C. Answer the following questions:

1. Mention four crops that are grown in plantations.
2. Explain what nomadic pastoralism means.
3. Describe the primary purposes for keeping cattle.
4. Outline main challenges facing livestock keeping in Tanzania.
5. Suggest ways of solving challenges facing livestock-keeping in Tanzania.
6. Elaborate challenges facing livestock-keeping in Australia.
7. Differentiate between traditional and commercial livestock-keeping.

Chapter Three

Water management for economic development

Introduction

In this chapter, you will learn about the uses and economic importance of water; the relationship between family size, water supply, and the quality of life; the relationship between vegetation and water supply; and the effects of distance to water sources from households to a girl child in Tanzania. You will also learn about river basin development, requirements for establishing a river basin project, as well as benefits and challenges facing river basin projects. Finally, you will learn about land reclamation, underground water, aquatic resources, pollution and water conservation.

The concept of water management

Water is a colourless liquid found naturally on the land surface, atmosphere and underground reservoirs. Water can exist in liquid, solid, or gas state. Although water is a familiar substance, it is also a unique material of the earth. For a long time, water has been considered to be an abundant resource which is found freely to all people. Today, most countries are facing increasing pressure on water resources and growing competition between differing interests. Chronic water scarcity is perceived to be one of the threats to global prosperity and stability. Other threats include hydrological uncertainty and extreme weather disasters such as floods and droughts.

Access to water is fundamental to economic and social development. However, population growth, rapid urbanisation and industrialisation, the expansion of agriculture and tourism, and climate change all put water under increasing stress. This situation has impacted negatively the socio-economic development of most developing countries. As a result, at the global level, there is a major concern regarding the management of water resources. Water resources management emerged as a response to real and foreseen water crises and increasingly unsustainable pressure on the freshwater resources, which emanate from rising populations, growing demands for water due to competing water uses, and increasing pollution.

Water resource management refers to the process of planning, developing, distributing and managing the effective use of water resources. In today's interconnected world, there is no doubt about the value of integrated planning for sustainable development. There is a need to have an integrated water resources management that supports the economic, social and environmental dimensions of sustainable development. Integrated Water Resources Management is one of the initiatives for sustainable use of water resources, and it refers to a process of promoting the coordinated development and management of water, land and related resources, in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems. The management helps to protect the environment, foster economic growth and sustainable agricultural development, promote democratic participation in governance, and improve human health.

Sources of water

There are several sources of water. These include rainfall, wells, springs, ponds, rivers, lakes, seas and oceans. There are various ways used to manage water resources. These are policies, by laws, laws, regulations, and awareness raising campaigns.

Fresh water and hydrological cycle

The hydrological cycle is a continuous circulation of water from the earth's surface to the atmosphere through the process of evaporation, evapotranspiration, condensation, precipitation and infiltration. Figure 3.1 illustrates the hydrological cycle.

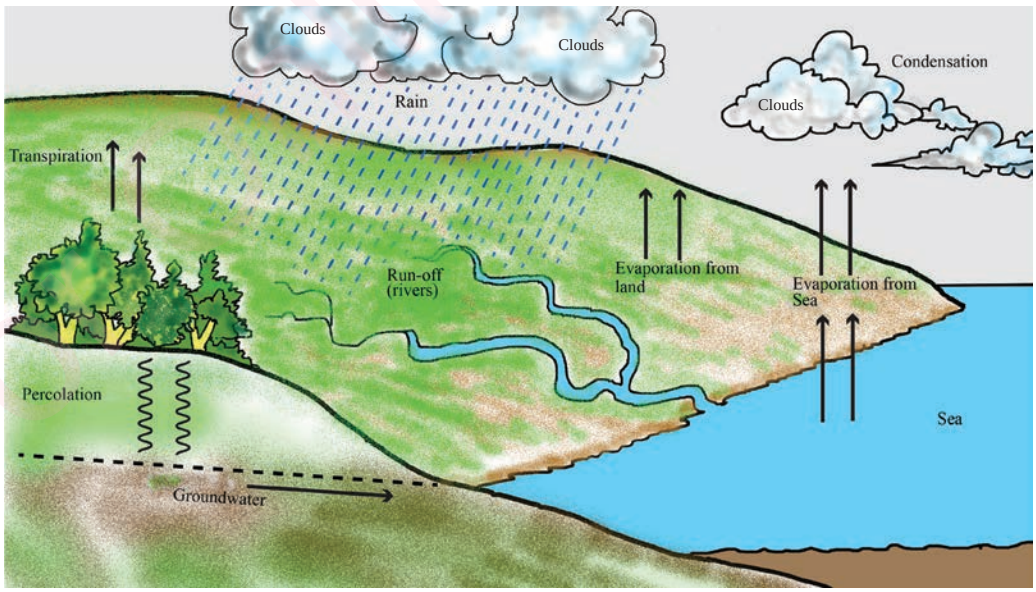

Figure 3.1 The hydrological cycle

Evaporation

Evaporation is the process by which water changes from liquid to gas or vapour. During evaporation, water moves into the atmosphere in the form of water vapour or moisture (see Figure 3.2). Water bodies such as rivers, lakes, seas and oceans contribute about 90% of the moisture found in the atmosphere through evaporation. Water changes into vapour under the great influence of temperature. Areas with high temperatures and low humidity experience a high rate of evaporation. Evaporation is also determined by humidity and wind.

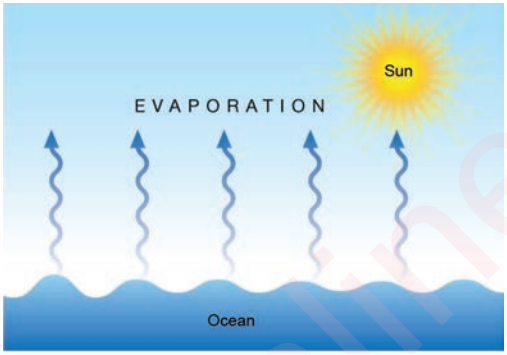

Figure 3.2 Evaporation from ocean water

Evapotranspiration

Evapotranspiration refers to the process whereby water is transferred from the land to the air through plant roots and leaves. Water from the land is carried by roots to the leaves, a process known as transpiration, and then from the leaves it changes into vapour and moves into atmosphere through the process of evaporation. The combination of these two processes form what is termed as evapotranspiration (Evaporation + transpiration = evapotranspiration) Figure 3.3. Evapotranspiration is determined by factors such as temperature, humidity, wind, soil and type of plants. These factors are hereby explained.

Temperature: An increase in temperature accelerates the rate of evaporation. During the warm season, plants open their stomata (pores) and then release water in the form of water vapour. During the cold season, plants close their stomata and thus prohibit the release of water. It should be noted that 10% of the moisture in the atmosphere is contributed by release of water from plants.

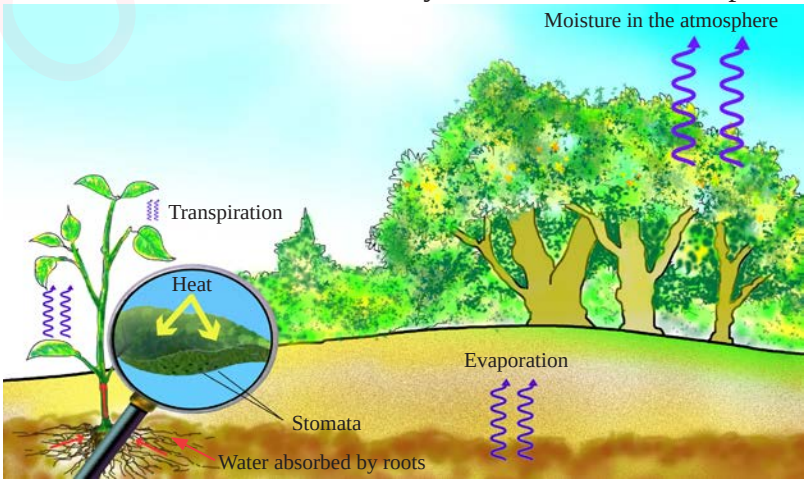

Figure 3.3 Evapotranspiration

Humidity: Evapotranspiration is also affected by humidity. When the air around the plant contains too much moisture, the rate of evapotranspiration is low. Indeed, when moist air surrounds the plant, the rate of evapotranspiration is low and vice-versa.

Wind: Wind affects evapotranspiration by keeping air in constant movement. This movement increases the rate of evapotranspiration as it clears any humidity around the plants, hence increasing the rate of transpiration.

Soil: The type of soil also determines the amount of water that can be retained in the soil and the amount of water that can be drawn from the soil through transpiration or evaporation. Fertile soil tends to support the growth of vegetation which increases the rate of evapotranspiration. Soil, which supports vegetation, allows much evapotranspiration to take place.

Types of plants: Plants with long taproots carry large amounts of water to the leaves, hence influencing the rate of evapotranspiration compared to plants with shallow roots.

Condensation

Condensation is the process whereby water in its gaseous form changes into liquid. The moist warm air from water bodies and plants moves upwards where there is very low temperature. Then it reaches a dew point (point at which water condenses) and forms clouds. Clouds are masses of water droplets which continue to accumulate and when they are saturated, they become dense and fall as rain. Condensation is a very essential process in the hydrological cycle because it leads to the formation of clouds which produce rainfall (Figure 3.4). Rainfall is the main route through which water returns to the earth's surface.

Figure 3.4 Heavy clouds in the air

Source: *ruvumapress.blogspot.com-mawingu mazito*

Precipitation

Precipitation is the falling of water from the clouds in form of rain, snow, sleet or hail. Figure 3.5 shows different forms of precipitation. It is the last stage that demonstrates the return of water to the earth's surface after changing into a gaseous form. Precipitation may be heavy or light thereby creating heavy rain, snow or hail. Whereas rain is directly in liquid form, snow and hail are water in solid form as a result of freezing. Water reaches the ground in form of snow or hail after the temperature in the atmosphere fails to melt it completely before reaching the

ground. Upon reaching the ground, which has higher temperature than the atmosphere, the snow and hail melt into liquid as surface run-off. Also some water infiltrates into the earth's surface through soil and cracks.

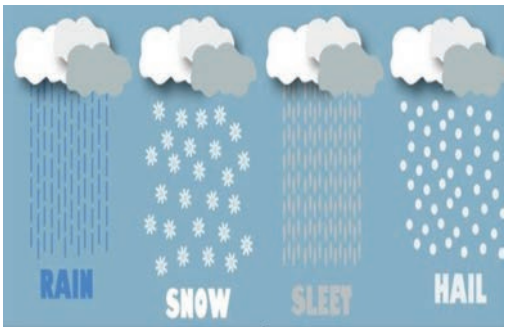

Figure 3.5 Different forms of precipitation
Source:*pinterest.com-forms of precipitation*

Infiltration: Infiltration, which is sometimes called percolation, is the process whereby water that has reached the ground penetrates into the soil or rocks (Figure 3.6).

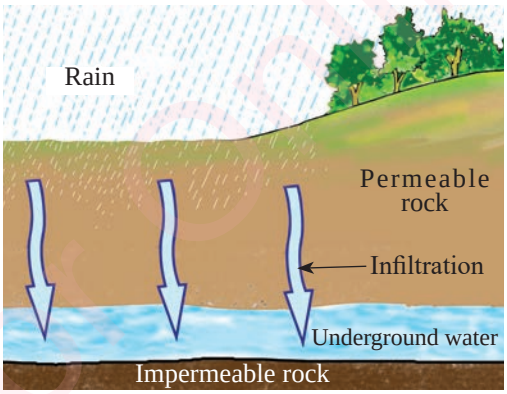

Figure 3.6 Water infiltration into the soil

Some of the water may seep through and go deep underground and create underground runoff or aquifer in the rocks. Water that percolates the land surface is called underground water. Infiltration is an essential process as it feeds water bodies and soils which are sources of evaporation and evapotranspiration.

Economic importance of water

Water is a source of life for almost all living organisms including animals and plants. Numerous economic activities are conducted in water while others use water as part of raw material.

Human beings are primary users of water and integrate it in their economic activities in various ways. Their ability to plan and conduct economic activities is basically supported by water. Water is used as an important ingredient in sustaining life, especially for cooking, drinking and maintaining cleanliness. Generally, water is essential for economic development. It is used in the manufacturing industry, hydro-electric power generation, and navigation as well as domestic activities and trade.

Moreover, water is used in various processing and manufacturing industries for the production of food and beverages. It is important in mixing ingredients that are added to raw materials during food and beverage processing and production. For example, water is a component of most beverages such as soft drinks, milk, coffee and tea. These beverages contribute to the economy of many countries as a source of income generation. They are sold locally and exported to earn foreign income. Other

industrial uses of water include cooling and washing.

