implemented by all farmers should be designed in a way to address the three objectives of CSA. It may not be a single practice that achieves these objectives but a combination of practices used in crop and animal production as well as natural resources management. Some of the common CSA practices are shown in figure 13.4. Some of the practices contribute towards increasing productivity (agricultural input management, water and soil management), others increase adaptation capacity (crop diversification, integrated crop-livestock management, improved grazing) or mitigation (planting trees/agroforestry). Some practices can contribute to more than one CSA objectives. Therefore, integrated use of these practices is important to achieve the triple objectives of CSA.

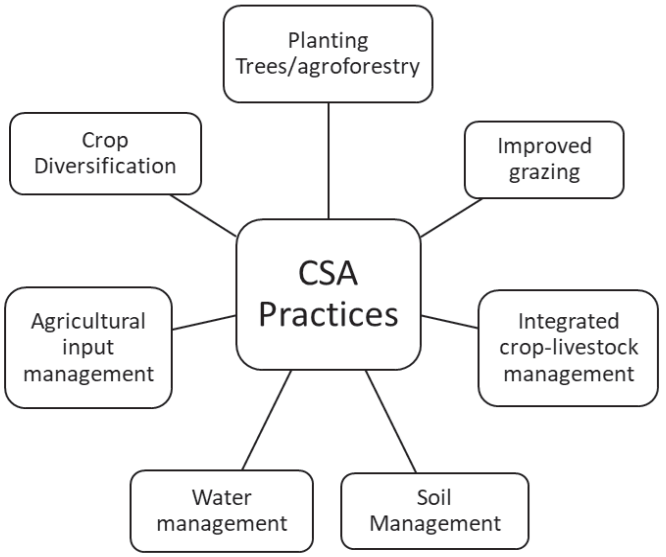


Figure 13.4. Some common CSA practices

13.5. Indigenous Knowledge in Climate Change Mitigation Strategies

Brainstorming 13.5.

Answer the following questions in small groups.

1. What indigenous knowledge practices are used for climate change adaptation and mitigation in your locality?
2. What types of climate change adaptation and mitigation options do you know in your community?

*Share your answers with other groups in your class

Gedeo environmental protection

The Gedeo community in southern Ethiopia have rich culture and indigenous knowledge that encourages environmental protection and conservation. The Gedeo community have great respect for nature. Nature including mountains, trees, hillsides and riversides are recognized as intermediates connecting the creator (God) and the creation (man). According to elders in the community, protecting these natural resources is a way of expressing human desire and prayers to God. Natural resources including forests, wildlife and water resources should be respected among the Gedeo just like humans. Some forest patches are considered sacred and therefore are protected.

This tradition has maintained the Gedeo agroforestry systems (shown in figure 13.5) for hundreds of years. This has contributed greatly to enhancing the climate mitigation potential of the agro forestry systems in the community.

Figure 13.5. Traditional agroforestry system in Gedeo

Key term:

Agroforestry is the deliberate integration of trees and shrubs with crops and livestock in agricultural systems.

Indigenous soil conservation of the Konso community

The Konso community in south western Ethiopia have a traditional landscape characterized by indigenous stone terraces. Indigenous stone terraces have been used for soil conservation for hundreds of years in the community. These indigenous practices protect soils from erosion. The stone terraces collect maximum amount of water and discharge the excess. They create suitable spaces for agriculture. The traditional soil conservation terrace of the Konso (see Figure 13.6) is a good example. The effect of soil erosion protection is improved soil capacity. Improved soil stores carbon. The carbon helps in the mitigation of changes in the climate.

Figure 13.6. Traditional soil conservation terrace of the Konso

Activity 13.1.

Group work

In a small group, survey the community elders', leaders' or experts' perceptions of climate change.

What do they use as indicators of climate change? If they think the climate is changing, ask about the adjustments they make to address the changes.

*Report your findings to the other groups in the classroom.

Unit Summary

In this unit you have learnt that:

- climate change is a long term change in weather patterns that leads to fundamental changes in ecosystems.
- the major causes for climate change are mainly human activities like fossil fuel burning, agriculture and land use change
- climate change has a wide range of effects. For example, global warming reduces water availability, increases droughts and floods, reduces agricultural productivity and destroys global ecosystems.
- there are different agricultural practices that are implemented to mitigate and adapt to climate change. These practices include adjusting agricultural activities, changing crop varieties, crop diversification, and income diversification.
- Climate Smart Agriculture is an integrated approach where crop and animal production as well as natural resources are managed to address the problems of food security and climate change. The approach aims to achieve triple objectives of sustainably increasing food production, enhancing the adaptive capacity to climate change and reducing greenhouse gas emissions from agriculture.
- indigenous knowledge practices can be useful in mitigating climate change and reducing its effects on agriculture.

Review Exercise

Part I: Choose the best answer from the given alternatives.

1. What is a long term change in climate patterns called?
   A. Climate variability
   B. Climate change
   C. Environmental change
   D. A and B
2. Which of the following can be an indicator of global climate change?
   A. Warming of global temperatures
   B. Sea level rise
   C. A and B
   D. Daily temperature fluctuations
3. Adjustments that farmers make in agricultural production systems to respond to actual or expected climate change are called_____.
   A. Climate adaptation
   B. Climate mitigation
   C. Sustainable agriculture
   D. None
4. Which of the following is a climate change mitigation practice?
   A. Agroforestry
   B. Afforestation
   C. Enhancing carbon storage in soils
   D. All
5. Which of the following practices is used as climate change adaptation mechanism in crop production?
   A. Changing crop variety
   B. Changing planting time
   C. Use of mixed cropping
   D. All

Part II: Answer the following questions.

1. What is the difference between climate variability and climate change?
2. Briefly, explain the possible consequences of climate change on agricultural crop production and animal rearing.
3. Describe your personal observations in your locality that can relate to climate change.
4. What is the difference between climate change mitigation and climate change adaptation?
5. Give examples of indigenous knowledge practices used to adapt to or mitigate climate change in general.

Unit 14 Mechanized Farming

Section	Learning Outcomes
14.1. Introduction to mechanized farming 14.2. Types of farm tools and equipment 14.3. Uses of some farm tools and equipment	At the end of this unit, you will be able to: ▪ define mechanized farming ▪ classify farm tools and equipment ▪ state types of farm tools, equipment and their uses ▪ use some farm tools and equipment

14.1. Introduction to Mechanized Farming

Brainstorming 14.1.

Discuss the following questions in small groups.

1. Have you ever seen any mechanized farming? If 'Yes', list down a few things you remember.
2. Do you think mechanization has disadvantages in agriculture?

Mechanization is the use of machinery to replace human or animal labor. Mechanization in agriculture involves the use of tools and machine for agricultural land development, crop production, harvesting, storage, animal rearing and processing of products at farm gate. Mechanized agriculture is needed to replace the use of simple farm tools or crude implements in agriculture. Simple farm tools or crude implements slow down farming activities.

