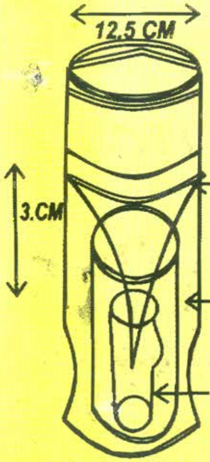
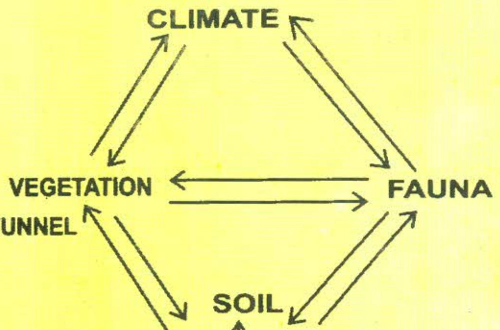
Agricultural Climate and Weather Forecast



A Rain Guage



Relationship among climate, plants animals 9including man) and soil.

A Wind Vane

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Meaning and Scope of Agro-Climatology

Agricultural meteorology or agroclimatology is concerned with the interactions between meteorological and hydrological factors, and agriculture including horticulture, animal husbandry crop production and forestry. It aims to apply knowledge of the atmosphere to practical agriculture use. In addition to natural climate and its local variations, agroclimatology is also concerned with modification in the environment (as brought about, for example, by shelterbelts, irrigation and frost protection): climatic condition during storage, weather indoors or in the fields, environmental conditions in animal shelters and farm buildings, and inside conveyances during transport of agricultural produce.

The scope of agro-climatology covers the collection, analysis and interpretation of climatological data for use in practical agriculture and its effects on agricultural management. The major goals of agroclimatology are as follows:

1. The prediction and control of the climatic environment for better agricultural production and operational management.
2. The protection of crops and livestock against climatic hazards.
3. The prediction, control and management of plant and animal pathogen and pests.
4. The appraisal of the climatic environment of an area for the introduction of a specific crop or domestic animal.

Agricultural production is still dependent on weather and climate despite the impressive advances in agricultural technology in recent times. Knowledge of available environmental resources and expected conditions from below the soil surface through the soil-air interface to the lower atmosphere provides guidance for strategic decisions in long-range planning or agricultural systems. Typical examples are design of irrigation schemes, choice of land use to farming patterns and selection of crops and animals, varieties and breeds, and farm machinery. Detailed real-time estimates of meteorological elements and derived indices are important for tactical decisions in short-term planning of agricultural operations. Tactical decisions include "average cost" type decisions regarding timing of cultural practices such as planting, cultivation and harvesting and "high cost" type decisions, such as the application of expensive chemicals or the operation of costly crop protection measures.

Regardless of the type of decision, a proper understanding of the effects of weather and climate on soils, plants and agricultural production is necessary to make efficient use of meteorological and climatological information for agriculture.

The practical application of this knowledge is linked to the availability and accuracy of weather forecasts or expected weather patterns depending on the time scale. The forecast requirements range from accurate details of short-term weather (one to three days) at certain critical times to seasonal predictions of weather patterns. Even an indication of the possible climatic variability against the background of historical climatic records as obtained from data and other evidence is useful especially in the case of probability statistics to ensure that development plans are not rendered meaningless by a significant change in weather behaviour.

Weather and Climate

It is appropriate to make a distinctions between 'Weather' and 'Climate' although the two are interrelated. **Weather** is the state of the atmosphere at a given point in time over a given area or location. The study of weather and its elements are called meteorology. It is concerned with the scientific study of the various properties of the atmosphere and the interactions between the atmosphere and the earth's surface. **Climate** is the synthesis of weather at a given location over a long period of time (usually 30 to 35 years) over a given location or area. Climate therefore refers to the characteristic condition of the atmosphere deduced from repeated weather observation over along period. Climatology is the scientific study of climate.

Importance of Climate and Weather

1. They determine to an extent the sort of food we eat, what we wear, how to live and eat.
2. The direction of winds once controlled the pattern of trading routes
3. The safety of modern air communication is closely tied to accurate meteorological reports from the ground stations.
4. Agricultural production is still dependent on weather and climate despite advances made in agricultural technology.
5. They provide guidance for strategic decisions in long range planning of agricultural systems, e.g. design of irrigation schemes

choice of land use and fanning patterns and Selection of crops, varieties and breeds and farm machinery.

6. Conditions of temperature, precipitation and humidity may promote or discourage the growth of fungus and diseases which may be injurious to both man and crops.
7. Death rates are normally high in tropical countries and low in deserts, because germs are not transmitted readily in regions of high temperature and low humidity. Also cool fresh mountain air is always good for health.

Principles and Practice of Climatology

Climate is better studied when the results of the study of weather elements and factors are pooled to now become climatic elements and factors. **Weather elements** are the characteristics of weather over a given location in which we determine the prevailing weather condition That is, they constitute the descriptive parameter of the prevailing weather over prevailing conditions, they therefore control the type of the weather we have. Weather elements include Temperature, Rainfall. Wind-speed, Humidity, Pressure, Wind-direction, Solar radiation, Cloud-cover among others. Weather factors are determining causes of weather and climate, e.g. latitude, altitude, location relative to large water bodies like seas and lakes, ocean current, relieve features, etc. These are the factors that determine the weather of a particular location.

The practice in the study of climatology mainly involve weather observation, which is mainly the observation of weather elements. Weather observations take place at weather stations, which are of different sizes and sophistication. These stations are principal or synoptic stations, minor stations, agricultural, climatical and rainfall stations where specialized information on the relevant field can be obtained.