Also, water is important for irrigation purposes. Many countries around the world do not depend completely on rainfall for agriculture due to its uneven distribution. To ensure that agricultural activities are carried out largely for commercial purposes, irrigation has proven to be the best option. For example, in Tanzania, there are irrigation schemes in rice paddy plantations; these are Mbarali rice farm, Kapunga rice farm in Mbeya Region and sugar-cane plantations in Kilombero and Mtibwa in Morogoro Region; and Kagera sugar plantation in Kagera Region. Other countries which use water for irrigation on a large-scale in Africa include Sudan and Egypt. The irrigated plantations produce high output which contributes to economic development through sale in local markets and for exportation.

Water is also a source of electrical power. Modern economies depend much on the supply of electricity. One of the sources of electric power is water to produce what is commonly known as hydroelectric power (HEP). HEP is one of the cheapest and environmentallyfriendly sources of power. This power is used in industries to run machines, transport goods and provide services as well as in communication systems. Moreover, power contributes to the establishment of small and large-scale economic activities which eventually contribute to the economic growth of a given country.

Furthermore, water is useful in the navigation sector in various ways. Human beings navigate different vessels such as canoes, boats, ferries and ships to move people and goods. Transportation of heavy machines for factories and industries, vehicles, timber and logs is made possible on water. In Tanzania, water transport on lakes and oceans facilitates the importation and exportation of various goods such as machines and vehicles. In fact, water as a means of transport is likely to reduce the transport cost compared to other means of transport and, hence, contribute meaningfully to economic growth. Water is the habitat for aquatic organisms such as fish which are useful to human beings. Usually, water bodies such as oceans, sea, lakes, rivers, dams and ponds attract fishing and, hence, fishing related activities. Fishing provides human beings with food and income through local selling and exportation of fishing products.
In addition, water is used for trading which supports local communities to earn income and the government to get the much-needed revenue.

Other uses of water which contribute to economic growth and prosperity are tourism and sports. Some water sceneries attract local and foreign tourists which helps to earn income for the host countries. Water-based sports such as skiing, surfing, canoeing and diving are also sources of income.

Family size, water supply and quality of life

Family size refers to the number of family members. The size of the family influences the household water demand and use, hence making it central to any measurement of socio-economic status. Indeed, the larger the family, the higher the water demand for domestic use. With adequate and reliable supply of water, the quality of life is improved as families will not need to spend most of their time searching for water.

International Treaties and Declarations of the United Nations recognise the right to water as essential for securing an adequate standard of living. The reason is that water is one of the most fundamental conditions for survival. The right to water, emphasises that everyone should have access to sufficient, safe and affordable water for personal and domestic uses. Article 11 of Human Rights of the United Nations recognises the right of everyone to adequate standard of living, including adequate health, sufficient food and shelter, all of which require access to clean water.

Many people in the world and particularly in the developing countries have inadequate water supply to meet their daily needs. Indeed, shortage of water has a serious health implication as it can lead to illness and even death among the poor in many developing countries. Water-borne diseases such as cholera, bilharzia, typhoid and diarrhoea are common in areas with scarcity of water supply. About three-quarters of households in sub-Saharan Africa get water from sources located away from their homes, with women and girls bearing the main task of collecting water for their respective households.

Effects of distance to water sources on the girl-child in Tanzania

Water fetching in most Tanzanian societies is a cultural and gender-related activity in terms of who is responsible for carrying it from the sources. The responsibility of fetching water and the overall water management in households is influenced by gender and cultural norms. The burden of fetching water is borne by both women and children, particularly girls. They travel over long distances to fetch water for domestic purposes.

These distances coupled with other factors such as difficult terrain, poor water flow, and queues at the water sources take a lot of time from girls. Fetching water appears to have direct effect on the physical health of the girls and their ability to participate in domestic responsibilities.

Children, particularly girls, experience pains or movement problems associated with walking long distances in search of water. This, in turn, is associated with disability linked to spinal disorders and cervical compression syndromes. In addition, walking over

long distances while carrying water contributes to psycho-social and emotional suffering. The suffering can have general health implications that may lead to disability and affect work performance. Moreover, incidents and fear of physical and sexual violence are widely reported by women and children in relation to water-fetching activities.

The extent of the problem of walking over long distances to water sources is more pronounced in low and middle income societies than in high income ones. Since economic, political and social inequalities are reflected in access to drinking water, the marginalised groups may suffer differently from the negative economic and health effects of carrying water over long distances. Furthermore, this situation leads to material deprivation for women, lack of voice and capacity to cope with any form of crisis. This, in turn, widens the poverty gap and gender inequalities in Tanzania.

In addition, carrying water over long distances limits women's participation in productive economic activities, hence low school enrolment for girls. Access to water and sanitation is, therefore, related to the time that girls need to attend school, and can be among the reasons that keep them out of school. Therefore, access to fresh water and sanitation does not only improve the health of a family, but also provides an opportunity for girls to attend school and spend their time more productively on academics than on fetching water.

Relationship between vegetation and water supply

Vegetation refers to the collection of plants growing in a particular area under certain climatic conditions. Vegetation growth depends on various factors such as rainfall, temperature, soil and relief. In particular, rainfall provides water which is required for the growth of plants. Areas with dense vegetation cover tend to experience high rates of evapotranspiration which is necessary for rain formation.

The amount of water supply in a particular area also determines the type of vegetation growth. For example, due to their semi-arid climatic conditions, central parts of Tanzania such as Dodoma and Singida experience little rainfall in a year. The vegetation cover is mainly shrubs with little influence on formation of rainfall. On the other hand, areas with equatorial climate are covered with thick vegetation (equatorial rainforests). This type of vegetation has significant influence on rain formation due to high rates of evapotranspiration determined by high temperatures in these regions. High rainfall results in adequate water supply.

Vegetation cover plays an important role in protecting catchment areas. In other words, vegetation reduces the amount of water loss in those areas. As a result, enough water supply to those areas is maintained. In Tanzania, the areas around the slopes of Mount Kilimanjaro experience constant flow of water throughout the year because of the presence of thick vegetation cover.

It should be noted that plants require different amounts of water for their growth. However, water is not evenly supplied. As such, plants adapt differently to their physical environment. This is one of the reasons for the different sizes and appearance of the plants in different geographical areas. For example, in dry areas, plants develop adaptation mechanisms.

The leaves develop thorny leaves or a waxy surface to reduce loss of water through transpiration. Plants develop deep roots in the ground to reach water. Other plants develop storage organs. For example, a baobab tree stores water in its trunk. Some plants shed their leaves during periods of water scarcity. The relationship between vegetation and water supply may be influenced by human activities such as water drilling and deforestation. Water drilling may increase water supply in areas with water scarcity and, thus, influence the growth of the planted vegetation. On the other hand, deforestation exposes the area previously covered by the forest to evaporation and thus destroys the catchment areas. As a matter of fact, deforestation may turn an area into arid or semi-arid land.

Exercise 3.1

Answer the following questions:

1. What is the correct term for plants releasing water from their leaves, which then evaporates?
   (a) Evaporation
   (b) Precipitation
   (c) Transpiration
   (d) Condensation

2. What is evaporation?
   (a) Water freezes
   (b) Water vapour meets cold air and changes back into liquid
   (c) Water gets warm and changes from liquid to water vapour
   (d) Plants take in water from the soil

3. What is the correct term for the rising water vapour meeting with colder air and turning back into water droplets?
   (a) Condensation
   (b) Precipitation
   (c) Evaporation
   (d) Infiltration

4. Transpiration is…
   (a) soil infiltration.
   (b) water turning directly from ice to water vapour.
   (c) evaporation from the leaves of trees.
   (d) runoff from steep hills.

5. The process by which water is taken up by plants and released into the atmosphere is called:
   (a) Condensation
   (b) Evaporation
   (c) Precipitation
   (d) Transpiration
6. Name five uses of groundwater.
7. How and where does groundwater flow?

River basin development

A river basin is an area of land drained by a river and its tributaries. It has features such as tributaries, watershed and convergence. Tributaries are small rivers flowing into larger rivers whereas a watershed is an area of highland surrounding a river basin. Convergence, also known as confluence, is a place where a river joins another river. Figure 3.7 shows the sections of a river basin.

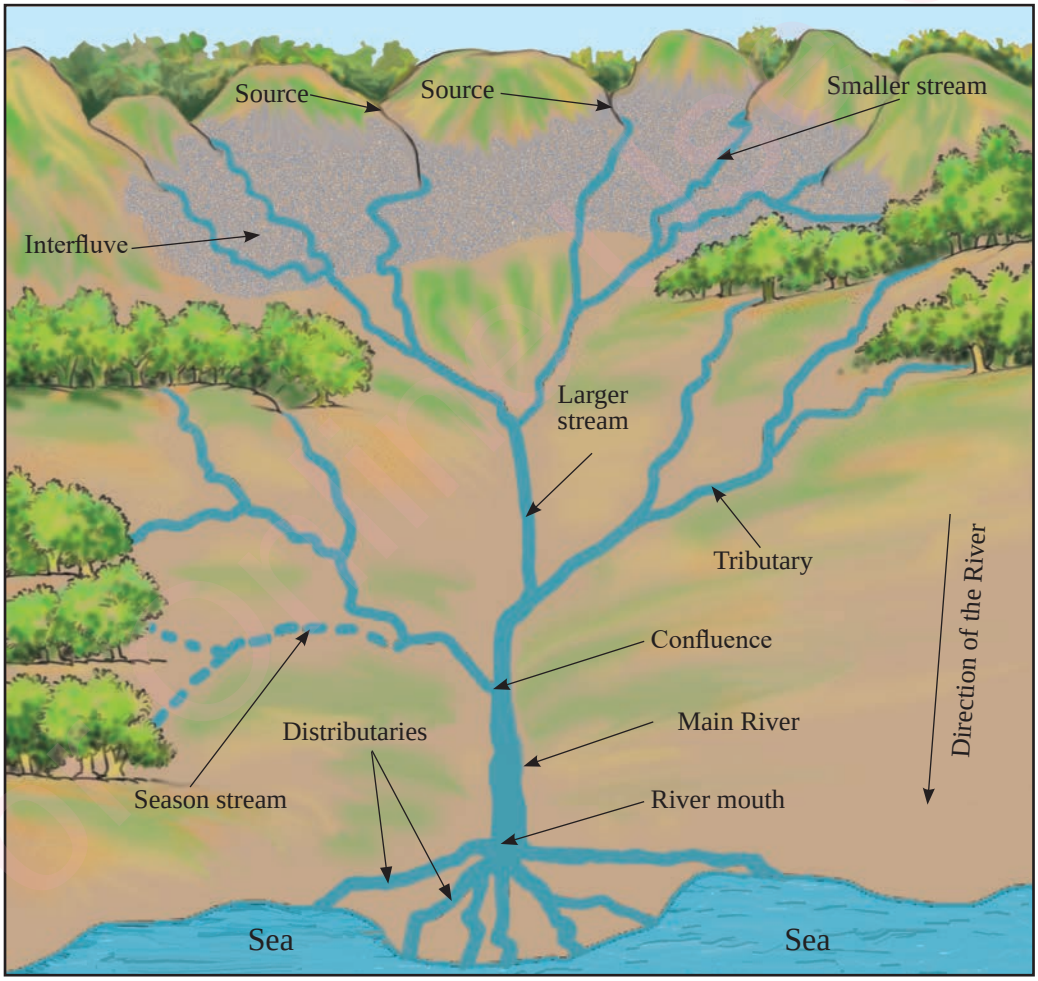

Figure 3.7 Sections of a river basin

River basin development is a long-term planning and management for a multipurpose project focusing on sustainable utilisation of the area within the basin. River basin development may include better land use, better water use, adequate energy and food supply, transport, flood control and protection of the environment.

A good river basin requires constant volume of water. This increases the possibility of carrying out various development projects. Projects which take place in river basins should not have negative impacts on the people or the environment. The impacts may include disturbing the habitat of various species such as fish. Other impacts are water pollution, disease outbreak and resettlement of villages.

In Tanzania, environmental impacts are controlled by carrying out Environmental Impact Assessment (EIA). The EIA aims to establish potential environmental impacts that may be caused by a given project that is planned to be conducted. It is usually done by a registered expert through the National Environment Management Council (NEMC).

Requirements for establishing a river basin project

As river basin projects serve social and economic purposes, they need to be carefully designed by observing a number of issues. The following are some of the requirements which should be observed when establishing a river basin project:

(a) Construction of dams for retaining water.
(b) Removal of silt or mud from the river or dam (dredging).
(c) For transport purposes, the river channels should be straightened and widened so that they can accommodate more water.
(d) Trees should be planted on marginal land, hill slopes and riverbanks. This will help to control soil erosion and check the movement of surface run-off, to reduce or prevent silting and flooding.

If such requirements are observed river basin projects will achieve the expected benefits.