Advantages of farm mechanization

Farm mechanization:

- saves time
- reduces the difficulty in farming
- saves labour
- reduces farm health hazards
- encourages large-scale farming
- increases on-farm output and income
- encourages cooperation among farmers (farmers buy the machinery together)

Disadvantages of farm mechanization

- Machinery can be expensive to purchase or hire.
- Machineries driven by fossil fuels cause environmental pollution.
- Trafficking by the tyres of heavy farm machines causes soil compaction, and poor root growth.

- Mechanization may hamper the well-established social capitals of farmers like Debo or Guza.
- Farm mechanization reduces the amount of manual farm work available for workers.
- Farm mechanization requires continuous supplies of energy from fuel and electricity.

Levels of mechanization

Mechanization in any area is categorized into three levels: low, fair and high level. The three main power sources involved in levels of mechanization are human, animal and mechanical.

1. Low level mechanization: manual power used exceeds 33%.
2. Fair level mechanization: animal power used is 34 to 66%.
3. High level mechanization: mechanical power used is 67 to 100%.

14.2. Types of Farm Tools and Equipment

There is a wide range of agricultural equipment used in mechanized farms. This ranges from the biggest combine harvesters to a hypodermic syringe for administering animal medication. Mechanized farm equipment can be divided into several categories, based on their functions.

- **Soil cultivation implements:** These are used for ploughing the soil and preparing it for cultivation. Examples of soil cultivation equipment include tilers, disk harrows, and moldboard ploughs.
- **Planting machines:** These are used for planting saplings and seeds after the soil has been cultivated. Seeder is a good example.
- **Harvesting equipment:** These are used to gather crops once they have reached full maturity. Examples are combine harvester, diggers, trailers, and pickers, etc.
- **Irrigation machinery:** These types of equipment are used for watering crops on large farms. Examples: central pivot irrigation systems and pump units.

- **Feed processing equipment:** Weighing scale, shovel, wheelbarrow baler, hacker, chopper, millers or grinders and mixers are important types of equipment used in feed processing industry.

- **Dairy machinery** includes buckets, milk containers, automatic milking machines, coolers and pasteurizers. Homogenizer, cream separator, batch mixers, continuous freezers, butter churner, and cheese molder are also important examples.

- **Miscellaneous agricultural equipment:** These are used for carrying out other activities such as hay-making, shredding, and loading. Forestry machines, aerosols, middle level machinery, sophisticated materials, remote sensing and fruit pickers are also some of the materials used for agriculture.

14.3. Uses of Some Farm Tools and Equipments

A tractor is one of the most popular and most essential pieces of farming equipment. Modern tractors can be used for planting, tilling, spreading fertilizer, etc.

A plough is one of the most ancient agricultural tools. Its function is to cultivate the soil and prepare it for sowing. In modern times, ploughs are pulled by tractors mainly in the developed world.

Subsoiler is a tractor-mounted equipment used to break up and loosen the soil during deep tillage. It helps to improve the growth of crops in areas where soil compaction is a problem.

Figure 14.1. Crop cultivation equipment: A) tractor, B) plough, C) subsoiler

A cultivator can be used to carry out secondary tillage on a field. In most cases, this machine is equipped with rotary motion. It is used for removing weeds and for pulverizing and stirring the soil before planting.

A cultipacker is a piece of equipment used for crushing soil clods. It can be used to eliminate cracks, press small stones, and remove air pockets to form a smooth, firm seedbed.

A harrow is a machine used for smoothing out and breaking up the surface of the soil. It breaks up lumps of soil and produces soil structure suitable for seedbeds.

Figure 14.2. Soil cultivation equipment: A) cultivator, B) cultipacker, C) set of harrows

Seed drill is a machine used for planting seeds at equal distance and at the proper depth.

Sprinkler is used to irrigate a field of crops. It helps to irrigate large areas and maintain the needed level of humidity.

Combiner harvester is a versatile machine designed to efficiently harvest a variety of grain crops. The name derives from its combining four separate harvesting operations (reaping, threshing, gathering, and winnowing) into a single process.

Figure 14.3. A) sprinkler, B) seed drill, C) combiner harvester

Straw collector collects straw or hay into small or large stacks. A baler compresses hay or straw into bales for easy transport and storage. A bale is

the simplest minimum package for marketing.

Figure 14.4. a) straw collector, b) baler

Feed miller/ grinder is a power grinding-mill for reducing maize, wheat, barley, etc. to coarse meal that is suitable for animal feeding. During ration formulation, the feed ingredients are thoroughly and hygienically mixed using appropriate equipment called **feed mixer**.

Figure 14.5. Feed processing equipment: A) feed miller, B) feed mixer

In a dairy farm, the **milking machine** is probably the most important piece of equipment. It is used to harvest milk automatically. Milk should be cooled down to below 4 ^{0}C within 2 hours of milking to avoid rapid deterioration.

Milk cooler helps to achieve this goal. The cream should be converted in to butter and butter milk by using a tool called **churner**.

Figure 14.6. Dairy machinery: A) milking machine, B) milk cooler, C) butter churner

An incubator is a device with a fan and heater to keep fertile eggs warm for 21-days of incubation.

A sprayer is used for spraying liquid. It can be used to spray insecticides, herbicides, pesticides, water, etc on a crop farm or on animals to control external parasites.

Pruning shears are sharp, heavy-duty scissors that are used for cutting branches of trees and plant stems.

Figure 14.7. A) egg incubator, B) knapsack sprayer, C) pruning shear

Activity 14.1.

Small group activity

Visit a mechanized farm, if available in your area. Then, list the farm tools and equipment in use on the farm. If mechanized farming is not available, write a list of what tools or machinery you think a farm in your area would find most useful and why.

Unit Summary

In this unit you have learnt that:

- mechanization is the use of machines in farm work
- agricultural mechanization boosts agricultural and food production
- there are three levels of mechanization in any area: low, fair and high
- main power sources involved in mechanization are human, animal and mechanical
- different types of tools are used in farming, each serves different purposes
- different tools are needed at the different stages of production
- based on functions, agricultural equipment can be divided into several categories
    - soil cultivation, planting, harvesting, irrigation, feed processing are some examples of functions for which the use of machinery and different equipment is needed

Review Exercise

Part I: Choose the best answer from the given alternatives.

1. Which one of the following is not a soil cultivation tool?
   A. Tilers
   B. Disk harrows
   C. Baler
   D. Moldboard ploughs
2. The level of mechanization that utilizes 34 to 66% animal power is _____
   A. Fair
   B. Low
   C. High
   D. Good
3. Among the following, which one is the most popular and most essential crop farming equipment?
   A. Chopper
   B. Tractor
   C. Churner
   D. Incubator
4. Which of the following is a limitation of mechanization?
   A. Mechanization promotes farmers cooperation.
   B. Mechanization saves time and labour.
   C. Mechanization has no maintenance cost.
   D. Mechanization requires continues supply of energy.
5. The primary function of a subsoiler is _____.
   A. for planting and tilling operation
   B. for spreading fertilizer
   C. to loosen the soil during deep tillage
   D. for weeding purpose

Part II: Answer the following questions.