Weather Elements

Weather elements are the various environmental effects that determine the overall performance of both plant and animal life. All stages of agricultural production are subject to the influence of weather. The various weather elements are:

1. Temperature
2. Humidity
3. Wind
4. Precipitation
5. Evaporation
6. Evapotranspiration
7. Sunshine
8. Clouds

Temperature

This is the relative amount of heat or warmth felt by a given body. There are three kinds of body temperature needed in Agriculture. These are air, soil and water. Air and soil temperature affect all the growth process of crops. Every crop require minimal, optimal and maximum temperature limits depending on the stage of growth. For example, arables such as tomato, cowpea, groundnut and pepper require temperature ranges between 29°-31°C for optimum performance.

Whereas some tree crops such as cocoa, coffee, banana, sugar cane, etc. require high temperature range of not less than 33°-60°C for performance.

Temperature below 10°C are lethal to most crops and animals. This is because various metabolic activities below this temperature retards growth and consequently kills such plants and animals. This is called **crop chilling.** Chilling may not kill plants directly but reduces water flow within the vascular tissues (phloemad xylem) and hence affect transpiration and nutrient availability.

Soil temperature have greater ecological significance to crop life than air temperature. Seed germination and root development are controlled by soil temperature. Other problems such as physical, biochemical and biological processes in the soil are affected by soil temperature.

In tropical region, soil temperature most adequate for crop life is between 12°C and 3°C.

Humidity

This is the degree to which water vapours is present at a given time in the atmosphere. The feeling of water vapour by a body is referred to as **dampness** and this varies from place to place at different times of the day. For a given temperature, there is a limit to the quantity of moisture that can be held by the air. This limit is known as the **saturation point.**

Specific humidity is the ratio of weight of water vapour to weight of moist air. When there is no gain or loss of moisture for time, the specific humidity remains constant.

Relative humidity is the proportion of water vapour present in a body relative to the maximum quantity available. This is expressed in percentage. At saturation point relative humidity is 100%.

Absolute humidity: This is the weight of water vapour contained in a given volume of air. Unlike specific humidity, absolute humidity does not remain constant for the same air body.

Precipitation

This is a term used in describing any aqueous deposit in liquid or solid form derived from the atmosphere. Precipitation can come in the following forms:

- Rain drops/drizzles.
- Snow
- Sleet
- Frost
- Fog/mist
- Dew.

Rain Drops

These are water droplets without continuous flow in the atmosphere. Drizzles are water droplets with more tiny droplets which may show continuous flow which in most cases do not last for long.

Snow

These are solid precipitates which has crystals and are called ice blocks. When such crystals are melting with smaller sizes they are called **sleet.**

Frost

These are aggregate of icy-deposits on surfaces. Frosts have temperatures below freezing point.

Dew

These are very minute water deposit on body surfaces. It is so formed when moisture condenses into a solid surface cooled to the dew point temperature of moistened air.

Fog/Mist

These are moistened air in motion which remains suspended in the atmosphere. This type of precipitation obstructs vision at about 1 km to 2 km distance ahead. It does not have much impact on agricultural production as the other forms of precipitation.

Types of Precipitation

This occur when minute droplets of water collapse to form larger drops and are heavy enough to overcome gravity of the ascending air currents and finally fall as rain. There are three types of rainfall:

1. Convectional rainfall.
2. Orographic rainfall.
3. Cyclonic rainfall.

Convectional Rainfall

This type occurs throughout the year near the Equator where there is high temperature. This rain occurs mainly in the hot afternoon. When the air is warm and humidity and the upper air is abnormally cold a condition of instability result. This instability will result in turbulence of the up-currents and eventually drops as rain.

Orographic Rainfall

This occur near mountains when air is forced to ascend the side of a mountain range. The air creates difference between the windward and leeward side of the mountains. The orographic factor increases precipitation produced on other causes.

Cyclonic (Frontal) Rainfall

This occur along the frontal zones of convergence at the polar fronts and the intertropical convergence zones (ITC2). Under warm humidity conditions, there is a build up of massive cumulonimbus clouds with torrential rain and thunderstorms. This rainfall is intensified by effect of relief as the coasts.

Evaporation

This is loss or transfer of water from body surfaces to the atmosphere. Evaporation occur at a temperature below boiling point. Temperature, humidity and sunshine affect and determine rate of evaporation. Evaporation is peculiar to water and ground surfaces.

Evaportranspiration

It is a combination of evaporation and transpiration. These two combine to form a major source of moisture loss by parts of crop plants. Two factors determine the rate of both evaporation and evapotranspiration.

These are:

1. Availability of moisture at the evaporating surfaces.
2. Ability of air to contain and transport the vapour upwards.

Both surfaces combine to form source of moisture in the atmosphere and also affect the availability of water in the soil for plant life.

Sunshine

This is the amount of sunlight decipated into the atmosphere and felt by body surfaces. The amount of sunshine received by a place depends on the season. Duration of sunlight refers to the number of hour per day with sunshine or daylight. In the tropics, sunshine is abundant hence, lesser crops plants are sensitive to daylength. Whereas, in the temperature region, greater number of crop plants are affected. This weather element is a major determination of crop type, grown in either Temperate or Tropic region, depending on the sensitivity of the crop to daylength.

Clouds

The clouds are tiny aggregates of water droplets which are too tiny to drop down as rainfall or other forms of precipitation. The form, shape, height and movement determines the condition of the sky. Clouds are formed when condensation occurs in a warm moist air that has risen following rainfall types.

Clouds are classified into two using:

1. Physicaappearance.
2. Height.

1. **Physicl appearance:** This involves the shape, structure or form. These re:

   a. *Criform clouds.* This clouds have fibrous appearance.

   b. *Statiform cloud:* This cloud have layers.

   c. *Cummuliform cloud:* They appear as heaps or mounds.