Benefits of river basin development projects

The benefits of a river basin project vary depending on the nature and scale of the project, location and administrative structure. The lower section of rivers is usually exposed to excessive rain water, causing floods. To prevent floods, basin management establishes dams which serve as collection areas of excessive water. River basins in their natural state may hardly be safe for human settlement. In fact, the establishment of basin development projects increases the value of the basins and makes them more conducive for human settlement. This compels governments to extend social services such as infrastructure, health and education.

River basin development also attracts irrigation. Due to availability of water in a basin, commercial agriculture is

established through irrigation schemes. Sometimes, individual peasants use a well-managed river basin for watering their small farms using traditional mechanisms such as buckets. In addition, river basin development projects involve planting of trees and construction of dams. They also involve strict measures for prohibiting deforestation and poor cultivation practises. All these measures aim to foster appropriate use of the land to keep it productive. These measures also enable the preservation of the ecosystem. By doing so, these projects contribute to preventing the land from being eroded by environmental problems such as soil erosion, floods and loss of soil fertility.

Basin development projects involve the establishment of hydroelectric power plants following the construction of dams. The water from the dams is used to generate electricity for domestic and industrial purposes. In Tanzania, Mtera, Kidatu and Kihansi dams in Rufiji Basin are hydroelectric power stations. In addition to hydroelectric power, the constructed dams create opportunities for fishing; for example, Mtera Dam is one of the dams where fishing activities take place. Moreover, well-managed basins which have gorges, waterfalls, man made reservoirs and land scenery attract tourism. Tourism is one of the potential sources of income and contributes significantly to the national economy.

Basin development projects also generate employment opportunities in agriculture, forestry, tourism, transport and fishing. Such development projects contribute to income generation for the country and, consequently, to the growth of its economy. Nevertheless, there are challenges resulting from the establishment and running of these projects.

Challenges facing river basin projects

River basin projects face numerous challenges. Many of these challenges are caused by natural events and human activities that take place in the basins. These are described below.

Siltation

Siltation is one of the challenges facing river basin projects. The water in dams depends on the supply of water from highland areas through streams and rivers. Usually streams flowing into dams carry some sediments which ultimately accumulate in the dams. This accumulation of sediments leads to a decrease in the volume of water which may have numerous impacts. These impacts may include lowering the ability of dams to produce enough water necessary for electricity generation, in addition to affecting transport and destroying marine organisms.

Water pollution

Water pollution is another challenge related to the dam projects. In many cases, modern agriculture involves the use of agro-chemicals. These agro-chemicals dissolve in water and get

transported to the dams through water streams which may affect marine organisms, including fish.

Costs

Generally, the establishment and maintenance of river basin projects is costly. The cost may be higher particularly when the basins encounter unexpected natural events such as droughts or excessive rainfall. Whereas droughts reduce the volume of water in dams, excessive rainfall may lead to overflow and too much siltation in the dams. The overflow damages property and farms in outlining areas.

Trans-boundary conflicts

Some basin projects face management challenges as they extend to different countries. As a result, establishing any project in one of the partner countries of the basin may require a consensus from other countries which is not always guaranteed. For example, the Nile Basin is shared by Tanzania, Uganda, Sudan, Egypt, Ethiopia, South Sudan, Kenya, Rwanda, Burundi and Eritrea. For decades, there has been complaints from upstream countries (Kenya, Uganda, Tanzania, Ethiopia and Sudan) about the dominant use of the Nile waters by Egypt. The Nile Valley Initiative is a project that aims to solve these disputes peacefully.

Rufiji Basin in Tanzania

The Rufiji river basin is managed by the Rufiji Basin Water Board (RBWB) under the Ministry of Water. It is one of the largest river basins in Africa, and covers an area of about 177,420 km^2. This basin occupies 20 percent of the country. It occupies parts of Iringa, Njombe, Mbeya, Ruvuma, Morogoro, Dodoma and Pwani Regions (Figure 3.8). The basin contains the Rufiji River which is the largest river in Tanzania. It originates from the south-western highlands. It has four main tributaries, namely, the Great Ruaha, Kilombero, Luwegu and the Rufiji lower section. These four tributaries join to form the Rufiji River.

There are several socio-economic activities within the basin which benefit individuals and the nation. These include agriculture, tourism, hydropower generation, fisheries, mining and livestock keeping. Land in the Rufiji Basin is used mainly for agriculture, tourism, wildlife conservation, fisheries and mining. Agriculture is mainly practised in the Usangu Plain in Mbeya and Kilombero Basin in Morogoro.

Apart from being rich in water resources and biodiversity, the basin is endowed with a good climate, fertile soil, minerals and human resources. It is known for its agricultural production and is often called the “bread basket” of Tanzania. Within the basin, there are important national parks (Kitulo, Ruaha, Mikumi, Udzungwa and Uluguru), large game reserves (the lower part of Selous, Rungwa, Usangu, Mpanga/ Kipengere, and Lunda), forest reserves, and pasture for livestock.

Fishery is practised in the Kilombero, Great Ruaha and Rufiji rivers.

Mining projects are developed in the Selous Basin at Namtumbo District where Uranium is developed and copper project in Iringa District at Nyang'oro Hills. Because of its large agricultural, hydroelectric and other potentials, the basin is the focus of the Government of Tanzania, donor and private development plans. It has also attracted large numbers of people migrating to the area seeking land for cropping and raising livestock. According to the national census of 2012, the districts within the basin had 9,032,089 people compared to 3,055,051 in 2002. It also contains Kihansi spray toads, which are a unique species for tourist attraction. These frog species are not found anywhere else in the world.

Benefits of the Rufiji Basin Water Board

i. It has promoted the market of HEP from Kidatu power plant.
ii. There has been flood control.
iii. It has led to the creation of employment opportunities in the valley, thus promoted living standards of people.
iv. It has led to the development of villages and towns, for example new towns like Kidatu, Makambako and Mikumi.
v. The board provides expert advice to the farmers on good farming practice and solutions to their farming problems.
vi. A number of large irrigation projects on sugar and rice are carried out in the Kilombero Valley and Usangu Plains respetively.
vii. There has been an increase in the planting of teak and rubber trees in some parts of the Rufiji Basin. These trees can potentially benefit the timber and rubber industries in the country. The irrigation projects also increase agricultural products for food and commercial purposes.

Challenges facing the Rufiji Basin Water Board

Apart from having benefits, the RBWB is also facing some challenges including the following:

i. Poor labour supply due to out-migration to urban centers.
ii. Diseases like cholera and malaria affect the farmers such that they fail to contribute effectively in the development of the scheme.
iii. Climate related problems like drought have been affecting water availability; sometimes the volume of water in the river decreases. Climatic changes are experienced in most parts of Tanzania including Rufiji Basin, with prolonged drought and unreliable rainfall leading to insufficient water supply. This situation affects food production in the basin, sugar plantations, HEP and wildlife.
iv. Transport problems prevail, especially during rainy season during which the area is not always accessible.

Figure 3.8 The Rufiji River Basin in Tanzania

Other river basin development projects

There are various river basin development projects in Africa under different authorities. In Tanzania, the river basins include Rufiji River Basin in which the Stiegler's Gorge project (Nyerere Hydroelectric Power Plant) for generation of hydroelectric power is located, and Kagera River Basin which is jointly managed by Tanzania, Rwanda, Uganda and Burundi. Other river basin development projects in Africa include the Gezira Irrigation Scheme (Sudan), Aswan High Dam (Egypt) and Galole Irrigation Scheme (Kenya). Others are the Volta River Project (Ghana), Orange River Project (South Africa), Cabora Bassa Basin (Mozambique) and Tana River Development Project in Kenya. Outside Africa, river basin development projects include the Ganges Project (India), Amazon Basin Development Scheme (Brazil), and Tennessee River Basin Project in USA.

The Tennessee Valley Authority

The Tennessee Valley Authority (TVA) is a federal cooperation agency in the United States of America (USA). It is the largest public power company in the United States. It supplies electricity to millions of people in the USA. Tennessee River is a tributary of the River Ohio River, and the Ohio is a tributary of the River Mississippi River (Figure 3.9). The Tennessee River Basin lies in a seven-state area in the

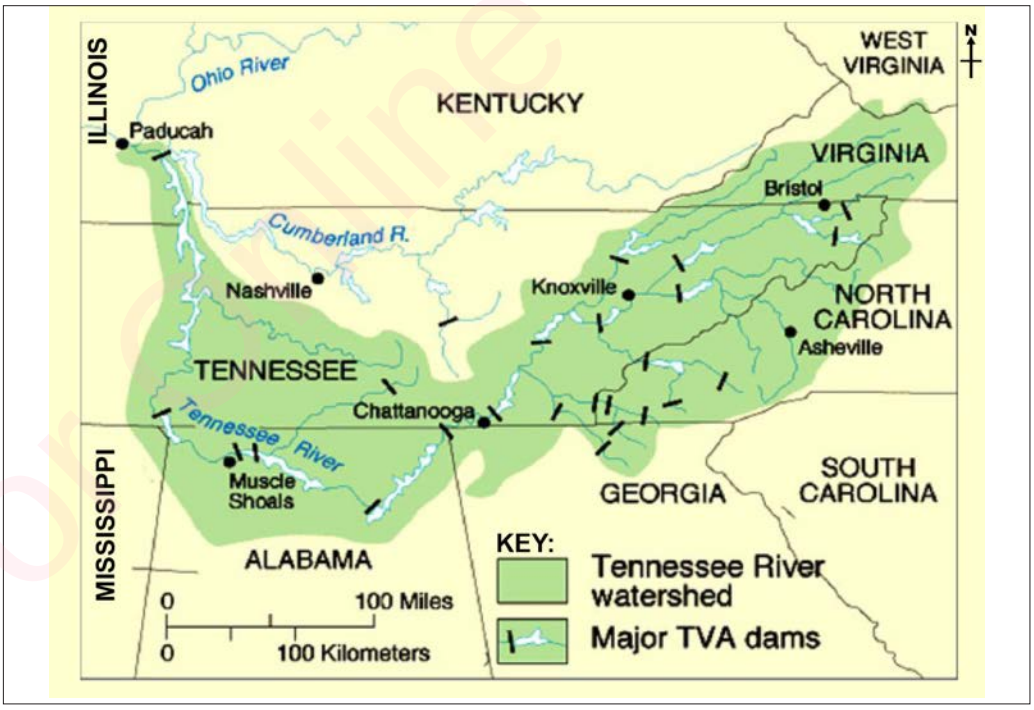

Figure 3.9 Tennessee Valley Authority
Source: *bkushistory.pbworks.com tva*

south-eastern part of United States. Its drainage area covers 40,900 square miles (105,930 square kilometers), mostly in the State of Tennessee, but with parts also in Kentucky, Virginia, North Carolina, Georgia, Alabama, and Mississippi.

The TVA was established in 1933 by the US Government. The development of TVA was triggered by social and economic conditions in the Tennessee Valley in the 1930s. During those years the region was largely rural and undeveloped, poverty-stricken, and characterised by degraded environmental conditions due to poor farming methods. Similarly, there was severe erosion, extensive deforestation and deteriorating environment.

The establishment of the TVA was meant to achieve four key functions, which are: (i) To improve navigability and provide for the flood control of the Tennessee River; (ii) To provide for reforestation and the proper use of marginal lands in the Tennessee Valley; (iii) To provide for agricultural and industrial development of the Tennessee Valley; and (iv) To provide for national defence by the creation of a corporation for the operation of government properties. Later, after its establishment, the functions of the TVA were expanded to include:

i. Management of the Tennessee Valley River system for multiple purposes including navigation, flood control, power generation, ensuring water quality, public land conversation, recreation, and economic development;
ii. Generation of electricity;
iii. Sale and transmission of electricity to wholesales and large industrial customers; and
iv. Transmission of economic development activities that generate a higher quality of life for citizens of the Tennessee Valley.

Benefits of the Tennessee Valley Authority

The TVA has achieved many aims for its establishment. These are described in the following sections.

Power generation

TVA has the responsibility of providing reliable, affordable electric power that helps businesses and families prosper. In 1998 the main sources of power were hydro and thermal, which represent nearly 14 percent of TVA's total generating capacity. In 2008 the authority supplied power to 159 local power companies that served 8.7 million people, and 650,000 businesses and industries in the seven-state TVA area. In 2017, TVA's power portfolio contained 30 dams or hydroelectric facilities, eight coal plants, 16 natural gas plants, three nuclear plants, 14 solar energy sites, and one wind energy site. Currently, TVA supplies power from a diverse energy portfolio that includes nuclear, coal-fired, natural gas, hydroelectric, and renewable power. This is supplied to more than 10 million customers within the valley. Today, TVA is the largest public utility and one of the largest

electricity providers in the United States. Likewise, the generation of power has stimulated different manufacturing and heavy industries in the valley.