1. What are the three levels of mechanization? What are the three main sources involved?
2. Summarise the advantages of mechanized farming.

Unit 15 Introduction to Human Nutrition

Contents	Learning Outcomes
15.1. Definition of basic terms in human nutrition	At the end of this unit, you will be able to: ▪ define basic terms used in human nutrition ▪ explain nutrients and their functions ▪ state food groups and their sources ▪ discuss food and nutrition security ▪ describe agriculture-nutrition linkage and nutrition-sensitive agriculture ▪ explain the status of malnutrition and its causes in Ethiopia
15.2. Nutrients and their functions	
15.3. Food groups and their sources	
15.4. Food and nutrition security	
15.5. Agriculture-nutrition linkage and nutrition-sensitive agriculture	
15.6. Malnutrition and its causes in Ethiopia	

15.1. Definition of Basic Terms in Human Nutrition

Nutrition is the science of ingestion, digestion, absorption, assimilation and biosynthesis of nutrient in the body.

Food is any nutritious substance that are culturally acceptable and people eat and drink to maintain life and growth.

Diet refers to the way people feed themselves and the foodstuffs they use. It is concerned with the eating patterns of individuals or a group, and the sequence of meals in a day. People may eat twice, three or four times in a day. This is strongly influenced by people's traditions and religion. People's economic position, their place in the society and the possibilities offered by their natural surroundings are also important considerations in talking about diet.

Nutrients are chemical substances that are needed for us to live and grow. They provide us energy, repair of body tissues, support growth and aid the normal functioning of the body system. Some are required in large quantity, while others are needed in minute quantities.

Macronutrients are needed in large amounts to maintain the body's structure and systems. Carbohydrates, fat and protein are macronutrients.

Micronutrients are needed in small quantities for a healthy life. Minerals and vitamins are important examples. Micronutrients are used by the body to produce enzymes, hormones, and other substances essential for proper growth and development.

Healthy eating means eating a variety of foods that give us all the essential nutrients we need to maintain our health, feel good, and have energy.

A healthy diet provides sufficient nutrients, balance, and variety. Healthy diets contain different foods that provide the optimal functioning of the body. A variety of food is required to obtain all the essential nutrients we need in the body.

Balanced diet is a diet that gives the body the right proportion of nutrients and calories needed to maintain healthy body. Balanced diet has the desired proportion of carbohydrates, proteins and micronutrients.

15.2. Nutrients and Their Functions

Brainstorming 15.1.

Work independently

1. What type of nutrient do you know?
2. What are the factors affecting nutrient requirements of the body?
3. Mention some of the functions of nutrient.
4. List some source of foods for each nutrient you know.

There are six main classes of nutrients the human body needs. These are

- Carbohydrates
- Lipids (fats and oils)
- Proteins
- Vitamins
- Minerals
- Water

Most nutrients have more than one function. The main functions are build and maintain body cells, regulate body functions and provide energy.

- Carbohydrate, fat/lipid and protein provide energy
- Protein for body building and repair
- Minerals and vitamins - regulate body function and defending force for diseases
- Water for optimal hydration

15.2.1. Carbohydrates

Carbohydrates are sugars, starches or fibers that provide energy to all the cells and tissues in the body. One gram of carbohydrate generates four kilocalories of energy. Most of the calories in human diets are obtained from carbohydrates. Carbohydrates should constitute 45 to 65% of the daily calorie for optimal nutrition. The carbohydrates in the human diet exist mainly in the form of starches and various forms of sugars. Free sugar should be limited to 5% of total energy intake in children and 10% for adults.

15.2.2. Lipids

Lipids include all fats and oils that occur in human diets. Usually "oil" refers to liquid, and 'fat' to solid lipids at a room temperature. Lipids are a concentrated source of energy for the human body. A gram of fat/oil generates 9 kilocalories up on combustion. Fat should comprise 20 to 35% of the daily calories of energy. Digestion of dietary lipid products consists of smaller molecules called fatty acids and glycerol. Fat/oils make diet more palatable. Lipids also serve as energy storage and in structural functions. Stored fats serve as fuel reserves for the body by storing excess calories. Excess calories from carbohydrates, protein and lipids are stored in the form of fat in the body. The best fats are plant-based uncooked oils.

15.2.3. Proteins

Protein carries out a variety of functions. It ensure the growth and development of muscles, bones, hair, and skin. It also contributes to the formation of antibodies and hormones. Protein serves as a fuel source for cells and tissues when needed. A gram of protein yields 4 kilocalories of energy. Proteins comprise 10 to 35% of the daily calorie for optimal nutrition.

Foods such as red meat, eggs, dairy products and fish contain protein. Beans, legumes, soy, nuts and some grains are also good sources of protein. Protein is made up of organic compounds called amino acids. Proteins that contain all of the 20 amino acids required by the body are called complete proteins. Proteins from animal products, including eggs and milk, are complete. They can supply all the amino acids that the body can't make on its own. Proteins from plant foods are incomplete, meaning that they do not contain all of the amino acids required by the body. However, incomplete proteins can still play an important part in providing protein in a healthy diet.

15.2.4. Vitamins

Vitamins can boost the immune system, strengthen teeth and bones and aid calcium absorption. They also help in maintaining healthy skin, and metabolizing proteins and carbohydrates. Vitamins also aid the brain and

nervous system to function well. Nutritionists divide vitamins into two groups: fat soluble and water soluble. The fat soluble vitamins are vitamin A, vitamin D, vitamin E and vitamin K. Water soluble vitamins are vitamin B and vitamin C. Fat-soluble vitamins can be stored in the body so do not need to be eaten every day and water-soluble vitamins are not stored so need to be eaten more frequently. Vegetables, fruits and meat are rich source all the vitamins. People with a restricted diet may need to take a vitamin supplement to avoid deficiency.

15.2.5. Minerals

The minerals are the second type of micronutrients. There are two groups of minerals: major and trace minerals. The body needs a balance of minerals from both groups for optimal health. Major or macro-minerals are elements with Recommended Dietary Allowance (RDA) greater than 150 mg/day. Examples are magnesium, calcium, phosphorus and potassium. Major minerals help the body to balance water levels, maintain healthy skin, hair, and nails and to improve bone health.

Trace minerals are elements required in smaller amounts (microgram quantities). They usually play a catalytic role in enzymes. Some trace mineral elements (RDA < 150 mg/day) are iron, selenium, zinc, and manganese. Trace minerals help in strengthening bones, preventing tooth decay, and in reducing blood clotting. Trace minerals carry oxygen and support the immune system.

Sources of minerals include iodized table salt, nuts and seeds, vegetables, leafy greens, fruits, poultry, egg yolks, whole grains, and fortified bread and cereals.