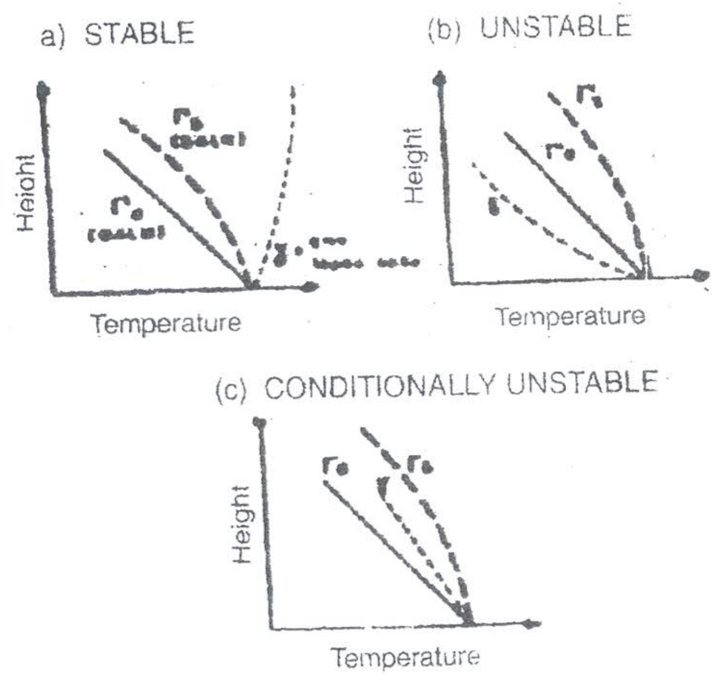


Fig. 1: tability diagrams illustrating the conditions of (a) stable (b) unstale (c) conditionally unstable atmospheres.

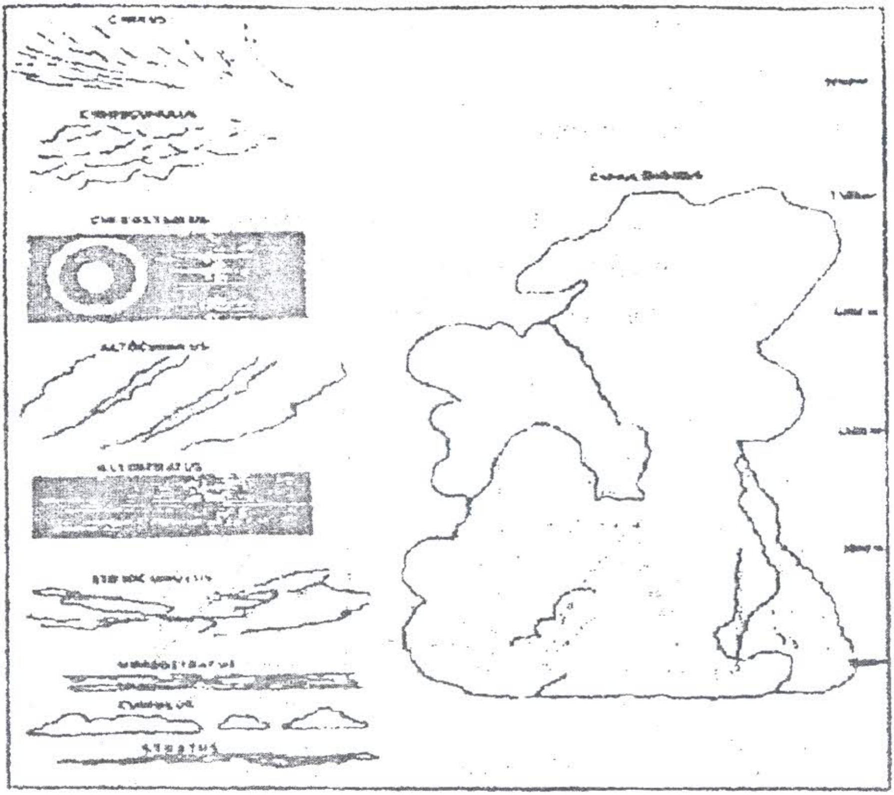


Fig. 2: Major types of clouds

2. **Height:** Clouds can be further classified depending on the level of height at which they occur in the atmosphere. These include:
   a. *High clouds:* These clouds are about 6100-122000m above ground level.
   b. *Medium clouds:* of 2100-600m above ground level.
   c. *Low clouds:* Below 2100m above ground level.

Wind

This is air in motion. Most activities carried out by both plant and animal life's are affected directly or indirectly by the direction or speed or wind.

Wind direction is stated in terms of the position from which it is coming from. Wind is important in Agriculture and that it affects and determines rate of stem breakage and plant loading.

The Earth's Environment and Resources

The earth is surrounded by four major spheres, they are the atmosphere, the hydrosphere, the lithosphere and the biosphere.

The Atmosphere

The earths atmosphere consists of a mixture of various gases surrounding the earth to a height of about 1000 km. The atmosphere can be described as a thin layer of odourless, colourless and tasteless gasses held to the earth by force of gravity. In the beginning atmosphere was made up of two main gases which are methane and ammonia, gradually these two gases were replaced by other gasses from volcanic eruptions. Later oxygen was added to the atmosphere through the breakdown of water vapour and later too as by product of photosynthesis.

Today the atmosphere is a mixture of many gases liquids and suspended solids; From the earth's surface to an altitude of about 80 km, the chemical composition of the atmosphere is highly uniform, i.e in terms of its component gases. The name homosphere has been applied to this lower uniform layer unlike the overlying, heterosphere which is non-uniform in arrangement.

Table 1: Average composition of the dry atmosphere below 25 km (Barry & Chorley 1976)

Gas	Volume % (dry air)
Nitrogen (N_2)	78.08
Oxygen (O_2)	20.94
Argon (Ar)	0.93
Carbondioxide (CO_2)	0.03 (variable)
Neon (Ne)	0.0018
Helium (He)	0.0005
Ozone (O_3)	0.00006
Hydrogen (H)	0.00005
Krypton (Kr)	Trace
Xenon (Xe)	Trace
Methane (He)	Trace

Pure, dry air of the homosphere consist largely at of nitrogen which accounted for 78.08% in volume. While carbondioxide takes 0.03%. Although carbondioxide constitute only a small amount, it is a gas of great importance because of its ability to absorb heat and thus allow the lower atmosphere to be warmed by heat radiation coming from the sun and from the earth's surface.