Environmental stewardship

TVA was mandated with the responsibility of managing the natural resources in the Valley for the benefit of the region and the nation. For example, the TVA manages the Tennessee River system and neighbouring public lands so as to reduce flooding, maintain navigation channels, support power production and recreation, improve water quality and supply, and protect shoreline resources. Currently, the authority has a sophisticated system of dams to control flooding along the Tennessee River watershed. This provides an opportunity of controlling the floods by controlling about $ 260 million in flood damage annually. To date, the operation of this system has prevented over US$5.4 billion in flood losses across the Tennessee Valley, including about US$ 4.9 billion in damage averted at Chattanooga the Valley's most flood-prone city. The system has also prevented about US$ 470 million in flood losses in the lower Ohio and Mississippi River drainage basin.

Economic development

TVA builds businesses and community partnerships that bring jobs to the region and keep them there with a view to making the economy stronger. For example, the Tennessee River has always been a key to the economic development of the TVA through commercial ships which facilitate the movement of goods and machinery. Likewise, the authority managed to construct dams which increase the water supply for irrigation, domestic and industrial uses. Consequently, the dams have also led to the development of fishing industries for domestic and commercial purposes.

The TVA has managed to increase the land for the cultivation of crops. The land, which was earlier affected by soil erosion, has now been controlled using various methods. Trees have been replanted and good cultivation practises, such as construction of terraces, have been applied on the valley slopes. All these measures have stabilised agricultural production, which is a good indicator of agriculture's contribution to the improvement of income of the people in the Tennessee Valley. The TVA was charged with the following short-term objectives: To control floods, improve navigation, develop HEP, improve the land along the river banks, conserve soils and carry out reforestation projects to check erosion in the region.

TVA was also involved in other activities such as industrial development, wildlife conservation, forest, road and rail development, malaria control, planning for towns and educating farmers in sound agriculture techniques. The long-term aim of TVA was to raise the

standard of living of the people in the area. Moreover, the TVA has established more than 100 public parks and camping sites to attract tourists. Tourists visit the valley because of a number of attractive natural and man-made land sceneries. These developments in the basin have contributed to the establishment of a strong tourism industry in the valley.

Prospects of the Tennessee Valley Authority

The Tennessee Valley Authority is one of the largest river basin development projects in the world. Despite the innumerable successes achieved so far, TVA still has more room to establish more development projects. The authority aims to exploit sustainably every potential opportunity undertaken in the valley. TVA intends to increase electricity production to meet the ever increasing demand for electricity in the valley. The authority has expressed a desire of achieving more success in its 2019 Integrated Resource Plan (IRP). This is a long-term plan that provides direction on how TVA can best meet the electricity demand in the next 20 years. TVA also intends to provide electricity to the people at a price affordable to everyone.

Through this plan, TVA intends to provide regular updates to customers and stakeholders on every development and opportunity available.

It has also plans to conduct periodical online seminars to the public. These seminars aim to inform the entire USA community on initiatives geared towards improving the Tennessee River Basin. The seminars also intend to collect views from the public on how to improve the valley in future. The main target of the projected improvement which is emphasised by TVA when seeking the views from the people include increasing tourist attraction centers, expanding employment opportunities, improving water quality and aquatic life. Generally, TVA plans to ensure that the Tennessee Valley becomes a habitable place with minimum challenges.

Exercise 3.2

A. Answer the following questions:

1. Define a river basin.
2. Explain what a river basin development project is.
3. Describe necessary conditions for river basin development.
4. With reference to Rufiji Water Basin and TVA, explain how a community can benefit from the river basin.
5. Explain why river basin development projects are challenging to the authorities that manage the basins.

B. Match the development scheme in Column A with its corresponding country in Column B

Column A	Column B
1. Gezira Irrigation Scheme	(a) Brazil
2. Aswan High Dam	(b) India
3. Galole Irrigation Scheme	(c) Pakistan
4. Rufiji Basin Water Board	(d) USA
5. Amazon Basin Development Scheme	(e) Sudan
	(f) Egypt
	(g) Kenya
	(h) Tanzania

Land reclamation

Land reclamation refers to a process of turning waste or poor land into a useful state. In other words, land is changed from not being valuable to being valuable. It is turned into a state in which it can be used for growing crops, keeping animals, fostering settlement and boosting industrial development.

When land is reclaimed, it is termed as reclamation ground. Land reclamation aims to increase areas for agriculture and settlement. The reclamation also aims to obtain land for industries and places for recreation. Further, the focus is also on improving transport systems on the land and waterways as well as controlling floods that might take place in an area. Nevertheless, land reclamation processes are expensive and may damage corals and marine life if not handled with great care. The reclaimed lands can also be vulnerable to natural hazards such as earthquakes because they are in most cases not as strong as naturally situated lands. In fact, the reclaimed land can easily sink when there is an earthquake. Erosion may also be severe in the reclaimed land because of the nature of the soil. Soil in the reclaimed land is not as compact as in the naturally situated land.

Methods used in land reclamation

Methods used for land reclamation depend on the nature, location and size of the land to be reclaimed. For example, land may be reclaimed from water bodies, dry land, saline land and swampy area.

These different types of land require different methods of reclamation as elaborated bellow:

(a) Land affected by stagnant water or covered by water, draining techniques can be applied. The excess water is removed from the land by draining to make it useful for the intended purpose. An example of land reclamation by draining out water is the Zuider Zee Project in the Netherlands. In this project, dykes or high walls were built to enclose seawater and thus prevent it from entering the land. Then, the enclosed water was pumped out. The land obtained is regularly drained to remove salt for farming and settlement use.

(b) Reclamation of a land affected by soil erosion differs from land covered by water. Soil affected by erosion calls for planting of trees. Trees will act as binding agents for keeping the soil particles together and absorbing excess water which would otherwise flow rapidly over the land. Moreover, using better methods of agriculture such as contour ploughing, terracing and strip farming especially in steep slopes helps to prevent erosion.

(c) Land may also be reclaimed by restoring its fertility. In this case, land which has lost fertility may require planting cover crops and addition of organic manure and fertilisers to improve its fertility. The fertility will attract vegetation growth. Vegetation will not only bind the soil but also protect it from excessive loss of water through transpiration.

(d) Land affected by excessive animal keeping can be restored by reducing the number of animals in the area. This simple reclamation method allows the land to be proportionally used.

(e) Steep slopes may be reclaimed by levelling the land.

Land reclamation in Tanzania

There have been various projects and efforts for land reclamation in Tanzania. The major reclamation projects have been carried out by the government through
its agencies and international agencies. In particular, major reclamation projects have been carried out in Dodoma and Shinyanga regions. They are soil conservation programmes better known by their Kiswahili acronyms as HADO (Hifadhi Ardhi Dodoma) and HASHI (Hifadhi Ardhi Shinyanga).

The HADO project was a large project implemented by the Government of Tanzania in 1973-1997, and was funded by the Swedish International Development Agency (SIDA). The main objective of the project was to conserve land and water, and rehabilitate the already depleted areas, particularly the severely affected Irangi Hills. The project strategies focused on promoting tree planting, bee-keeping, soil and water conservation, reclaiming degraded land, and local participation in conservation matters. The method of land reclamation involved the construction of terraces and cutting off drainage to check the speed of runoff water. However, the construction was not successful as grazing animals and uncontrolled runoff destroyed the barriers. HADO also involved wide areas, which were eroded due to uncontrolled livestock-keeping. As a result, huge gullies developed.

Therefore, to minimise the destruction of the barriers, about 85,000 animals (cattle, goats, sheep, and donkeys) were removed from the area. Afforestation was carried out to hold the soil and check the speed of runoff. The government stopped livestock from using these areas. The government through HADO campaigns also advised people interested in grazing to size down their livestock and try to practise zero-grazing. Significant gains have emerged from HADO initiatives.

Generally, the land has been restored as soil fertility and vegetation in the worst degraded areas have gained a new lease of life. The areas which were no longer useful for supporting human activities have been transformed into potential farming areas also suitable for other nature dependent activities.

Sustainable use of water resources

Water resources come in many forms, but the three main categories are saltwater, groundwater and surface water. Sustainable use of water resources includes all activities relating to current and future use of water resources in terms of protection, conservation and management. There are surface and underground water sources.

Salt water: Salt water fish are a staple in much of the world's diet (although overfishing and pollution has put much of the marine life population at risk). Furthermore, tidal waters are being used as a source of hydroelectric energy. So, while saltwater is not helpful in dealing with scarce water supplies, it does provide resources that humans rely on.

Underground water: This is the most plentiful of all freshwater resources. As water percolates into the ground through layers of soil, clay, and rock, some of it adheres to the topmost layers to support plant growth. Most often, groundwater is accessed by humans via wells. To build a well, one must drill down past the water table. In most cases, a pump is placed at the bottom of the well, and water is pumped into homes, businesses and water treatment plants, where it is then distributed for usage.

Surface water: Surface water is water that exists in streams and lakes. This water is primarily used for potable water supply, recreation, irrigation, industry, livestock, transportation and hydroelectric energy. Over 63 percent of the public water supply is withdrawn from surface water. Irrigation gets 58 percent of its water supply from surface water. Industry gets almost 98 percent of its water from surface water systems. Small amounts may come form small channels.

Some springs release hot water, hence the name "hot springs". Other springs may eject hot water and steam hence the tag "geysers".

Boreholes

Sometimes, underground water gets out through human force. One way of getting out the water for various uses is through drilling of holes which are

called bores, hence the term borehole. The hole is drilled through the earth using a drilling machine until the water table is reached. The depth of the borehole may range from few to several hundred metres depending on the level of the water table. For a constant supply of water, the borehole is deepened down to a permanent water table. The water has to be raised by a mechanical or by electrical water pump. Figure 3.10 illustrates a borehole.

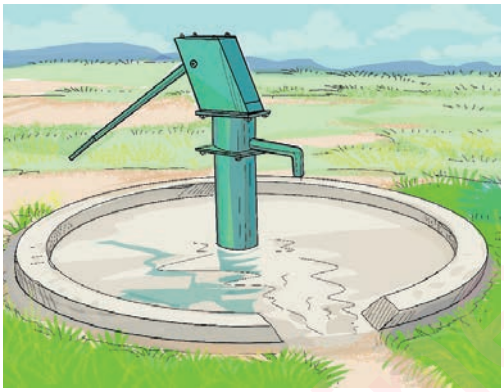

Figure 3. 10 A borehole

Underground water

Underground water is water beneath the earth's surface particularly in the faults or joints of rocks and soil pores. Usually, underground water is found in the rock spaces (aquifers) which collect after infiltration through rock faults or joints. The rocks that allow water to seep through are called permeable rocks (Figure 3.11). The rocks with holes or pores through which water can pass are called porous rocks whereas rocks with joints or faults through which water infiltrates are called pervious rocks.

The process of underground water formation primarily depends on the amount of rainfall in a particular area and the nature of rocks found there. When rain falls, water infiltrates through the soil and fills the joints and forms underground water. The water becomes naturally stored and ultimately gets out through springs, bore holes and wells.

Springs

Springs refer to natural overflows onto the land surface after the aquifer has been filled with infiltrating water, or when the water table meets the earth's surface. The amount of water released from the spring depends on the nature of the rocks and the position of the water table. A large amount of water from a spring can form a river while small amounts may form small channels.

Wells

A well is a structure usually constructed in the ground by digging to access water. The depth of the well depends on the level of the water table of the area. The walls of the well may be lined with bricks or stones to prevent them from collapsing into the bottom of the well. Sometimes well water is drawn from a shallow well. The water from shallow wells is mostly obtained from the soil and not rocks. In many cases, the water from shallow wells is largely unsafe for drinking by human beings if not treated. Figure 3.12 illustrates a water well whose water is drawn manually using a bucket.