15.2.6. Water

A person can only survive a few days without water. Slight dehydration can cause headaches and impaired physical and mental functioning. The human body is made up of mostly water. Every cell requires water to function. Water helps several functions. Flushing toxins out, absorbing shock, transporting nutrients, preventing constipation, lubricating and rehydrating the body. The best thing to do related to water is to drink natural, unsweetened water from the tap or bottled sources.

Activity 15.1.

Group activity

1. Consult health professionals on the impact of consumption of saturated fats.
2. Consult a nutritionist or master chef and write a note on how the vitamin rich foods are cooked and serviced to an individual at different places.
3. How vitamin A supplementation is provided at facility and community levels, what will be the impacts?
4. Animal source proteins are complete, but plant source is incomplete, do you think the community are getting complete protein? If 'yes' how? If 'no' propose the appropriate solutions?
5. Why should individuals limit consumption of simple carbohydrate and fat?
6. Review national and global evidence to identify the most common mineral deficiencies and propose the solutions.
7. Describe the relation between water and agriculture, food, and nutrition.

15.3. Food Groups and Their Sources

Brainstorming 15.2.

Think-Pair-Share.

What food types are available in your area? Mention some you know. Categorize them into groups. Explain the criteria used in your classification.

*Share your answers with some students sitting next to you.

A food group is a collection of foods that shares similar nutritional properties or biological classifications. Foods are often grouped according to the nutrient that they contain in abundance. Foods are typically divided into six groups (Table 15.1) based on the major nutrients they contain. Most people, particularly the poor, consume only one or two types of staple foods. Since the different food groups provide different benefits,

consumption of diversified foods is important for the health of adults and proper growth and development of children.

Table 15.1. Description of the six food groups

Food group	Functions	Representative examples
Vegetables	Vegetable food groups provide mostly vitamins, minerals, and water. They also contain fiber, which is necessary for proper digestion and helps to prevent constipation.	
Fruits	Fruits mostly provide carbohydrates, vitamins, minerals and water.	
Legumes and nuts	This food group provides mainly protein and are important for growth, repair and body building. They also contain a lot of fat and carbohydrates in addition to protein.	 
Animal foods	Animal foods provide protein, fats, vitamins, and minerals. They contribute to growth and the development of strong bones.	

Food group	Functions	Representative examples
Fats and oils	Foods of this group includes oil seeds such soybeans, sesame seeds, linseeds, and groundnuts. Cooking oil and margarine are similar examples. They provide an additional energy (fat), essential fatty acids and fat-soluble vitamins.	
Staples	Staple foods include cereal grains such as sorghum, maize, barley and oats. Wheat, teff, rice, starchy roots (such as sweet potato, cassava, and false banana), and starchy fruits like banana are similar examples. They are good sources of energy, proteins, vitamins and minerals depending on how they are processed.	

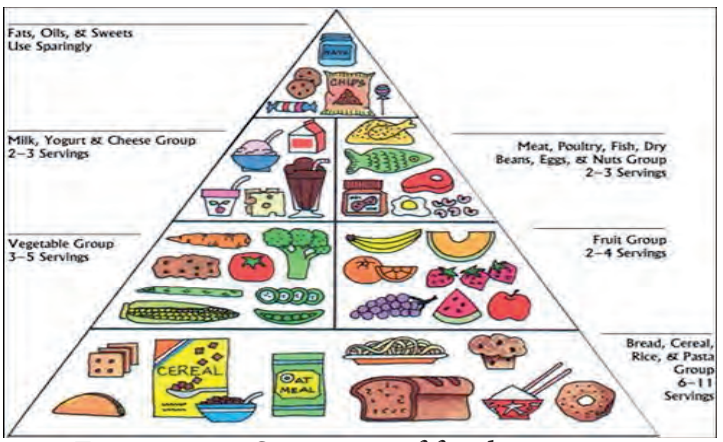


Figure 15.1. Summary of food groups

Activity 15.2.

Group work

1. Keep a food diary for one week of everything you eat and assess it at the end of the week and see whether you are following a healthy diet. What food groups do you think you should eat more or less of?
2. Consult your mother on how the vegetables are considered their families dish and ask their understanding on the benefit of vegetables. Explain how your families' meals are addressing vegetables per day and per week.
3. Assess the availability and affordability of legumes and nuts in your community, which one are commonly consumed; and how they are consumed.
4. In small groups, assess your community common animal source foods; narrative how they frequent they consume, is there any gaps, compare from the recommendation among different targets. Dialogues on the benefit and consumption of animal source food during holidays; the students can be grouped in to two; one group can support the important of consumption every day during holiday, the other group will support the disadvantage of overconsumption.

15.4. Food and Nutrition Security

Brainstorming 15.3.

Pair-work.

Do you have information about the need for 'food and nutrition security'? Share with your partner if you have any information about food and nutrition security.

The United Nations' Committee on World Food Security refers "food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life". A more basic definition

of food security would only include access to sufficient quantity of food, while nutrition security relates to have a sufficiently nutritious food.

Nutrition security is a situation whereby individuals have access to sufficient, safe, and nutritious foods, safe water and adequate sanitation, the ability to access health care services, and knowledge of sound household and community practices in childcare, food storage and preparation and hygiene. The knowledge needed to care for and ensure a healthy and active life for all household members also falls under nutrition security.

Pillars of food and nutrition security

The four pillars of food/nutrition security are food availability, access, utilization and stability.

- **Availability** is about having sufficient quantities of appropriate food. It refers to the physical existence of food. At a household level, food can be obtained from own production or bought from the local markets.

- **Access** refers to having adequate income or other resources to access food. This is ensured when all households have enough resources to obtain food in sufficient quantity, quality and diversity for a nutritious diet. This depends mainly on the amount of household resources and prices.

- **Utilization/consumption** is having adequate dietary intake and the ability to absorb and use nutrients in the body. It is related to the ability of the human body to take food and convert it.

- **Stability** is having access to adequate food at all times. Stability is achieved when the supply on household level remains constant during the year and in the long-term.

Drivers of food insecurity

Food and nutrition insecurity is a situation in which people do not have access to the basic elements of good nutrition. People experiencing food insecurity often consume a nutrient-poor diet. People experience food insecurity due to lack of

- resources (i.e., financial and other resource types)
- access to nutritious food at affordable prices
- access to food due to geographical isolation
- motivation or knowledge about a nutritious diet
- access to clean drinking water
- environmental hygiene
- good health infrastructure

Activity 15.3.

Food and nutrition security

In small groups, investigate the status of food and nutrition security in Ethiopia (or your specific region). Is there food security for everyone? If not, what food insecurity exists and are there any programmes in place to help with this?

15.5. Agriculture-Nutrition Linkage and Nutrition-Sensitive Agriculture

Agriculture produces the vast majority of the world's food supply. Agriculture-nutrition linkage describes the set of relationships that shows the mutual dependence of nutrition, health and agriculture. Changes in the agricultural sector can have significant effects on individual health and nutritional status. Conversely, changes in nutrition or health status are expected to affect agricultural production. Agriculture has great potential to impact the food and nutrition security of poor, rural households. People have long recognized the most obvious connection. Food security is one of the three pillars of good nutrition, along with good care and good health.