Green plants also utilize carbondioxide for photosynthesis There has been a noticeable increase in the presence of carbondioxide in the atmosphere, this has been attributed to man's combustion of vast quantities of wood, coal, petroleum and natural gases. The effect of the increase in CO_2 in the atmosphere is appreciable increase in average temperature. Other gases in the atmosphere are Oxygen, Argon, Neon, Helium, Ozone and Hydrogen. Other gases found in trace are Krypton, Xenon and Methane. The importance of most of these gases in the atmosphere is much more than the volume suggested for example water vapour, carbondioxide and ozone are present in the atmosphere in minute quantities and they are very essential for the maintenance of life. Without water vapour, there would be no water cycle to sustain our ecosystem. Carbondioxide, water vapour and zone also act as a blanket over the earth surface.

Structure of the Atmosphere

The atmosphere may be divided into a series of species on the bases of changes in temperature with altitude, there are four main species in the atmosphere. These are:

1. Troposphere
2. Stratosphere
3. Mesosphere
4. Thermosphere

Troposphere

It starts from the earth surface to an altitude that ranges from 16 kms as in the equator and 6 kms at the poles, here temperature decreases with altitude.

The troposphere is of most direct importance to man in his environment at the bottom of the atmosphere. Almost all phenomenon of weather and climate that physically affect man take place within the troposphere.

Stratopshere

This is the next layer after the Troposphere. It extends to a height of about 50 km, the lower portion is characterized by uniform temperature, at the upper and there is a gradual increase of temperature with height.

Mesophere

Next of the above is the mesophere. It extend to a height of 80 kms; here temperature decreases with altitude (height). Above is the Thermosphere where temperature increases with altitude.

Structure of the Atmosphere

The important thing to note about the spheres is that they are classified by their temperature/altitude relationship. Starting at the earth's surface, air temperature falls steadily with increasing altitude at the fairly uniform average rate of $3\frac{1}{2}$ °F per 1000ft (6.4°C per km). This rate of temperature drop is known as the **environmental temperature lapse rate**. The layer in which the environmental lapse rate is approximately uniform is known as the Troposphere.

The uniform lapse rate gives way rather abruptly at a height of about 12.5-15 km to the stratisphere where temperature at first holds essentially constant with increasing altitude. The level at which the troposphere gives way to the strosphere is termed the tropopause. Upward through the stratosphere there sets in a slow rise in temperature to about 32°F at about 50 km. Here at the stratopause, a reversal to falling temperature sets in. Temperature decreases through the overlying mesosphere, a layer extending upward to about 80 km where a low point of −12°F is reached. This level of temperature minimum and reversal termed the mesopause. As altitude increase, a steep climb in temperature is observed within the thermosphere.

Hydrosphere

The hydrosphere is the totality of the global reserve of water in the three main forms by which water exists; these are in liquid, solid or gas. Water is one of the most important substances for life, it does not only account for over 65% of man's body weight, it serves as the medium for the life sustaining processes. Water is also important to the society in many different ways, these ways include:

1. Transportation
2. Recreation
3. Power processing
4. Waste processing
5. Domestic uses
6. Agricultural uses.

The total volume of water on the earth is relatively constant, although a very small amount of water vapour is lost annually from the upper atmosphere, this loss is compensated for by the addition of water vapour through volcanic eruption. The various forms of water are distributed among oceans, atmosphere and terestial reservoirs.

Oceans makes up the largest reservoir, the remaining water is tied up as ice in polar and mountainous areas. Comparatively the amount is minute. Reservoirs of water in lakes rivers groundwater and atmosphere is minute. Water is continuously distributed among these reservoirs, the pattern of movement of these water is called the Hydrological cycle.

A rock in any of the three rock families may be altered by geological processes into another type of rock cycle implies a continuous transformation of rocks from one type to another.

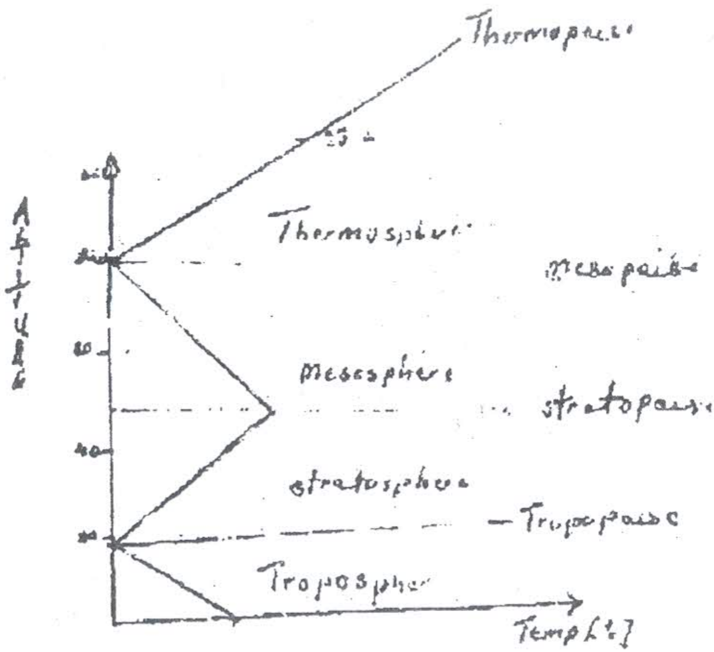


Fig. 1: The rock cycle

Biosphere

The biosohpere summaries the entire near surface zone of the earth favorable to life (plants and animals) in one form or the other. It is referred to as the life layer because it is the environs of living things. The biosphere lies at the contact between the atmosphere, the ocean surface and land surface. This contact zones which we may call interface experiences intense activities in the form of exchanges of energy and matter. Man and all other life forms participate in the processes of the life layer. Organism receive from their environments energy and matte necessary for life processes. The study of these interactions is referred to as ecology. The biosphere may be subdivided into environmental division:

1. Salt water (ocean).
2. Fresh water (streams, lakes and ponds).
3. The land (soil and air in contact with it).

Climate Control

There is a relationship between the climate of a region and its natural vegetation. Climate is a controlling factor in both plant and animal environments. Climate determines whether or not rainfed agriculture will be realistic and the type of crops that can be successfully cultivated in a given area.