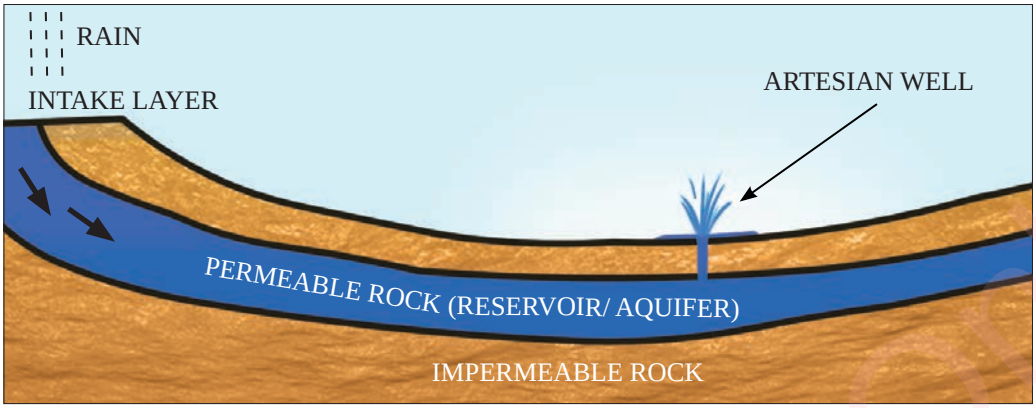

Figure 3.11 Rock structure for underground water

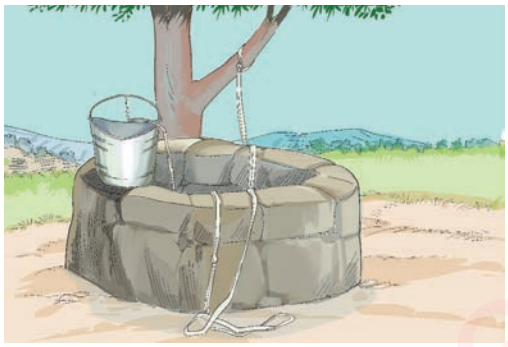

Figure 3.12 A well for drawing water manually

Areas where tapping underground water is practised widely in Tanzania include Dodoma, Singida, Dar es Salaam, Shinyanga, Manyara, Mara and Tabora. Due to climatic change, even areas which had enough surface water are facing water shortages. As a result, the government and individuals are now tapping underground water for different uses.

Resources obtained from water

A resource is anything useful that can be utilised if necessary. It is a stock consisting of substances such as water, minerals, air, forestry resources or land. Water resources are essential and important assets for human beings. There are different types of water resources. These include fish, plantations, oil, natural gas, decoration materials, salt and some building materials. The seas and oceans possess mineral riches whose exploitation could be of great use to people. Exploitation of oil in Nigeria has made the country one of the stable countries in Africa in terms of economic development. The seas and oceans possess a wealth of minerals such as copper, manganese, nickel, cobalt and salt. Apart from vast oilfields, the continental shelves are rich in gas fields. All these water resources are of great use for the wellbeing of people in Africa.

Water resources are tapped using varying methods in different countries. Fishing is done using traditional as well as modern methods. Mwanza, Kigoma, Ruvuma, the coast of the Indian Ocean and Zanzibar are good examples of areas that exploit fish for domestic and industrial use. Japan is an excellent example of a country that exploits water resources through fish farming.

Fish can be farmed and harvested in the same way as crops. Fish is carefully tamed in special areas and containers and harvested for domestic use.

Other applicable methods depend on the scale of fishing. In many cases, small-scale fishing relies on the use of traditional methods as described below:

Hand lining method: This consists of a long stick or rod and hook attached to a string. A bait is attached to the hook to attract fish. The fisherman sinks the hook into the water to catch the fish. The method is time-consuming.

Trap method: A trap is used where there is a flood or along the coast where there are tides. The traps are set up at the bank of a river or on beaches. The fish is washed onto the banks or beaches by water and as the water goes back, the fish remains trapped behind in the traps.

Fish basket method: This method is used in shallow water lagoons and swamps, whereby a woven basket with an opening protruding inward is placed at the bottom of the water. A bait is placed inside the basket to attract fish. The fish enters the basket and fails to move back-Large-scale fishing is carried out in deep waters in the oceans and lakes. In Tanzania, large-scale fishing is practised in lake Victoria, Tanganyika, and Nyasa as well as in the Indian Ocean.

Figure 3.13 Fishing using a basket
***Source**:thisisafrica.me*

Trawling method: A trawl net is a big bag-shaped net whose mouth is kept open by boards. Its mouth has floats at the top and weights at the bottom to pull it down (Figure 3.14.) The net is pulled by a trawler.
As the vessel moves. the fish is caught in the open mouth of the trawler net. When sufficient amounts of fish have been trapped the vessel stops and the net is pulled into the boat.

Other water resources

Other water resources include **oil**. Oil in Nigeria is obtained using a process of distillation after the extraction of crude oil. Refineries are used to distil crude oil into different by-products. **Building materials** from the sea are usually obtained by quarrying. Tanzania is one of the countries which quarry building materials along the Indian coast at an area known as Kunduchi.

Salt in Tanzania is obtained at Uvinza (Kigoma) and from Lake Balangida in Manyara through extraction and evaporation.

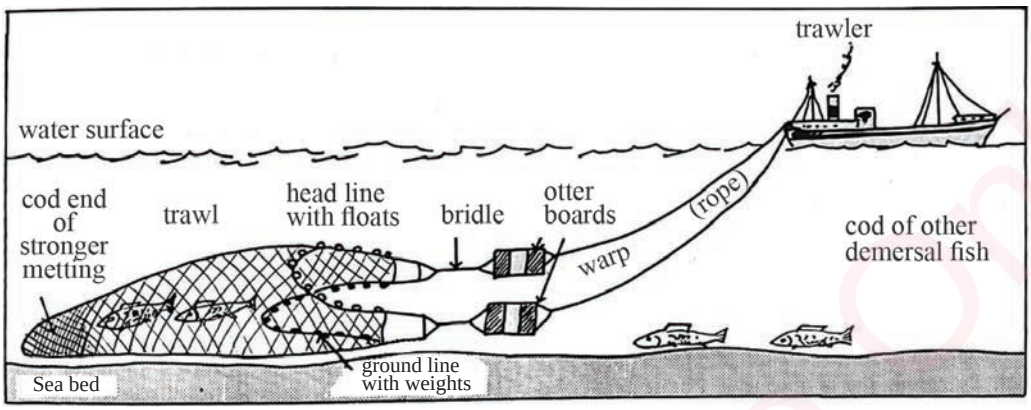

Figure 3.14 Fishing by trawling

Problems resulting from the extraction of water resources

Different methods used in harnessing water resources have resulted in both social and environmental impacts as explained below.

(i) Pollution of marine water is one of the impacts the world is facing as a result of poor and bad methods of exploiting water resources. Polluted water affects marine animals such as fish and planktons.

(ii) Illegal, unreported and unregulated fishing has resulted in some fish species disappearing.

(iii) Poor methods of quarrying for building materials has led to further land degradation of shores in addition to the destruction of fish breeding areas and coral reefs.

(iv) Excessive exploitation of marine life does not only lead to loss of life but also reduces the amount of fish, cuts down breeding capacity and replacement capacity of other species.

(v) Pollution of water, apart from affecting the life of fish, may also damage the near shore marine environment.

(vi) Pollution from industrial activities as is the case with oil drilling regions of the Niger Delta has resulted in damage to the environment in nearby shores.

(vii) When fresh water resources become saline, they can no longer be used for irrigation or drinking. Saline water is toxic to plants, and high sodium levels cause dry soils to become hard and compact and reduce their ability to absorb

water. Ground water extraction and irrigation can increase salt concentrations in water. Irrigation can also cause salinization by raising the water table and lifting saline ground water near the surface into the root zone. This occurs when irrigation efficiency is poor, so a large fraction of irrigation water infiltrates into the soil, and groundwater flow is slow. A similar problem occurs in some regions when trees are cut down.

Water pollution

Water pollution occurs when harmful substances of different quality, quantity and form are mixed in underground water. The water may be polluted through discharging waste in it or mixing it with chemicals usually from factories and industries. Besides, water pollution is also caused by domestic practises especially channelling toilet waste into water streams. All the materials which pollute water are called pollutants. Water pollution is at times caused by the construction of latrines directly in the ground. This way of pollution affects mostly underground water. The latrines tend to seep wastes into the underground water. Many homes and industries with no access to sewerage systems rely on shallow underground disposal of waste.

This way of waste disposal contaminates shallow wells which may cause water-borne diseases such as cholera, diarrhoea and typhoid. Shallow wells are mostly the source of water for domestic use in many communities, especially those which have no formal water supply from authorised dealers.

Transportation and storage of materials which may spill and leak is another source of underground water pollution. For example, chemicals used in manufacturing, processing and construction industries sometimes are not transported and stored by observing any specified handling precautions. This leads to spillage and leakage to the ground and, consequently, seepage into the soil which pollutes underground water through infiltration.

Furthermore, underground water is at times polluted by human activities in their effort to use the land to earn a livelihood. Experience shows that modern farming is characterised by the use of fertilisers, herbicides, insecticides and pesticides. The misuse of these chemicals in farming harms the soil and once rain falls the chemicals contaminate the underground water through infiltration.

Underground water can also be polluted naturally through volcanic eruption. This occurs in areas characterised by eruption of poisonous volcanic materials from the interior of the Earth. The erupted materials finally seep into the soil and mix with underground water. Generally, pollution of underground water is harmful to the lives of people and other living

organisms, which directly or indirectly use the water.

Ways of conserving water

Water conservation refers to the process of preserving and using water efficiently to reduce unnecessary loss. Water conservation is best done when collective efforts from individuals, groups, private agencies and the government bring about the desired results.

Each of the members in a given nation has a role to play in water conservation. The following are some of the measures for water conservation.

(a) Preventing loss of water during irrigation can be achieved by applying efficient methods such as drip irrigation.

(b) People should be educated on the importance of conserving water.

(c) Water re-use is largely advisable. For example, water from the kitchen may be used for plant watering and water from laundry may be used for cleaning toilets.

(d) It is advisable to make routine check-ups in the water supply system to ensure that there are no leakages. Doing so will ensure efficient use of water because most of the water will end up in the intended places.

(e) Watering should be done when necessary, particularly in the morning or late in the evening when the temperature is low, to avoid excessive evaporation.

(f) Sewage pits and canals should be properly connected to recycling systems for effective disposal. Therefore, there is a need to ensure that the laws and regulations of the land aimed to protect and conserve water are adhered to.

Exercise 3.3

A. Write **True** or **False** for each of the following statements:

1. Condensation causes water vapour to turn into water droplets.
2. Rocks that contain joints or faults are called porous rocks.
3. Rocks that have pores through which water can infiltrate are called pervious rocks.
4. There is a relationship between rainfall and underground water.
5. Underground water can be polluted by improper solid waste disposal.

B. Briefly answer the following questions:

1. What are the causes of water pollution?
2. How can water pollution be controlled among communities in Tanzania?
3. What were the reasons for the establishment of HADO and HASHI projects?
4. What is the contribution of Rufiji Water Basin to environmental conservation?
5. What are the advantages of TVA in the United States of America?
6. What are the common domestic practises for water conservation in your community?
7. How is underground water accessed in Tanzania's societies?

Chapter Four

Sustainable use of forest resources

Introduction

In this chapter, you will learn about types of forests, distribution of forests by type, factors for their distribution, and the importance of forests in social and economic life. You will also learn about the importance of forests in the ecological and environmental balance as well as challenges facing the forest industry.

The concept of forest

A forest is an extensive area of land mostly covered by trees of different sizes, species and other forms of undergrowth. By 2015, it was estimated that forests covered about 31% of the earth's surface. Forest distribution on the earth's surface varies. Such variation is caused by the amount of rainfall available and the length of wet and warm seasons per year. Forests can be absent in some areas even where the climatic conditions allow tree growth. Absence of forests in extensive areas can be caused by actions of human beings and wild animals.

Human beings obtain various products and services from forests. Forest products can be timber and non-timber products that help to sustain human life. Non-timber forest products include fruits, honey, leaves, roots and barks. The process of managing forest resources for human use is known as forestry. Foresters engage in lumbering, which is an activity that involves cutting, transporting, processing and selling timber. The terms 'timber' and 'log' are used interchangeably to mean branches or pieces of the trunk of a tree, but with the bark attached. Harvesting of forest resources is generally sustainable when there is no or little damage to the general environment. A forest can be natural or planted. Animals, birds and insects use forests to support their lives. Forests provide aesthetic value and services to human beings.

***Natural forests*:** A natural forest refers to a collection of trees that have grown naturally. The types of natural forests include equatorial rainforest, tropical monsoon, deciduous, coniferous and mangrove. The natural forests are found in many countries. Figure 4.1 shows the distribution of various world natural forests.