The links between improved nutrition status and improved work capacity and productivity are clear. Yet to enhance agricultural productivity and

incomes, the agriculture sector must pay even more attention to nutrition. Agricultural development is now expected to proceed in a way that maximizes opportunities to improve health and nutrition. The emergence of nutrition-sensitive agriculture in the past few decades is one of such developmental approaches.

Nutrition-sensitive agriculture is a food-based approach to agricultural development that prioritizes nutritionally rich foods, dietary diversity, and food fortification to overcome malnutrition. Agriculture is nutrition-sensitive when it goes beyond food production to address the underlying causes of malnutrition and micronutrient deficiencies. This approach stresses the multiple benefits derived from enjoying a variety of foods, recognizing the nutritional value of food for good nutrition, and the importance and social significance of food and the agricultural sector for supporting livelihoods. The overall objective of nutrition-sensitive agriculture is to make the global food system better equipped to produce good nutritional outcomes.

15.6. Malnutrition and Its Causes in Ethiopia

Malnutrition is a condition that happens when your diet does not contain the right amount of nutrients. There are two main types of malnutrition: lack of healthy foods in the diet (under-nutrition), or an excessive intake of unhealthy foods (over-nutrition), which can be reflected in several forms.

- **Obesity (being overweight):** an indicator of excess nutrient intake relative to the requirements. People are considered clinically overweight when their body weight more than 20% greater than recommended for the relevant height. Such people are at risk of several chronic illnesses, like diabetes, heart disease and various forms of cancer.
- **Stunting** a chronic or recurrent under nutrition from poor diet, repeated infection, and inadequate psychosocial stimulation. Children are defined as stunted if their height-for-age is below the average for their age. This usually comes from insufficient food intake or frequent infections.

- **Wasting** is an indicator of acute or short-term undernutrition. It results in a child who is very thin for their height and sex. This often occurs because of a lack of access to food, infection or acute illness such as diarrhea. Severe wasting often lead to child mortality. Children are defined as wasted if their weight-for-height is less than negative two standard deviations (<-2 SD) according to the WHO child growth standard. Severe wasting often leads to child mortality.
- **Being underweight** is an indicator of both acute and chronic undernutrition. Underweight children have low weight for their age. People are considered underweight when their body mass is 15% below what is considered the normal range for a person's age and height. Children are defined to be underweight if their weight-for-age is below negative two standard deviations (<-2 SD) according to the WHO child growth standard.
- **Micronutrient deficiency:** a deficiency of one or more vitamins or minerals required for the body function, optimal health, growth, and development. This can occur when the body is unable to absorb the nutrients from food or if not enough food that contains a specific nutrient is consumed. The most important micronutrient deficiencies of global public health are iron deficiency (anemia), vitamin A deficiency (night blindness), and iodine deficiency (goiter), zinc (poor growth), calcium (weak bone), folic acid (neural tube defect).

Body Mass Index

Body Mass Index (BMI) measurements tells us if enough energy is being consumed adequately. BMI is a person's weight in kilograms divided by the square of height in meters. A high BMI can indicate high body fatness. BMI screens for weight categories that may lead to health problems, but it does not diagnose the body fatness or health of an individual. A normal BMI is when the weight of a person is appropriate for her/his height. For adults, simple BMI can be used as an indicator of nutritional status because most individuals over 18 years have completed their physical development. However, children and adolescents are still experiencing growth and development. Therefore, it is necessary to consider the age and sex of the adolescent when using BMI as an indicator of nutritional status.

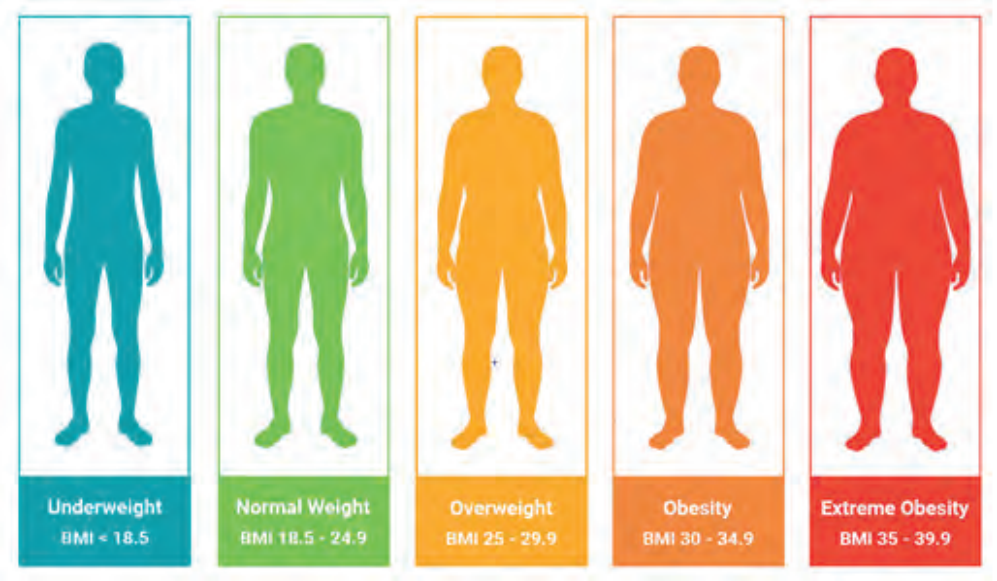


Figure 15.2. Body Mass Index

The magnitude of malnutrition in Ethiopia

Malnutrition is among the major public health problems in Ethiopia. Malnutrition affects many people, primarily children, pregnant and lactating women. Table 15.2 shows the trend of malnutrition among children under age 5.

Table 15.2. The trend of child malnutrition in Ethiopia

Indicators of malnutrition	2000	2005	2011	2016	2019	Status
Stunting (short for their age)	57.7 %	50.8 %	44.4 %	38.4 %	36.8 %	Very high
Wasting (thin for their height)	12.2 %	12.2 %	9.7 %	9.9 %	7.0 %	Medium
Underweight (thin for their age)	41%	33%	29%	23.3%	21%	High
Overweight (heavy for their height)	1.8 %	4.0 %	1.7 %	2.8 %	2.3 %	-

Source: Ethiopia Demographic Health Survey (EDHS)

Activity 15.4.

Answer the following data response questions.

Look carefully at the data in the Table above.

1. Review national evidence and explain why stunting and underweight decline in 2019 compared to 2000?
2. Visit the nearby health office, consult them and identify major changes that resulted in a decrease in the status of malnutrition over the past few years?

Causes of malnutrition

The cause of malnutrition can be classified as immediate, underline and basics.