All crops therefore have their climatic limits for economic production. The influence of one climatic factor is modified by the other factor. The following is a summary of climatic factors and there their effects on the environment.

Table 1: Climatic factors and effect on environment

1. Ocean current	Determines amount of moisture available in a given area/region.
2. Hills and lows	These are barriers, e.g. mnountains, hills, valleys, etc. causes physical obstructions and reduces amount of moisture made available to plant and animal lives.
3. Latitude/Sun angle	Determines amount of energy (solar) released for man's use.
4. Distribution of land and sea	Determines amount and rate of heat gain or heat loss from body surfaces via evaporation and condensation. This determines moisture availability.

Effects of Weather Elements on Agriculture

Climatic parameters have an influence on all stages of the agricultural production chain including land preparation, sowing, crop growth and management, harvesting, storage, transports, and marketing. These parameters include solar radiation temperature and moisture (rainfall). These climatic parameter and other dependent on them largely determine the global distribution of crop and livestock as well as crop yield and livestock productivity within a given climatic zone. All crops have their climatic limits for economic production. These limits can be extended to some extent by plant breeding and selection and by cultivation methods in respect of crops and by animal breeding and improved animal husbandry in respect of livestock.

Solar Radiation

Solar radiation is of vital importance in agriculture since it is this energy that powers the agricultural system like any other ecosystem. Solar radiation determines the thermal characteristic of the environment, namely the air and soil temperature, sunshine and day length or the photoperiod. Photosynthesis the basic process of food manufacture in nature and photoperiodism, the flowering response to daylight are both controlled by solar radiation. The maximum amount of plant tissue which can be photosynthesized within a crop depends on the availability of suitable radiation assuming unlimited carbon dioxide, water, and soil nutrients.

Radiation intensity is also an important factor. The optimum light values for normal crop growth and development are generally around 8-20 kololus. Light values for optimum flowering and fruiting determined for some crops are as follows

Table 2: Radiation intensity on some crops

Pea	850-1100 lux
Maize	1400-1800 lux
Wheat	1800-2000 lux
Bean and Cucumber	2400 lux
Tomatoes	4000 lux

If there is insufficient radiation the root system of the crop is underdeveloped, the foliage is yellowish and there is tendency for the stalk to grow at the expense of the foliage.

In photoperiodism, some plants are indifferent to day length while others are very sensitive to variations in day length. Also, some plants are light loving while others love shade. This is not to say that shade loving plants do not require solar radiation. Crops may be classified as short-day or long-day types, depending on the period when they achieve their optimum growth during the period of short days (about 10 hours sunlight) are said to be short-day crops and they include beans, maize, cotton, millet, cucumber and tomatoes. Crops which achieve their optimum growth during the period of long days (about 14 hours sunlight) are long-day crops and they include barley, clover, mustard, oats, rye, and wheat.

Temperature

The temperature of the air and soil affects all the growth processes of

All crops have minimal, optimum and maximal temperature limits each of their stages of growth. Tropical crops like cocoa and dates uire high temperature throughout the year. Many crops such as coffee, ana and sugarcane are very sensitive to frosts. Temperature below C are lethal to most plants. The upper lethal temperature for most lants range from 50 to 60°C depending on the species, stage of growth, and length of exposure to the high temperature. Low temperatures kill or damage plants. Prolonged chilling of plants at temperatures above eezing retards plant growth and may kill those plants adapted only to m conditions.

ienerally, high temperatures are not as destructive to plants as low ratures provided the moisture supply is adequate to prevent wilting plant is adapted to the climatic region. Excessive heat can destroy la protoplasm. It has a desiccating effect on plants and the rapid of transpiration may lead to wilting.

Most crops cannot be grown successfully unless the temperature eds some critical threshold values. For instance, coconuts and apples thrive only when temperatures are always above 21°C for at part of the growing season. Citrus fruit, cotton, sugarcane, and e will not grow well if temperatures are below 15°C. Many vegetables uire temperatures of at least 8°C. The growing season is determined the temperature region by the temperature conditions. Unlike in the pical where the rainfall conditions determine the growing season.

Soil temperatures are more important than air temperatures because directly influence seed germination. Cotton seeds require the soil mperature to be at least 10°C but below 18°C for germination.

Moisture and Crops

Water in all its forms plays a vital role in h gowth of plants and the production of all crops. It provides the rdim by which chemicals and nutrients are carried through the pl. Vater is also the main constituent of the physiological plan isue and a reagent in photosynthesis. Soil moisture is the sourc f vater of importance to crop and the state of soil moisture is atolled by rainfall, the evaporation rate and soil characteristics. h upply of soil moisture may range from wilting point when no wae i available for plant use to field capacity when the soil is fully saattd with moisture but is still well drained. When soil moisture is excsve all the soil pores are completely filled with water and a waterlge condition prevails. In such a situation free movement of air wini e soil is impeded and compounds toxic to the roots of plants ma eormed.

At the other extreme is the condition ofught in which the amount of water required for evapotranspiration exed the amount of available water in the soil. Unless this water defici made good by rainfall or irrigation the plant will begin to wilt and ie

Thus, like extremely low and high teprares, too much or too little water is not good for agriculture.