Equatorial rainforest: This type of forest is found in the equatorial region between 5˚N and 5˚S of the Equator. In this forest there are large and tall trees

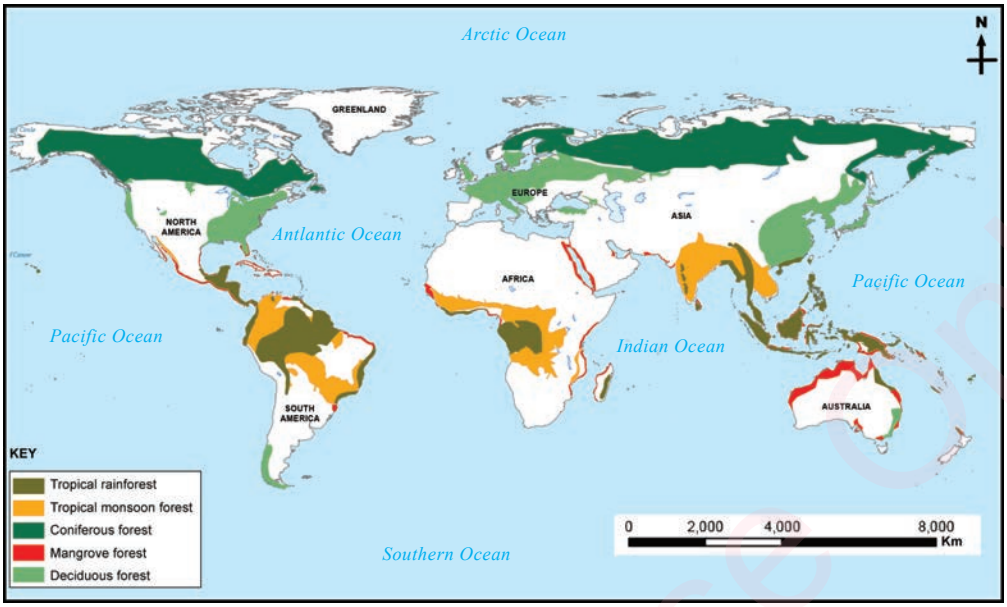

Figure 4.1 Distribution of the world's natural forests

that grows to over 80 metres high. Figure 4.2 shows an equatorial rainforest.

In Tanzania, equatorial rainforests are found in coastal areas, Kagera, Kilimanjaro and Kigoma regions. Other areas in the rest of the world that have equatorial rainforests are low-lying lands of the Congo Basin in Central Africa and the coastal lands of West Africa. This type of forest is also found in the Gulf of Guinea, West of Sierra Leone, Cameroon and Gabon, Eastern Coast of Madagascar, Amazon Basin and Malaysia.

Figure 4.2. Equatorial rainforest

Source: *http://erdkundegeography.blogspot.com*

Characteristics of an equatorial rainforest

An equatorial rainforest has some characteristics that distinguish it from other types of forests. In an equatorial rainforest, the vegetation grows in layers. The upper layer forms a continuous canopy, which provides shade for lower layers. Trees grow to over 80 metres high. The second or middle layer grows up to about 30 metres high. The lower canopy grows to a range of 5 to 15 metres high. It consists of shrubs, palms and ferns with little undergrowth.

The trees in this tropical rainforest are of different species, which include mahogany, rosewood, greenheart, ironwood and ebony. Most trees have large buttress roots. In addition, tropical rainforests contain climber trees.

Nearly all the trees are broad-leaved and evergreen due to the availability of

rainfall throughout the year. However, due to constant climatic conditions, plants produce flowers, fruits and shade their leaves at the same time.

Mangrove forests: Mangroves are a collection of salt tolerant trees and shrubs that grow on estuaries and deltas of tropical and subtropical coastlines. Figure 4.3 shows mangrove forests. Mangroves grow well in places where fresh water mixes with sea water and where sediments are composed of accumulated deposits of mud. Most of the mangroves grow within 30° North and South of the Equator. Only a few of them have adapted to temperate climates.

In Tanzania, mangrove forests cover most of the coast of the Indian Ocean (Dar es Salaam, Tanga, Mtwara, Pwani and Zanzibar). Many mangrove forests are disturbed by human activities. In Tanzania, the least disturbed mangrove forests are found in the Rufiji Delta. Other countries with mangrove forests include Nigeria, Mozambique and Madagascar.

Figure 4.3 Mangrove forest

Source: *https://www.animalwised.com/endangered*

Characteristics of a mangrove forest: A mangrove forest has various characteristics that distinguish it from other types of forests. Trees in mangrove forests have deep root systems to enable them to withstand wave action. The roots in these forests are stilt and project above mud and water to absorb oxygen. Trees in these forests tolerate high salt concentration, which makes them grow and survive in salty water and mud. Mangrove trees usually provide hard timber. Hard timber is very useful in building houses or making boats.

Tropical monsoon forests: Tropical monsoon forests consist of deciduous trees that shed their leaves during the dry season. Figure 4.4 shows a section of a monsoon forest. These forests are located in the monsoon climate beyond the equatorial region between 10° and 25° North and South of the Equator. These forests are found in areas with seasonal rainfall, along coastal regions of Southwest India, Sri Lanka, Bangladesh, Myanmar, South Western Africa and North-East and South-East Brazil.

Figure 4.4 Tropical monsoon forest

Source: *https://www.wikiwand.com/en/Tropical*

Characteristics of a tropical monsoon forest: A monsoon forest has characteristics that distinguish it from other types of forests. Monsoon forests contain thick undergrowth of shrubs and small trees. This poses a challenge to people and animals when it comes to passing through these forests. However, the forest is more open compared to equatorial rainforests. The main trees in these forests are teak, acacia, casuarina and bamboo. Trees in this forest are moderately tall compared to trees of other types of forests. They grow up to 30 metres high. Trees are not as close as in tropical evergreen forests. Due to this reason the undergrowth tends to be a bit thick.

Deciduous forests: Deciduous forests are composed mainly of broad-leaved trees that shed all their leaves during the dry season. Figure 4.5 shows a part of a deciduous forest. These forests are located between 30º and 50º North and South of the Equator. They are found in the eastern side of North America, Western Europe, Northern Coast of China, Japan, Southern and Western Australia.

Figure 4.5 Deciduous forest
Source: *https://pediaa.com/wp-content/uploads/2018/08*

Characteristics of a deciduous forest
Deciduous forests have characteristics that distinguish them from other types of forests. They contain trees with broad leaves. Trees in these forests usually shed their leaves in autumn and they remain leafless throughout the cold winters to minimise loss of water by transpiration. Deciduous forests are composed of a mixture of various tree species. Deciduous forest trees include oak, elm, chestnut, maple, willow, ash and beech.

Coniferous forests: Coniferous forests have needle-like leaves and cone-shaped fruits. They are found in areas with long winters and moderate to high annual precipitation. Figure 4.6 shows a part of a coniferous forest. Coniferous forests are located between 50º and 70º North of the Equator. They cover an extensive area
of North America and Asia. They are also found on highlands and in mountainous areas. In Tanzania, coniferous forests are found in Mufindi in Iringa and Njombe. The climatic condition in these areas is mostly cold, which supports the growth of coniferous trees.

Figure 4.6 Coniferous forest
Source: *https://sites.google.com/site/teambarb28*

Characteristics of coniferous forests: Coniferous forests have characteristics that distinguish them from other types of forests. Trees in these forests are in most cases evergreen. In addition, the trees have needle-shaped leaves that limit transpiration in winter. Trees and fruits are conical in shape to avoid the accumulation of snow on branches and leaves. The trees in coniferous forests are of one type covering large areas. Species of coniferous trees produce soft wood. Coniferous trees include pines, fir, spruce and hemlock.

Planted forests: Planted forests refer to a collection of trees by human beings. These forests cover relatively large areas of land. Figure 4.7 shows part of a planted forest at Sao Hill in Iringa. Trees in these forests are of specific value such as commercial or land conservation. Planted forests are usually grown on a large-scale or small-scale basis. In many cases governments and companies or groups of people establish large-scale forests while small groups of people or individuals establish small-scale forests. In Tanzania, notable planted forests are in Iringa, Kagera, Kigoma, Kilimanjaro and Arusha regions. Trees are established through seeding and planting of either native or exotic species. These forests are properly managed from planting to harvesting time to ensure high productivity.

Characteristics of planted forests: The major characteristic of planted forests is that they are composed of trees which result from deliberate influence or intervention of human beings. However, there are other characteristics which distinguish them from natural forests.

Figure 4.7 Planted forest at Sao Hill Mafinga - Iringa
Source: *https://dailynews.co.tz/news*

Most of the planted trees are of the same species because forest growers aim at specific tree species for targeted value. For example, at Sao Hill, most of the trees are pine and eucalyptus. Usually, trees in planted forests are of the same age because they are planted at the same time though the growth speed of the trees may vary. The difference in growth may cause them to be harvested at different periods. In addition, the difference in the harvesting of trees in planted forests may be caused by a system of planting trees in blocks.

Planted forests are regularly cleaned by removing unwanted undergrowth, which may hinder the healthy growth of the planted species. Foresters provide close

and strict supervision from planting to harvesting because of the commercial value of the trees. For example, planted trees in Sao Hill are for electrical polls, paper-making and timber production. Timber is sold locally or exported.

Factors influencing distribution of forests

The distribution of forests on the earth's surface depends on many factors. The common ones are temperature, rainfall, relief, soil, drainage and aspect.

Temperature: Temperature is a notable factor influencing the distribution of forests. Different plants require different temperature ranges. Temperature limits the growth of trees, thus leading to shallow forests or no forest at all. Areas that are hot and humid such as the equatorial region encourage the growth of large trees with broad leaves. Cooler temperate climates that experience snowfalls support coniferous type of trees that can withstand low temperatures and freezing conditions.

Rainfall: The distribution of forests is also influenced by rainfall. Forests thrive well in areas with plenty of rainfall of over 1200 mm throughout the year. The dense equatorial forests have thrived well because of the presence of heavy rainfall that is well distributed throughout the year. In deciduous forest regions, trees that can survive the dry season exist. These trees shed their leaves during the dry season to reduce water loss through transpiration as their means of survival.

Relief is another factor that influences the distribution of forests. It determines soil, temperature and vegetation distribution across gradient. Tree distribution varies with altitude. For example, on Mount Kilimanjaro at 1800-3000 m above sea level, forests consist of diverse tree species. At higher altitude (3000 m), alpine heath dominate. Thus, differences in relief are associated with variations in the type of forests.

Soil: Soil contributes much to the distribution of forests. In this case, soil type, drainage, texture, permeability, porosity and chemical composition play a significant role in tree growth. For example, soil rich in humus encourages tree growth, which may turn into a forest. Regarding drainage, well-drained soils support a variety of trees whereas poorly drained soils such as swamps or steep slope areas with immature soil cannot support tree growth. For example, coastal tropical areas with sea alluvial salty water attract mangrove forests growth. Also, tropical rainforest trees require deep well-drained soils for proper binding together whereas coniferous trees have fibrous roots which can grow in shallow soils.

Aspect: Aspect refers to the position of a place in relation to the sun. The influence of aspect on tree growth is well noted in temperate latitudes. In the Northern Hemisphere, the south-facing slopes are warmer than the north-facing slopes. In the Southern Hemisphere, on the other hand, the south facing slopes are cooler

than the north facing slopes. Trees need temperature and rainfall as important elements for their growth. Therefore, in the Northern Hemisphere the south facing slopes tend to have more dense forests compared to the north-facing slopes.

Human activities: Forest distribution can also be influenced by human activities in different ways. For example, cultivation, herding and mining contribute to the disappearance of forests. Indeed, large-scale agriculture requires the clearance of large areas of forests. In the meantime, industrial demand for hard and soft wood necessitates people to increase the size of planted forests. Extensive planted forests in Tanzania are found at Sao Hill in Iringa and Kawetere in Mbeya.

Importance of forest resources

Forests have significant contribution to social, economic and ecological development. They provide various products for human use such as timber, poles, wood, logs, leaves, roots and honey.

Source of income: Forest products are sold in the country or exported to earn income. It is common for products such as timber, rubber, wood and poles to be exported to earn foreign currency. Likewise, forests make up 22.2% of household incomes in developing countries. The main forest products that contribute to incomes are fuel wood, building poles, timber and building materials.

Paper-based materials: Logs are processed to make different types of paper. Also some trees have tissues which are processed to make glue commonly known as wood-glue.

Source of energy: Forests provide firewood and charcoal which are used as sources of energy in the households. Wood energy provides 9% of the global primary energy supply, making it the most important source of bioenergy in the world. In some parts of Africa, fuel wood is the most affordable source of energy and it accounts for about 90% of primary energy consumption.

Employment: Individuals are employed in the forestry sector as forest officers and forest guards. Others are employed as lumberers while some are self -employed in carpentry and joinery, and others are timber merchants who buy and sell timber. Forest industries provide formal employment to 0.4% of the global labour force, contributing to nearly 1% of global GDP in 2008.

Medicinal value: Some forest trees have medicinal value. They have roots, leaves, and bark which are used as medicine or processed to make medicine for human beings and animals. For example, the bark of the cinchona tree is used in manufacturing quinine which is useful for treatment of malaria. Also, some trees are used in making herbicides for use in agriculture.

Tourist attraction: Some forests have rare and unique species of animals and plants which attract people to observe. For example, Gombe Forests in Kigoma have chimpanzees, which are a great attraction for both local and foreign tourists. Many of the natural parks have forests that serve as habitats for attracting animals and plants.