1. **Immediate causes:** lack of access to sufficient quality and quantity of food and poor health status and frequent incidences of infectious diseases.
2. **Underlying causes:** household food insecurity, sub-optimal feeding and caring practices and health services, WASH (Water Access, Sanitation and Hygiene) practices, etc.
3. **Basic causes:** political, financial, social, cultural, and environmental conditions, and infrastructure.

Impacts of malnutrition

Malnutrition has a multifaceted impact at individual, community and region/ country level. It has short and long-term impacts. In the short-term, malnutrition is often associated with weakness and altered immunity. This make individuals much more vulnerable to infections and death. One-third of child mortality is attributed to malnutrition worldwide.

In the long-term, malnutrition can lead to impaired mental development, poor educational performance in childhood and decrease ability to work productively in adulthood. Low birth weight tracks into adulthood and may increase the risk of chronic diseases such as diabetes and cardiovascular diseases. Malnourished individuals fail to recover from diseases and

can't perform their daily work. Failure to perform physical work directly decreases individual productivity. This will eventually lead to poor economic status for individuals, societies and the country at large.

Mechanisms for solving the malnutrition problem

Some possible options that help to manage all forms of malnutrition involve the following

- Educating communities about the dangers of malnutrition.
- Promoting improved and nutrition-sensitive agricultural practices.
- Prioritizing infants, pregnant and lactating women for nutrition-based interventions.
- Adopting dietary changes, such as eating variety of foods that are rich in essential nutrients.
- Promoting consumption of diversified, nutrient dense and safe foods
- Promoting consumption of animal source foods, fruits, vegetables, bio-fortified and fortified foods; including Iodized salt
- Supporting families to help them manage factors affecting the child's nutritional intake.
- Timely treating any undelying medical conditions causing malnutrition.

Activity 15.5.

Impact of malnutrition (class work)

Summarize the long term and short term impacts of malnutrition.

Unit Summary

In this unit you have learnt that:

- the six major classes of nutrients are carbohydrates, fats, proteins, minerals, vitamins, and water. All are classified as essential to our bodies function properly
- nutrients can be grouped as either macronutrients or micronutrients
  - carbohydrates, fats, and proteins are macronutrients
  - vitamins and minerals are micronutrients
- for a healthy life, the energy share of carbohydrates, fats and proteins is recommended to be 55%, 30% and 15%, respectively
- there are many different groups of food
  - vegetables like tomato and cabbage provide vitamins, minerals, fiver, and water
  - fruits such as oranges and apples provide mostly carbohydrates, vitamins, and water
  - legumes and nuts such as soybean provide mainly protein and carbohydrates
  - animal foods include meat, egg, and milk; provide protein, fats, vitamins, and minerals
  - fats and oils includes oil seeds oil seeds. These mainly provide energy.
  - staple foods include cereal grains mainly provide energy
- healthy diet can be achieved by consuming food from at least four food groups
- food security is the availability and accessibility of food to all people at all times
- the four pillars of food security are availability, access, utilization and stability
- nutrition security demands the intake of variety foods that provide the six essential nutrients
- BMI screens for weight categories that may lead to health problems
  - BMI of 18.5 – 25 is considered normal, 25 - 30 is overweight, over 30 is obese and < 18.5 is thin/underweight.

- nutrition-sensitive agriculture is a food-based approach to agricultural development that aims to overcome malnutrition and micronutrient deficiencies
- overweight, stunting, wasting, micronutrient deficiency and being underweight are sub-forms of malnutrition
- the cause of malnutrition can be classified as immediate, underline and basics
- the impact of malnutrition is multifaceted
- it does not only affect the health of women and children; it also decreases individual productivity, educational performance and eventually creates poor economic status for individuals and societies
- infants, pregnant and lactating women are the most vulnerable group to malnutrition and priority needs to be given to them

Review Exercise

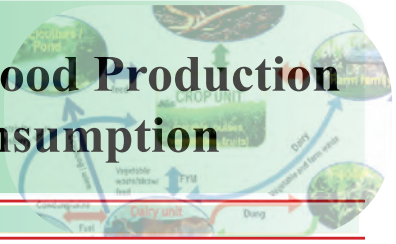
Part I: Choose the best answer from the given alternatives.

1. Nutrients that primarily provide calories to meet energy needs are _____ and _____.
   A. Carbohydrates and fats
   B. Carbohydrates and proteins
   C. Vitamins and minerals
   D. Lipids and minerals
2. Which one of the following food group mainly provides carbohydrates?
   A. Vegetable food
   B. Fruit foods
   C. Staple foods
   D. Oils and sweets foods
3. The state of having adequate dietary intake and the ability to absorb and use nutrients in the body is _____.
   A. vailability
   B. Access
   C. Stability
   D. Utilization
4. Children whose height is below the average for their age are considered to be _____.
   A. Underweighted
   B. Stunted
   C. Wasted
   D. Overweighed
5. A diet that contains variety of foods to provide sufficient levels of calories and essential nutrients is _____.
   A. Healthy eating
   B. Food group
   C. Adequate diet
   D. Balanced diet
6. Which of the following micronutrient is supplemented to adolescent and pregnant women.
   A. Calcium
   B. Zinc
   C. Iron folic acid
   D. Iodine
7. Which forms of malnutrition is occurs from long time food shortages.
   A. Obesity
   B. Stunting
   C. Underweight
   D. Both B and C

Part II: Answer the following questions.

1. What are the different types of food nutrients?
2. Describe the differences between food and nutrition security?
3. What are the basic components of food and nutrition security?
4. What are the different forms of malnutrition? List the mechanism to tackle malnutrition in Ethiopia.

Unit 16 Diversified Food Production and Consumption



Contents	Learning Outcomes
16.1. Importance of diversified food production 16.2. Dietary diversification strategies 16.3. Nutrient enrichment strategies 16.4. Indigenous knowledge in nutrition sensitive agriculture	At the end of this unit, you will be able to: ▪ explain the significance of diversified food production ▪ describe the dietary diversification strategies ▪ describe the nutrient enrichment/ modification strategies ▪ appreciate the roles of indigenous knowledge in nutrition-sensitive agriculture

16.1. Importance of Diversified Food Production

Brainstorming 16.1.

Individual work.

1. What is food diversification?
2. Do you always eat the same type of food? List down the types of food you enjoy eating. From how many food groups do you consume daily?
3. List the benefits of food diversification and consumption?

*Check your answers as the lesson progresses.

Agriculture is an indispensable sector for food and nutrition security. Agricultural food diversification is the act of introducing or producing a variety of food from agricultural activities. It is important to produce and consume different types of food. Different food types provide different nutrients that people need to be healthy. Children need a variety of food to grow well and develop properly. Adults need a variety of food to have energy and be productive. Women who are pregnant or breastfeeding need different foods for the baby and for themselves to be healthy and strong.