The role of moisture in agriculture is vn rore spectacular in the tropics because of relatively high temperars troughout the year, the rates of evapotranspiration are constantly hg O the other hand, rainfall is highly seasonal over most parts of the toics

Because temperatures are high enoughouhout the year to ensure the growth of crops over most parts of th tops, the growing season unlike in the temperate region, is determined by the availability of rainfall. Some have used critical threshold values of rainfall to delimit the length of the growing season. For instance, the number of months having at least 100 mm rainfall has been regarded as constituting the growing season. A more useful parameter is the number of months when rainfall is enough to satisfy the evapotranspiration needs of plants. It has been shown in Nigeria by Kassam *et al* (1976) that crop water requirements are usually fully met when rainfall is only half the value of potential evapotranspiration. The growing season in the northern Nigeria has, therefore, been defined by them as the period during which rainfall is at least half the amount of potential evapotranspiration.

The rainfall requirements of some food and commercial crops widely grown in West Africa are shown in the Table 3.

Table 3: Rainfall requirements of selected food and commercial crops grown in West Africa

Crops	Mean annual rainfall
Yam	At least 1250 mm
Kolanut	At least 1250 mm
Groundnut	500-1000 mm
Beniseed and soya beans	1250-1500 mm
Oil palm	1500-3000 mm
Cocoa	1250-2000 mm
Rubber	2000-2500 mm
Cotton	625-1250 mm

Wind

Wind, air in motion, is another climatic parameter that affects agriculture. On the positive side, wind is an effective agent for the dispersal of plants. The carbon dioxide intake of plants and rate of transpiration tend to increase with increasing wind speed up to a certain level. On the negative side, wind may cause physical damage to crops. By encouraging a high rates of transpiration high winds can also result in plants desiccation. Winds help in the transport of pollen and seeds of undesirable plants such as weeds. Wind erosion can damage good agricultural land by removing the top soil. Also high velocity winds in relatively dry areas or during the dry season in sub humid regions can increase the risk of forest fires that can damage farm crops.

Crop damage by winds may be minimized or prevented by the use of wind breaks (shelter belts). These are natural (e.g. trees, shrubs, or hedges) or artificial (e.g. walls, fences) barriers to wind flow to shelter animals or crops. Apart from influencing wind speed and rates of evaporation, air temperature and humidity, soil temperature and moisture are also altered over the area affected by the presence of wind break.

Weather Aspects of Crop Pests and Diseases

Agricultural production suffers periodic outbreaks of pests and diseases which are weather dependent. Crop losses caused by pests and diseases may be considerable, particularly in the humid and sub humid tropics. Crop losses due to insect pests in Nigeria have, for instance been estimated to be of 50-60%.

The pests attack the crops in the field and after harvest in barn where they are stored Some insect also act as vectors of disease causing germs and should therefore be considered as deadly as the germs they carry.

The period or seasonal nature of outbreaks of many crops pests and diseases suggest that weather conditions play an important role. These epidemics are often weather dependent either in terms of local weather of local weather conditions being favourable for their growth and development or in terms of the prevailing winds helping to import air bone germs or spores into given areas. Also, some disease-causing viruses are transmitted or spread by insects (e.g. aphids and leaf hoppers) so that the weather conditions suitable for the propagation of these vectors are those which favor the transmission of such diseases.

In the humid tropics and temperate region temperatures appears to be the critical factor Influencing the outbreaks of crop pests and diseases. In arid, semi-arid and subhumid environments rainfall is the dominant factor. Whatever the environment, however, the crop micro climate is of fundamental importance in the epidimediology of crop diseases. The optimum temperature for the reproduction off aphids is about 26 C. Over most parts of the African savanna, grasshoppers and locusts destroy many farmlands every year. The locusts generally originate in the Sahara desert margins where there is enough moisture for breeding and for vegetable growth to feed the larvae. The locusts fly in swarms southwards with the northeasterly winds during the day when temperatures are between 20 and 40°C. Locusts find it impossible to hold to a course if the wind speed exceeds 16-20 km/hour.

Other crop enemies like downy mildew, rusts, scabs and blight reproduce and spread most rapidly when the weather is warm and very humid. In the cocoa growing areas of southwest Nigeria, it has been established that too much rainfall reduces the number of cocoa pods per tree and increases the degree of infection by black pod disease (Adejuwon, 1962). Also in Nigeria the incidence of head mould which attacks sorghum in northern Nigeria has been partly attributed to high atmospheric humidity (Kassam *et al.*, 1976). Spores of fungus diseases are spread by wind and this makes their control rather difficult.

The spraying of crops with chemicals (insecticides, pesticides) is best done under conditions of light winds when the dispersal of such chemicals will be minimized. In the tropics where atmospheric turbulence and instability are commonplace, such calm conditions occur most often in the mornings and evenings.

Climate and Animal Husbandry

Climatic conditions influence animal husbandry directly or indirectly in three main ways. First, the availability of feed is highly rather dependent and since domestic animals are highly dependent on the availability of feed, climatic factors which influence the growth of pastures exert influence indirectly on livestock. Climatic conditions determine the type, quantity, and quality of the available feed. These climatic elements include rainfall temperature and radiation.

Climate conditions also have direct influence on domestic animals as they have effect on their normal body functions. For animals to survive in a given climatic zone they must be physiologically adjusted to that climatic environment.

Finally, climate influences livestock production indirectly by determining the types of animals and diseases that would be prevalent in a given environment.

Let us briefly elaborate on the above three ways in which climate influences animal husbandry. The amount and nutritive quality of pastures are impaired by drought conditions. Consequently, under such conditions there is reduction in milk production and general loss of weight of the animals. There is also a shortage of water for drinking by the animals. This adds to the discomfort of animals, particularly in the warm season and environments. Livestock numbers are drastically reduced by drought as many animals die of hunger and thirst and others are slaughtered for sale by their owners to prevent further deaths and facilitate rationing available feed amongst fewer livestock.