Rainfall formation: Areas with heavy forests are characterised by frequent rainfall. For example, in the Amazon forests, 30 percent of rainfall is said to be influenced by moist air from trees.

Importance of forests in ecological and environmental balance

Ecology is the way in which plants, animals and people relate to each other and to their environment. Ecological and environmental balance is the mutual symbiotic system or state in which plants and animals benefit from each other, thus maintaining their survival in the environment. Plants, insects and animals live together in a particular environment. They live a symbiotic relationship by benefiting from each other. The specific roles forests play in fostering ecological and environmental balance are as elaborated in the paragraphs that follow:

During photosynthesis, oxygen is released by plants into the environment through the stomata, and this is used by animals. At the same time animals release carbon dioxide that is absorbed by the plants. By doing so, a balance between oxygen and carbon dioxide in the environment is maintained. Forests provide suitable habitats for wildlife and, therefore, contribute to the balance of ecosystem. Various animals live in the forest which gives them shelter and food as they eat leaves, roots and fruits. Moreover, forests help to control soil erosion as they protect the soil from being eroded by blowing wind and running water. Trees in the forest bind together the soil particles using roots, and reduce the impact of raindrops with the same roots. Plant leaves reduce the impact of rain drops on the soil and reduce excessive evaporation of soil water.

Also, the remains of forest trees including foliage contribute to soil development through decomposition into organic matter, leading to formation of humus. Soil in the forest is very fertile due to humus from decomposed plant remains. Solar energy helps plants to manufacture their own food through photosynthesis. Plants are eaten by herbivores; likewise, herbivores are consumed by carnivores who feed on meat. When they all die, their remains are decomposed by bacteria which break down dead matter and release nutrients into the soil. Therefore, forests have input in the food chain.

Tree canopies control the evaporation of water from the soil beneath, hence allow more retention of water in the soil. The canopies also enable recharging of ground water by controlling over land flow after rainfall. In addition, forest trees contribute to water vapour in the atmosphere which is important in regulating atmospheric conditions.

The humidity in the atmosphere is important in the rain formation process.

Activity 4.1

Visit any nearby forest and collect information that will help you to answer the following questions:

(i) What type of forest is it?
(ii) What factors may have contributed to its existence?
(iii) Based on your observation, how is the forest being used by the people around it?
(iv) Have you detected any problem facing the forest? If the answer is yes, explain what that problem is.
(v) Explain what is likely to happen if the forest you visited is cleared or destroyed.

Exercise 4.1

Answer the following questions:

1. Define a forest.
2. List five types of natural forests.
3. Explain how temperature and rainfall influence the distribution of forests.
4. Mention three species of trees that are found in the following types of forests.
   (a) Equatorial forests
   (b) Coniferous forests
   (c) Deciduous forests
5. Mention five products obtained from forests.
6. In four points, explain the importance of forest resources.
7. What is ecology?
8. In four points, explain the importance of forests in the environment.

Timber production in the world

Timber production is a process of growing, harvesting, and regenerating trees for industrial or domestic use. Worldwide, USA is leading in timber production with 481,092,992 cubic metres. In Africa, Ethiopia is a leading country with 91, 283, 543 cubic metres. There are ten leading timber- producing countries in the world as listed in Table 4.1. Tanzania is one of the countries that produce timber. The major timber producing regions of Tanzania are Tabora, Ruvuma, Coast, Njombe, Morogoro, Kilimanjaro, Kigoma, Kagera, Iringa, Lindi and Arusha.

Transportation of timber

In many parts of the world, logs are transported using different means. In Tanzania, timber and logs are transported mainly by road using large trucks and by railway. For example, the central railway and the Tanzania- Zambia Railway are used to transport logs. Some logs are transported by trucks to harbours like Dar es Salaam, Tanga, Mtwara and Mwanza for exportation. In other parts of the world, logs are transported by water to ports or industrial centers.

Table 4.1 World timber producing countries

Countries	Cubic Meters
USA	481,092,992
India	296,234,016
China	284, 910, 024
Brazil	236, 422, 218
Canada	176, 692, 000
Russia	162,300,000
Indonesia	119, 208, 572
Ethiopia	91, 283,543
Democratic Republic of Congo	69,733,688
Nigeria	69,115,552

Source: Compare Infobase Limited, 2006 (Updated Feb, 2016)

This means of transportation of logs by water is common in the USA and Canada. It is considered relatively cheaper compared to other means of transportation. In Brazil and Mexico well connected networks of railways and roads are widely used as means of transportation of logs. In Russia, the trans-Siberia railway line is used for such transportation. Figure 4.8 shows logs floating in the Angara River on the way to downstream ports. In Asian countries, especially Myanmar (formerly Burma), logs are pulled to the edge of water bodies by elephants or tractors. Then, the logs are floated downstream during the rainy season.

Figure 4.8 Transporting timber using the Angara River, Russia
Source: *https://www.robertharding.com/preview/869-10/forestry-trees-transport-logs-river/*

Heavy greenheart logs are transported by road. Later they are transported to river banks where they are loaded into pantoons and ferries. In the dense network of streams and major rivers in the Amazon and Congo basins, waterways have not sufficiently been utilised to transport logs. This leads to frequent stopage of logs at difficult spots. In addition, the weight of huge logs make floating in rivers difficult. Rapids and falls interrupt these rivers, making floating of logs impossible. The scattered distribution of the most valuable trees complicates even further the river transportation of logs.

Challenges facing timber transportation in the world

Timber is useful for the achievement of social and economic development of various countries. However, transportation of timber faces a number of challenges.

The countries that depend on floating logs in water as the main means of transport, face challenges to transport heavy logs. Timber transportation may also pose a challenge especially when forests are located in remote areas away from market centers. In fact, this situation increases the transportation cost for harvested forest resources. For example, in the equatorial rainforest, forests are dense and located in hardly accessible areas and, therefore, making it difficult to transport logs to the processing areas.

Seasonal variation of water in rivers is also a challenge for timber transportation. Water in rivers fluctuate seasonally. During the dry season, the volume of water decreases whereas during the rainy season the volume increases. In this case, the reduction in the volume of water in the rivers hinders the transportation of logs to the processing industries. Similarly undeveloped means of transportation also pose challenges in timber transportation from the forest to the processing centers, by road and railway.

Challenges facing the forestry industry

Although forest resources contribute to the welfare of people, the forestry industry faces numerous challenges. Over-exploitation of forest resources is one of the challenges. Forest resources are harvested to the point of reducing their ability to regenerate. For example, some forest tree species, especially natural trees, are usually in high demand. The demand compels over-harvesting of such forest resources so much so that they face extinction. In some cases, forests are harvested without following governing procedures and, consequently, some tree species may disappear. Experience indicates that ungoverned exploitation is usually serious in public-owned natural forests than in private planted forests. Forests also face the problem of fire outbreaks with some fires occuring naturally while others are set by people. The fire, particularly during late burning, destroys trees and the undergrowth, which are the main constituents of forests. Estimates indicate that each year fires burn 6 – 14 million

hectares of forests around the world. Construction of different infrastructure for social and economic support is a challenge to the forestry industry. Different construction activities lead to the devastation of forests. For example, the construction of dams, roads and railway lines forces the clearing of some forest hectares. In addition, population increase presents another challenge to the forestry industry. As the population increases, more space for human settlement and life support is required. As a result, people tend to invade the forests and clear them for settlements, farming, charcoal burning and firewood fetching.Then there is the challenge of global warming. Global warming results from the accumulation of harmful gases in the atmosphere. In this case, the gases destroy the ozone layer and makes some trees in the forest wither and dry after failing to withstand the situation. Similarly, deforestation is a challenge to the forests. It exposes the soil, which was once protected by the forest cover, hence making it vulnerable to the agents of soil erosion such as wind, rainfall and water runoff. The resultant erosion affects the quality of the soil which loses its fertility, and limits the growth of trees.

Destruction of animal habitats is also a challenge to the forestry industry. Cutting down, burning and over-exploitation of trees destroy the homes of animals and soil organisms. Some animals may migrate to other less favourable and inhospitable areas only to die there. This act may lead to forest extinction due to the absence of animals and other organisms that matter to the eco-system by keeping the forest soil fertile. Besides, destroying forest habitats may lead to scarcity of forest products such as trees of medicinal value, and honey.

Addressing challenges facing forest resources

Although forests continually face a number of challenges across the world, countries have been making concerted efforts to find lasting solutions to these challenges. Simply put, deforested area should be reforested. Reforestation is the establishment of a forest through planting trees in an area where plant cover was destroyed through careless felling of trees. A reforestation programme that has been implemented in Tanzania is the Management of Natural Resources Programme funded by the Governments of Norway and Tanzania. The programme was implemented by the Ministry of Natural Resources and Tourism (MNRT) between July 2002-June 2006. The objective of the programme was to increase benefits to rural communities based on sustainable natural resource management in Tanzania. The outcomes of the programme were to:

(a) improve the quality of forests in all project regions: the number and intensity of fires have decreased significantly, woody vegetation, and canopy cover have increased, and the quantity and quality of water has improved;

(b) enhance the regeneration of vegetation in degraded areas around Karatu villages; and

(c) inculcate the culture of tree planting in some areas, particularly in Ruvu, which has enabled trees to be planted in people's farms.

Furthermore, there are two projects with a component of planting trees. These are Hifadhi Ardhi Shinyanga (HASHI) and Hifadhi Ardhi Dodoma (HADO) Improving tree harvesting practises in the forest as an appropriate mechanism for ensuring the trees are not depleted is important. Such eco-friendly practises include selective cutting of trees where only mature or weak (i.e. diseased trees) are removed. Selective cutting is practised in many countries including Tanzania, Southern USA, Finland and Sweden. This selective tree cutting ensures that enough trees are left to grow.

Moreover, forests must be protected from natural hazards such as fire and pests through close supervision and use of watch towers and air patrol. In the USA and Canada, an early sign of fire outbreak can be reported and addressed immediately. Fire can also be controlled through creating fire-breaks. Insects and pests must be prevented by regular inspection and spraying. Furthermore, it is also important to set preventive measures such as laws, regulations and creation of public awareness. Laws are to be enforced to prevent uncontrolled harvesting of trees. In Kilimanjaro Region, no trees for timber can be cut without permission from local government authorities. Forest guards also patrol forest areas.

In East Africa, forest guards receive training at forest training institutes such as Olmotonyi in Tanzania, Nakuru in Kenya and Uganda Forest School in Uganda. Regarding public awareness, people have to be educated on the importance of forest conservation. This awareness creation should extend to persuading people to participate fully in all activities involving the protection of forests. This may be done through the mass media such as radio, television and public meetings. Multiple uses of forest and forest products may also act as a measure for overcoming some of the forestry industry challenges. This is a practise whereby some species used for timber marketing could be used for extracting tannin and those used for the extraction of tannin could be used as a source of hardwood.

The practise is well established in developed countries such as the USA where old rubber trees could also be used for other purposes.

In Tanzania, forests serve as water catchment areas, which in turn enhance forest management. Alongside multiple uses, re-use and recycling of waste papers can also serve as a measure for forest conservation. It is also advisable to recycle used paper into other products or re-use it for other purposes. This may reducts cutting trees for paper-making. Products such as egg trays, packaging boxes, toilet paper and newsprints can be made from recycled paper products. In addition, alternative sources of energy may be opted to reduce the speed of use of forest resources. For example, the use

of alternative sources of energy such as solar energy, biogas, hydroelectric power, natural gas, instead of fuel wood and charcoal reduces pressure on the use of forest resources.

In Tanzania, the government puts emphasis on the use of alternative energy, especially for domestic use. It also stresses the use of recycled paper charcoal instead of charcoal made from trees. In addition, there has been an increase in the use of solar power, especially where there is no power.

Activity 4.2

A. Visit a place where charcoal is sold in large quantities. Ask the charcoal sellers the following questions and then write a brief essay based on the answers they provide:

1. Where do they get charcoal?
2. How is charcoal prepared?
3. Which type of trees are used in preparing charcoal?
4. Are the trees used for charcoal preparation regenerating?

B. In a group of five students

1. Explain the types of energy used at your home for lighting and cooking.
2. Explain how the energy in use contributes to destruction or conservation of forests.

Exercise 4.2

A. Answer the following questions:

1. With examples, mention problems facing forests resource harvesting.
2. Explain the role of mass media in forest conservation.
3. Outline efforts made by Tanzania in conserving forests.
4. List alternative sources of energy and explain how they can assist in reducing the use of forest products for fuel wood.
5. Draw a map of Africa and shade areas where equatorial forests are found.

B. Write **True** or **False** for each of the following statements:

1. A forest is an extensive lowland area covered with undergrowth.
2. A natural forest refers to a collection of trees that have naturally grown.
3. Most mangrove trees grow within 30^{o} and 45^{o} North of the Equator.
4. Planting trees where all the trees have been removed is called reforestation.
5. Important natural forests in Tanzania are found in Morogoro, Kagera, Coast, Kilimanjaro, Njombe, Tanga and Tabora regions.