Diversification of foods grown by a household can improve dietary diversity and nutrition outcomes. Different foods and food groups are good sources for various macro and micronutrients. This means a diverse diet is the best way of ensuring people have all the nutrients they need. Agricultural diversification or **integrated farming systems** involve several subsystems including crops, animals and fish. These synergistic interactions have a greater total effect than the sum of the individual effects on nutrition. It is recommended that an individual consume at least four food groups in each meal. A diverse diet most likely meets both known, and as yet, unknown needs for human health. Improved nutritional and health status can increase individual productivity which leads to improved household production and income.

Key term:
Integrated farming system is a sustainable agricultural system that integrates livestock, crop production, fish, poultry, tree crops, plantation crops and other systems that benefit each other. It is based on the concept that 'there is no waste'.

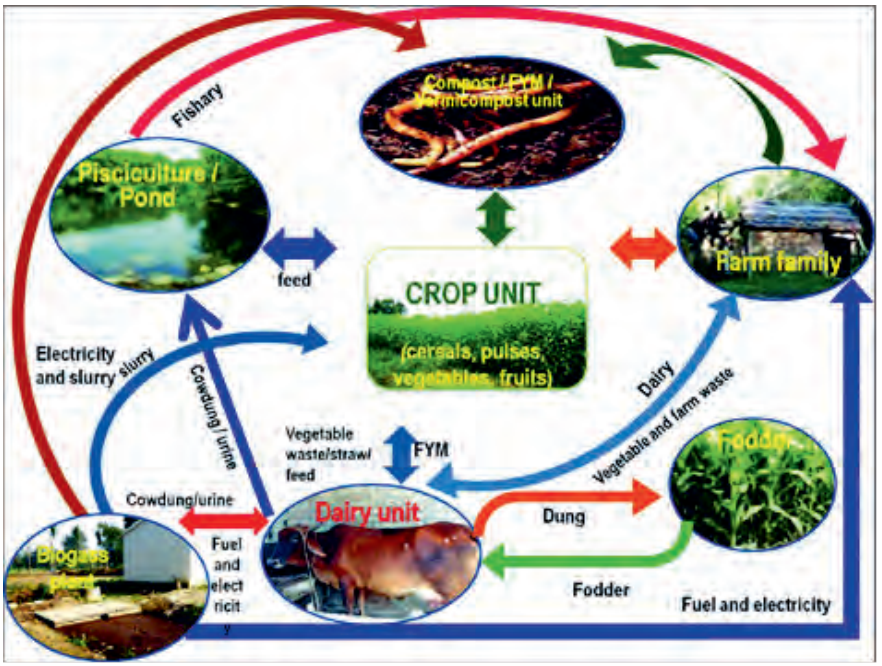


Figure 16.1. Example of integrated farming system

16.2. Dietary Diversification Strategies

Dietary diversity is defined as the number of different individual food items or food groups consumed over a given period of time. Low dietary diversity is a particular problem in Ethiopia where the diet is frequently based on starchy staples such as teff, maize, sorghum, enset, and wheat. The diet often lacks animal source foods, (meat, fish, eggs and dairy products) and fruits and vegetables. Since the different food groups provide different benefits, consumption of diversified foods is important for the health of adults and proper growth and development of children.

Strategies for food and dietary diversification at the community and household levels can maximize the availability of adequate amounts and greater variety of nutritious foods. Such activities include:

- promotion of mixed cropping and integrated farming systems
- introduction of new crops with high nutritional/health importance such as soybean
- encouraging the use of underexploited traditional foods and home

gardens

- fostering urban farming of crops with high nutritional value, i.e., deep colored fruits and green leafy vegetables
- encouraging the keeping of small animals (goats, sheep and poultry) and fish farming
- advancing improved preservation and storage of fruits and vegetables to reduce wastage, post-harvest losses and effects of seasonality
- strengthening small-scale agro-processing and food industries
- encouraging income generation at individual or household level
- promotion of nutrition education such as complementary feeding (food in addition to breast milk for children between 6 and 23 months of age), food quality and safety, hygiene and sanitation issues, etc.

Activity 16.1.

Group Work

In small groups, discuss the dietary diversification strategies practiced in your community. Report the summary of your discussion to the whole class.

16.3. Nutrient Enrichment Strategies

Brainstorming 16.2.

Individual work

1. What does nutrient enrichment mean?
2. What does nutrient enrichment involve, in your opinion?
3. Why is enriching nutrients important?

Dietary modifications are changes made to increase the **bioavailability** of micronutrients in food at the commercial or household level. Changes may occur during food preparation, processing, and consumption. Most modifications aim to reduce micronutrient deficiencies. One example of dietary modification is the simultaneous consumption of iron-rich foods with ascorbic acid (vitamin C).

Key term:
Bioavailability is the ability of a substance to be absorbed and used by the body.

Reasons for diet modification

The normal diet may be modified to:

- provide a change in the constituents of the diet
- maintain, restore or correct nutritional status
- include all nutrients in the diet
- increase or decrease the energy value of the diet
- provide foods bland in flavor
- modify the intervals of feeding

There are several types of nutrient enrichment/modification strategies. The four techniques of nutrient enrichment are described below.

16.3.1. Fortification

Food fortification is the practice of deliberately increasing the content of an essential micronutrient, i.e., vitamins, minerals, and trace elements in a food. It aims to improve the nutritional quality of the food supply and provide a public health benefit with minimal risk to health. It reduces the number of people with dietary deficiencies within a population. Diets that lack variety can be deficient in certain nutrients. Sometimes the staple foods of a region can lack particular nutrients. Addition of micronutrients to staples and condiments can prevent large scale deficiencies.

The FAO outlined that most common fortified foods are cereals and cereal-based products, milk/milk products, fats and oils, tea and other beverages and infant formulas. Food fortification is a sound public health strategy because it is cost effective, can reach large segments of at-risk populations through existing food delivery systems without requiring major changes in existing consumption patterns.

16.3.2. Germination

Germination of pulses and cereals is one of the traditional methods of food processing. It is extensively used in the preparation of foods for weaning babies and for elderly people. Germination is a process in which a pulse or cereal will sprout small shoots when kept with small amount

of water. The grains and pulses to be sprouted need to be soaked in just enough water so that all of it is absorbed. If the extra water in which they are soaked is thrown away, a lot of nutrients are lost.

Grains like wheat, barley, sorghum, etc. can be sprouted. These grains can then be dried in shade and roasted lightly. They can be ground and used in many dishes. Pulses are also sprouted first and then steamed and consumed. The time and water which each grain or pulse needs for soaking and sprouting is different. Normally, 8 to16 hours are needed for soaking and 12 to 24 hours for sprouting. The cloth in which the soaked grain or pulse is tied should be kept moist all the time. When sprouting is followed by fermentation, the vitamin content becomes much more improved.

Germination helps to increase the digestibility of foods. Some carbohydrates and proteins are broken down into smaller and easily digestible forms. Grains and pulses become soft after sprouting, so they take less time for cooking and are easy to digest. This means germination increases the nutritive value of food with no additional cost. Some vitamins and minerals also increase when grains or pulses are germinated. For example, vitamin B becomes almost double in quantity while vitamin C increases almost 10 times.