Animals, like human beings, are directly affected by the weather elements. Extremely low or high temperatures interfere with the physiological function of animals including man. The productive capacities of animals are generally reduced by high temperatures. Dairy cows tend to produce less milk under hot conditions while beef cattle produce less fat and flesh. This is because these animals reduce their intake of feed under hot conditions. For instance, cattle generally prefer grazing in shaded location than in the sun and they normally rest during the afternoon when temperatures are high and sunlight is strongest.

The reproductive capacities of animal also tend to decrease under high temperature conditions. Temperate breeds have been known to show a marked decline in fertilities under tropical climates (Critchfield, 1974). High temperatures also leads to increase in the water requirements of livestock. Some of the increased water intake is used to replace water lost from the body of the animal by evaporation.

Finally, climate indirectly influences animal production through its effects on the incidence and spread of diseases and pests that directly attack the animals or that influence the quantity and quality of forage crops and feed. In Nigeria, for instance, the more humid southern parts of the country have been shown to be as suitable as the northern parts for tropical cattle and more suitable for imported temperate cattle because the heat load on cattle is less in the south than in the north (Ojo, 1971).

Besides the south has the advantage of better and more reliable water supplies to meet the water requirements of animals. The observed distribution of livestock in Nigeria, is however, at variance with the above theoretical findings primarily because most of the south is infested with the tsetse fly while the north is relatively free of this insect which causes high rates of morbidity and mortality amongst cattle. The insect transmits and spreads the germ that cause human and cattle trypanosomiasis.

Drought and Crop Performance

Drought is an insufficient supply of moisture through direct precipitation and or indirect moisture (e.g. water stores in soil) such that crop needs for water are not fulfilled.

It is a serious problem to agriculture in tropical and temperate regions. Agricultural drought can be divided into four:

a. Permanent Drought
b. Seasonal Drought
c. Contingent Drought
d. Invisible Drought

A. Permanent Drought

This occur in very dry area called arid regions. In this areas, precipitation rarely occurs, and where it occurs it is insufficient to meet crop moisture requirement. In such areas, agricultural practices becomes impossible.

B. Seasonal Drought

This occurs where though there is a given pattern of wet and dry seasons but the drought occur during seasonal changes in atmospheric circulation. Agricultural practices can be possible in such periods of drought through irrigation.

C. Contingent Drought

This occurs when rainfall becomes irregular and variable in its intensity. This type of drought is found in humid and sub-humid tropics. It is unpredictable and therefore a serious problem to agriculture as farmers are not allowed to prepare for the hazard

D. Invisible Drought

This type is not noticed until the crop begin to whither and die. It is caused by non-supply of moisture from the soil or non-consistent supply of water through precipitation to meet crop needs.

Effect of Drought on Agricultural Practices

The primary effect of drought is seen on the reduce/total crop failure and consequently poor crop yield. Animal life and management is also endangered. This sum total effect is manifested in the following:

1. Persistent occurrence of drought in semi-arid areas lead to soil erosion and desertification.
2. The vigorous growth of roots, stems, leaves and fruits are reduced.
3. Flowering may be delayed or prevented.

How to Manage Droughts

Drought can be effectively controlled by:

A. **Reducing the water needs of crops:** In this, plants that require little water for optimal production can be planted in drought prone areas, e.g. annual which include vegetables: amaranths, pepper, cowpea.

Also drought resistant crops and quick-maturing or short season crops can be planted in drought prone areas Cultivation should be such that creeping crops e.g. legumes are planted to help conserve soil moisture. Drought is also effectively managed by irrigation.

Irrigation

Irrigation is an artificial means of supplying water into soil and or crops to provide moisture for crop growth. Irrigation is practiced in areas where precipitation is insufficient to adequately supply moisture to crops throughout the plant growth phase. Such areas are said to be too dry or too drought prone for successful agriculture practices. Examples of areas where irrigation is constantly practiced are arid, semi-arid and some times sub-humid areas.

Irrigation frequency is also affected by weather status. Intensity of sunshine affects consumptive use of water and therefore regulates scheduling of irrigation.

Importance of Irrigation

Irrigation allows effective agricultural practices in and out of season. The advantages are as follows:

1. Crops are grown to full maturity in and out of season. Hence crops are made available all year round, e.g. vegetables, grains, etc.
2. Crops losses are minimized.
3. It facilitates the cultivation of crops that cannot be grown under insufficient water supply.
4. Crop yield is improved.

Method of Irrigation

There are three ways by which irrigation water can be applied to crops:

a. Surface irrigation.

b. Sub surface irrigation.

c. Overhead irrigation.

Surface Irrigation

This is by direct water supply to the field by flooding and by furrow irrigation. Flooding is done by uncontrolled turn of water to the field. This method wastes water and requires leveled ground/field to achieve thorough irrigation.

Controlled flooding is achieved by the use of borders or any other divisions. The water flow is turned into such borders to stand until it infiltrates.

Furrow irrigation is achieved where narrow pathways or furrows are created between crops.

Subsurface Irrigation

This is water application to the lower parts of plants. It involves the use of porous or open-jointed pipes buried underground and which allows water to slowly drip into the soil. Another type of subsurface irrigation is called trickle irrigation. Here small plastic tubes are used to apply water and nutrients to the base of the plants. Subsurface irrigation reduces evaporation, percolation and run off.

Overhead Irrigation

This is water application to plants from above the ground level. This is also called sprinkler irrigation. Water is pumped and carried through a network of pipes over the crops from rows of nozzles in pipelines.

Advantages of Sprinkler Irrigation

1. It can apart from supplying water to crops, used to supply fertilizers or organic manure to crops
2. It adequately supplies water to every field area.
3. It can be used in hills and mountain tops.
4. It is controlled i.e. application can be selected to suit soil type and infiltration rate.

5.

6.