Chapter Five

Mining industry

Introduction

In this chapter, you will learn about types of minerals found in the world, different ways of mining, ways of processing different types of minerals, and the contribution of the mining industry to the economy of Tanzania. You will also learn about the effects of mining on the environment, oil production in the Middle East, and natural gas production in Tanzania.

The concept of mining industry

Mining

Mining is a process of extracting valuable geological substances from the crust of the earth. The extracted materials may be minerals, fossil fuels, and other geological materials. However, not all geological substances are categorised as minerals. In science, a mineral has specific characteristics such as being solid, inorganic, naturally occurring, has definite chemical composition and ordered internal structure. Although oil, coal and natural gas do not possess most of these characteristics, they may be categorised as minerals. From a non-scientific view, a mineral refers to a non-living naturally occurring resource from the earth. As such, oil, coal, and natural gas also qualify to be called mineral resources. Thus, petroleum and natural gas which are discussed as case studies in this chapter are treated as minerals. Mining in a wider sense includes extraction of any non-renewable resource such as petroleum, natural gas, or even water.

There are two main types of mining, namely, surface and underground mining. Minerals such as salts are found close to the earth surface; as such, open cast method of mining is used to exploit them. Other minerals like gold and diamond are found deep in the ground, hence underground mining methods are used to obtain them.

The world is full of different types of minerals. Minerals can be classified into five main groups, that is, rocks used as building stones, and for brick making; non–metallic minerals such as salt, sulphur, nitrates, and asbestos; metals like gold, iron, and silver; mineral fuels including coal, petroleum and gas; and water. The whole of the earth, therefore, is full of minerals which are of great value to human beings.

Mining industry

Mining is the branch of manufacturing industries and trade based on the extraction of ores, fossil fuels, minerals, stone, clay, gravel, and similar commodities. This does not include the refinement of these commodities. The mining industry contains five categories, which are defined by the resources they produce: oil and gas extraction, coal mining, metal ore mining, non-metallic mineral mining and quarrying, and support activities for mining.

Coal mining industry: The coal mining industry covers all industries established to produce bituminous coal, anthracite, and lignite, a fossil fuel that is used primarily for electric power generation and in the production of steel. Many coal seams are located close to the surface, however, which makes the extraction of this resource easier.

Metal mining industry: The metal mining industry covers all industries established to engage in mining, developing mines, or exploring for metallic minerals (ores) primarily gold, silver, iron, lead, and zinc. The extracted minerals have a variety of industrial purposes: gold and silver are primarily used in jewelry and high-end electronics, iron is used to produce steel, copper is the main component of electrical wiring, lead is used in batteries, and zinc is used to coat iron and steel to reduce corrosion and as an alloy in the making of bronze and brass.

Non-metallic mineral mining industry: This industry is the one established primarily to engage in mining or quarrying, developing mines, or exploring for non-metallic minerals. The majority of the industry produces crushed stone, sand, and gravel for use in the construction of roads and buildings. Other important minerals produced are clays, primarily for ceramics, water filtration, and cement making; gypsum, the primary material used in wallboards; salt, used in foodstuffs and as an ice remover; phosphate, for use in fertilisers; and sulfur, the main component of sulfuric acid, a major industrial input.

Oil and gas extraction industry: This industry is established to produce crude petroleum and natural gas; extract oil from sands and oil shale; produce natural gasoline and cycle condensate, and produce gas and hydrocarbon liquids from coal at the mine site. The petroleum and natural gas are used to heat homes, fuel cars, and power factories. Petroleum products are also raw materials for plastics, chemicals, medicines, fertilisers, and synthetic fibers.

The occurrence of minerals: The occurrence of minerals falls into one of the four main types of modes of formation. These are veins and lodes, bed and seams, weathering products and alluvial or place deposits. Veins and lodes are formed when molten materials containing minerals intrude and solidify into cracks and crevices. These are mainly associated with igneous and

metamorphic intrusions. Examples of minerals formed in veins and lodes are tin, copper, silver, lead, manganese and zinc.

Bed and seams constitute another type of mineral formation. Coal, iron ore, gypsum, potash, salts and common salts are formed as a direct result of deposition, accumulation and concentration in the horizontal strata of the earth's crust. Gypsum, potash and salts, for example, are formed by the evaporation of lakes in desert areas and later are covered by other deposits so that they appear as seams.

Bauxite, the ore of aluminium is formed by the deep weathering of a variety of rocks. Leaching by underground water, produces red lateric deposits which are iron concentrations found in many tropical soils. Many minerals such as gold, tin and platinum are found as alluvial deposits in mud, gravel and sands of alluvial fans at the base of hills or bottoms of valleys.

Distribution of minerals in the world

Minerals are unevenly distributed in the world. Some countries are rich in minerals while others are not. The distribution of minerals depends on geological processes which have taken place over a long period of time. The processes may lead to variation in the amount and types of minerals in different parts of the world. The availability of minerals may resemble or differ from country to country or region to region, within the same country. Tanzania is one of the countries in the world that are rich in minerals. It is established that Tanzania has almost all types of minerals which are found in other parts of the world.

Diamond, gold, iron, coal, gypsum, copper, uranium, mica, graphite, tin and tanzanite are some of the minerals found in Tanzania. Figure 5.1 shows the distribution of various minerals in Tanzania. Tanzanite is a gemstone only found in Tanzania. Other minerals found in Tanzania are nickel, salt, asbestos, silver, titanium, lead, zinc, platinum, bauxite, soda ash, lime phosphate, sand and natural gas.

Minerals are also found in other countries on all continents of the world. For example, copper is found in Zambia, Democratic Republic of Congo (DRC), South Africa, Uganda, United States of America (USA) and Canada. Diamond is found in Botswana, Ghana, DRC, Canada, Brazil, Russia and Australia. Iron is found in Mauritania, Liberia and Canada. Coal is found in Russia, South Africa and Zambia. Gold is found in Russia, Ghana and Zimbabwe.

Tin is found in South Africa, Nigeria, Rwanda, DRC, China, Indonesia, Peru and Bolivia. Figure 5.2 shows the distribution of some of the major minerals in the world. Major factors affecting exploitation of mineral resources in the world include: quality of the ore (richness or grade), size of deposits, methods of mining, deposits,

Figure 5.1 Distribution of minerals in Tanzania

methods of mining, accessibility, transport facilities (cost), stage of industrial development of the country, technology, and other factors such as cheap labour, competition from other sources, political influence, and economic system and tariff policies of a country.

Uses of some minerals

Minerals are used for different purposes. This part explains the uses of eight minerals. These minerals are tanzanite, copper, diamond, gold, iron, coal, petroleum and natural gas.

Tanzanite: Tanzanite is the blue and violet of the mineral ziosite caused by small amounts of vanadium, belonging to the epidote group. Tanzanite is only found in Tanzania in a very small mining area approximately 7 km near Mererani Hills in Arusha. It was discovered in1967.

Tanzanite is noted for its remarkably strong trichoism, appearing alternately as blue, violet and burgundy depending on crystal orientation. Tanzanite can also appear differently when viewed under different lighting conditions.

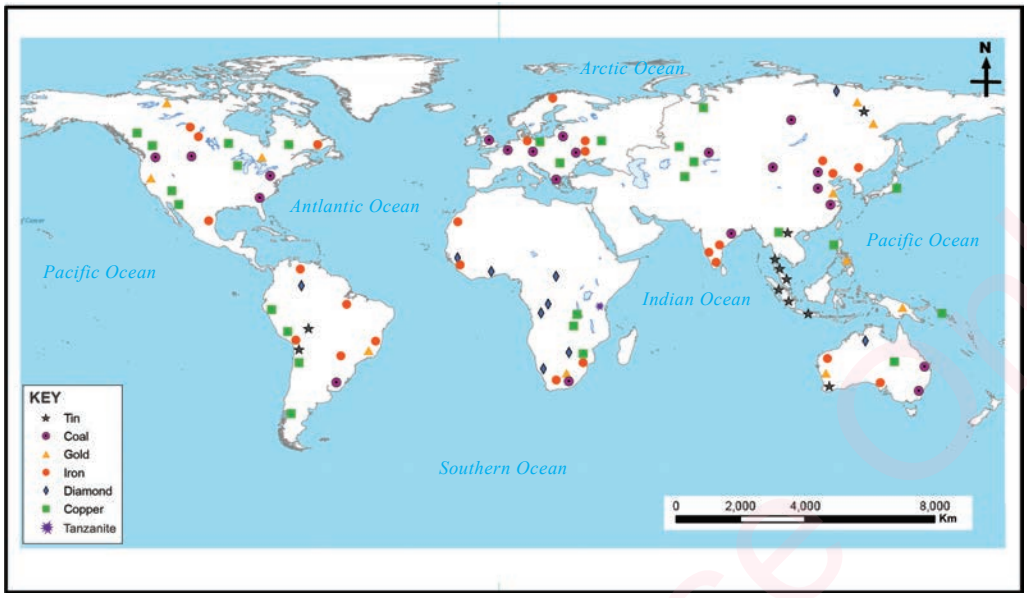

Figure 5.2 Distribution of some major minerals in the world

The gemstone was named 'tanzanite' by Tiffany and Company, after Tanzania, the country in which it was discovered. It is used in making bracelets, necklaces and earrings.

Copper: Copper is one of the most widely used industrial metals because it is a good conductor of heat and electricity. Copper is also very resistant to atmospheric corrosion; therefore, it is useful in the transmission of electricity. Copper is used in making alloys since it combines easily with other metals to produce new compounds. For example, copper combines with zinc to produce bronze which is used in making coins, ornaments and utensils. It is also used in making electronic and telecommunication appliances such as sockets, holders, connectors and parts of mobile phones. These appliances are useful in industries and homes. In addition, copper is used in making corrosion-resistant materials for roofing, tubes, pipes, radiators and boilers.

Diamond: Diamond is a rare and the hardest naturally occurring mineral composed of pure carbon. It occurs commonly in rocks called kimberlite. It is used in glass cutting. Glass dealers use it to cut and sharpen glass into different shapes and sizes. Besides, the dust diamond is used for polishing other gemstone minerals such as tanzanite.

Moreover, diamond is used in making jewels and ornaments which are used as decorations in homes, offices, hotels and other public places. It is also used in making bits for drilling purposes and during oil and gas extraction.

Gold: Gold is one of the most valuable minerals in the world. Gold is able to conduct both electricity and heat easily. It does not lose its colour and brilliancy. It is useful in making jewels and ornaments. Gold is also used to make necklaces, and ear, arm and finger rings. Jewels and ornaments made of gold are usually expensive compared to most of the jewels and ornaments made from other minerals. The mineral is used in making valuable decorations for households, offices, hotels, places of worship such as churches, temples, synagogues and mosques. It is also used in making electronic appliances such as connectors and switches. Sometimes, gold is used in making gold coins. Some precious coins made of gold are used as currency. Other uses include making gold alloys for filling teeth gaps as well as medals, placards and trophies. Famous people in the world receive gold medals as recognition for their outstanding performance.

Iron: Iron is a basic raw material for iron and steel industries. When iron ore is smelt, iron metal is formed. Iron is used in making roofing maerials and hardboards for vehicles, ferries and boats. It is also used in making machines, especially for heavy industries. Most of the parts in cars, vehicles and milling machines are made of iron. Furthermore, iron is used in making agricultural equipment such as hand-hoes, oxen ploughs, power tillers and tractors. Other uses of iron include the production of building and construction materials. Iron-bars are useful in the construction and building of physical structures such as houses, railways, bridges and roads. Iron is also useful in designing fencing materials for security purposes. For example, people use iron-made fences to demarcate houses and plots and for providing security. Apart from that, iron is used for making tools that are useful in cutting and grinding other metals.

Coal: Coal is a black or brownish-black rock made of organic substances that have been deposited for a long period. The most significant uses of coal are in electricity generation, steel production, cement manufacturing and as a liquid fuel. A number of manufacturing industries use coal to run machines. For example, in Tanzania, coal from Mbinga and Kiwira is used as a source of energy in cement production industries. In addition, the carbon present in coal is an important element when mixed with other chemicals in paper, ink and pencil-making. The carbon in coal is also an ingredient used in drugs and chemical production. For example, aspirin contains some percentages of carbon from coal. Coal is also used in the production of valuable fertilisers that are used in agriculture. Some coal products are useful in making soap, solvents and plastic fibres such as rayon and nylon used for making clothes. Other uses of coal include making construction materials, particularly when it is mixed with cement, gravel and water to form concrete which is a basic building element in various infrastructures. China is the leading coal producer in the world.