Experimental Activity 16.2.

Investigating germination in grains/pulses

Make a simple investigation to run-through germination of a range of different grains/pulses such as bean or chickpeas or lentil. Several students can work together. Place a filter paper over the Petri dish. Scatter the grains/pulses over the paper. Then moisten or soak it with ample amount of water. Do these daily until it become sprouted. This investigation may take several days. Prepare a note on benefit of germination and present to your families and report back to the class.

16.3.3. Fermentation

Fermentation is a process in which some micro-organisms are added to the food. There are different micro-organisms used, for example, yeast for bread and bacteria for yoghurt. The process involves the chemical breakdown of a substance by bacteria, yeasts, or other microorganisms, typically involving effervescence and the giving off of heat. The micro-organisms change nutrients already present in the foods into simpler and more easily digested forms and also make other new nutrients. Fermentation is what makes dough rise and become almost double in quantity. During fermentation the micro-organisms use up some of the nutrients present in the dough and change them into other better quality nutrients. They also make some new nutrients. Milk curd, bread and *Injera* are examples of fermented foods in Ethiopia.

Fermentation has several advantages. Fermentation improves the digestibility of foods. The micro-organisms break the proteins and carbohydrates into smaller parts, which are easier to digest. During fermentation of cereals and foods (such as peas, chickpeas, beans, etc.), calcium, phosphorus, and iron are changed into better quality. These are then easily absorbed by the body. Fermented foods become spongy and soft. They are liked by children and adults.

16.3.4. Roasting

Roasting is a cooking method that uses dry heat where hot air envelops the food. Roasting can enhance flavor of the food. Roasting uses indirect, diffused heat as in an oven. This is suitable for slower cooking of meat in a larger, whole piece. Meats and most root and bulb vegetables can be roasted. In roasting, the heat seals the outside part of the food and the juice inside the food cooks the food. Roasting is mainly used when cooking fleshy food like fish, meat or chicken. When heat is applied to the outer covering of the food, it seals it up thereby trapping all the juices inside the food.

Activity 16.3.

Individual work

1. Keep a diary to list all of the different foods that you eat within a week. Count the number of different foods. Do you think that your diet is sufficiently diverse?
2. Visit a market in your area and find out if there are any new foods which you have not tried. Make a list of new foods you have seen which you could add to your diet to make it more diverse.

*Share your finding and compare with others.

16.4. Indigenous Knowledge in Nutrition Sensitive Agriculture

In Ethiopia, farmers are engaged in mixed crop/livestock farming systems. They produce both plant- and animal-based foods for household consumption and for market. Organic vegetable and fruit production is becoming a common practice in most parts of the country. There are also area-specific traditional foods. For example, *Chuko* is common food in most parts of Oromia regional state. It is made from barley flour mixed with concentrated butter. It is a very rich source of essential nutrients. Enset is utilized in its many forms (e.g., *Kocho*) mainly in Southern part of Ethiopia. Such nutrient-rich traditional foods are luxurious and often used to complement staple foods or during ceremonies.

There are also different wild plants with the potential to contribute to diversified food consumption, as well as both food and nutritional security. For example, wild plants like shoot of bamboo (*Oxytenanthera abyssinica L.*), stinging nettle (*Urtica simensis L.*) and some wild mushroom species have been found to be rich in valuable minerals. These wild plants are dominantly found in north-western Ethiopia, central highlands and south-western Ethiopia. Moreover, these plants are consumed as food by local communities in the areas they are found. Domestication of these edible wild plants in appropriate agroecologies and their promotion for consumption can contribute towards improving food diversification of diet and nutritional security.

Unit Summary

In this unit you have learnt that:

- agriculture plays essential roles in improving nutrition outcomes
- the primary focus of diversified food production is to improve dietary diversity and nutrition outcomes
  - diets that lack variety are deficient in certain nutrients
  - a diverse diet best ensures nutrient adequacy
- dietary diversification strategies involves a range of food-based activities that can maximize the availability of adequate amounts and greater variety of nutritious foods
  - mixed cropping
  - integrated farming systems
  - introduction of new crops of high nutritional importance
  - poultry and fish farming
  - vegetable and fruit production are examples of diversification strategies
- dietary modifications are made to increase the bioavailability of micronutrients in food
- dietary modifications can be done at the commercial or household level
- the goal of dietary modifications is to reduce the number of population that suffer from micro-nutrient deficiencies
- nutrient enrichment or modification strategies include fortification, fermentation, germination and roasting
- dietary modifications aim to increases the nutritive value of food

Review Exercise

Part I: Choose the best answer from the given alternatives.

1. Which one of the following is not a dietary diversification strategy?
   A. Sheep farming
   B. Soybean production
   C. Mono-cropping
   D. Complementary feeding
2. Which one of the following nutrient enrichment technique is low cost compared to the others?
   A. Fortification
   B. Germination
   C. Fermentation
   D. Roasting
3. The act of introducing or producing a variety food from agricultural activities is _____.
   A. Nutrient enrichment
   B. Dietary diversification
   C. Food fortification
   D. Food diversification
4. Fortified foods:
   A. provide essential vitamins and minerals
   B. have low amounts of micronutrients
   C. maximize risk to public health
   D. reduce nutritional quality of the food supply
5. All of the following are examples of fermented foods in Ethiopia except _____.
   A. Milk curd
   B. Bread
   C. *Kita*
   D. *Injera*

Part III: Answer the following questions.

1. Write the advantages of germination technique of nutrient enrichment.
2. Summarise the concept of nutrition-sensitive agriculture.
3. Why is it important to eat different foods?

Figure References

Figure	Source
Figure 1.1	a) kit.nl b) digitalgreen.org
Figure 2.2	a) www.wur.nl/ Breeding for a biotic stress tolerance.
Figure 2.3	www.mdpi.com
Figure 3.3	a) www.heddels.com b) www.business-standard.com
Figure 3.3	a) www.agrihunt.com b) www.iplantz.com
Figure 4.2	adopted from research paper PhD in Animal Science (especially Genetics and Breeding) by Markos Tibbo
Figure 5.1	b) www.hindustantimes.com
Figure 6.2	www.pashudhanpraharee.com
Figure 7.3	b) www.aa.com.tr d) www.kalro.org
Figure 7.4	b) www.bigdutchman.com
Figure 9.1	www.ojafr.ir
Figure 9.2	www.semanticscholar.org
Figure 9.3	www.researchgate.net/figure/Arsi-cattle-Courtesy-of-DAGRIS
Figure 9.4	news.trust.org
Figure 9.5	www.exportersindia.com
Figure 9.6	http://bovin.qc.ca/
Figure 11.1	www.zylemsa.co.za
Figure 11.2	www.eos.com
Figure 11.3	taken from Tolossa et al., Cogent Food & Agriculture (2020), 6: 1724354).
Figure 12.1	a) www.dw.com