Agrometeorological Forecasting

Scope

Agrometeorology forecasting is concerned with the assessment of current and expected crop performance, including dates of crop -development stage (especially maturity) and yields (quantity and quality), and other factors affecting production patterns such as, densities of sowing and locations and acreages of planting. The weather forecasting for agriculture deals with special forecasts of weather elements affecting farm operations, e.g. forecast for spraying and for estimating probabilities of occurrence of potential hazards (frost, fire, hail, severe rainfall).

Agrometeorological forecasting may be called crop prediction without weather forecasting, since it uses actual past and present meteorological data to predict crop performance in the future by using two principles:

(a) The continuation of the current inertia of the crop (i.e. its general health and well being) and its environment (i e. the general climate of the area in which the crop is grown), and
(b) The dependence of the present crop inertia on current and past weather conditions.

Importance

In many countries agrometeorological forecasts are at present the most important means of serving agriculture, especially for planning agricultural production.

They help agriculture to make the most complete and rational use of climatic and weather data: to operate economically, to produce high and consistent yields and to maximize productivity of animal husbandry. For making many operational decisions, both for long range or strategic decisions and for short-range or tactical decisions. These allow the farmer to make such long-range decisions as choosing the crop, variety, equipment, market, etc. once made, these decisions are irrevocable for the season.

Tactical decisions are the general "routine" decision that affects cultural practices and the "high cost" decision, involving the operation of expensive crop protection systems. These decisions are revocable, although changing them may prove costly at times.

Agricultural planning bodies need to know: the expected times of onset of the phenological phases in the growth of crops and moisture supply in order to institute adequate cultural measures; the expected times of ripening and harvesting in order to prepare the necessary machinery in advance; the expected yields of crops for making important planning decisions (e.g. export and import of food grains).

Basic Principles of Agrometeorological Forecasting

Many of the techniques of agrometeorological forecasting are based on the statistical relationships existing between the dependent variables to be estimated (yields, date of flowering, etc.) and independent agrometeorological variables (precipitation, temperature) or derived variables (index of soil moisture, atmospheric moisture stress). The independent variables or predictors can often be readily chosen by agrometeorological experience or intuition, where several variables are interrelated (e.g. moisture as affected by temperature) the dominant variables may be chosen using multivariate regression analysis.

The principles of agrometeorological forecasts can be postulated as follows:

(a) Current crop conditions can be assessed from past weather data and determine to some extent the potential yielding ability.
(b) Soil moisture can be estimated from past weather data and is one of the more important environmental variables determining quality and quantity of crop yields.
(c) Current weather conditions have a tendency to persist into future for a number of days and thereafter tend in a statistical sense to the normal, with a known probability distribution.
(d) The probability distribution of the most important weather element can be used to determine probable future changes in the current crop condition and its potential yielding ability.
(e) Weather elements, particularly, temperature and radiation, are conservative elements as regards their macro-scale distribution so that weather records, even from a number of observing stations, can be used for estimating yields and production over a relatively large area.

The usefulness of statistical equations representing crop-weather relationships are for:

(a) Assessment of expected yields over large regions.
(b) Agroclimatic analysis of crop production.

(c) Evaluation of crop responses to weather elements, and

(d) Assessment of the impact of natural or man-induced climatic variabilities on crop yields.

Forecasts for Agriculture

The fear of adverse weather condition is always daunting to farmers. Prediction of the weather conditions has become a game of statistical chess. Only faint confidence can be given. This indicates that the small chances of success in farming would still be appreciable to any farmer. This predictions and forecasts are still very useful.

Forecasting is not expected to provide an exact knowledge about weather in the near future. It is to propose the extent of confidence or assurance or probability with which a likely weather event will take place. There are already known seasons and cycles of seasons and weather. Within these data supported base of knowledge about the weather we draw inferences. However, slight or large variations from prediction may occur. Thus, we say during the rainy season that some aspect of variable, e.g. rainfall, was higher or lower than 'normal'.

It must also be noted that the reliability of data available for making predictions and forecasts affect the confidence one could put on the predictions. When data for a location are absent, then extrapolation is made using data of nearby stations. This also reduces the reliability to an extent. Rainfall data could be applied for areas within 10 km radius from one weather recording station Beyond this radius, applicability of estimates is low with increasing unreliability. Agricultural weather forecasts should include such items as sunshine percentage, occurrence of dew, relative humidity, rainfall probability and other elements which occur seasonally. This enables the farmer to plan his operations to make the most efficient use of his labour and materials.

Elements of Agricultural Weather Forecasts

An agricultural weather forecast should refer to all weather elements which immediately affect farm planning or operations. The elements will vary from place to place and from season, but should include the following:

(a) Sky cover. Cloud and sunshine percentage.
(b) "Weather" and rainfall probability.
(c) Temperatures.
(d) Winds.
(e) Humidity.
(f) Dew.
(g) Drying conditions.

Format of Forecast

The format of the agricultural weather forecast should be fixed with all elements in the same relative position in each forecast. This will enable farmers to become accustomed to a given flow of information.

Example of a forecast format:

(a) **Wind:** Forecasts of wind direction and speed and expected change should be given.

(b) **Sky conditions:**

Actual coverage (average)	Forecost – day	Forecast – night
Less than $\frac{2}{10}$	Sunny with more than 90 per cent sunshine	Fair
More than $\frac{9}{10}$	Cloudy with less than 10 percent sunshine	Normal

(c) **Temperatures:** Maximum and minimum temperatures at least a spread covering the highest maximum and lowest minimum temperatures should be given. Forecast should be for ground or crop level so that the minimum will be generally lower than the temperature in public weather forecasts.

(d) **Rain fall Probability:** The percent probability of rain for each period should be given as a separate statement. It is important to emphasize the likelihood of no rain occurring by using probabilities less than 10 percent.

(e) **Humidity:** Relative humidity forecasts should include afternoon minima and night-time maxima.

(f) **Dew:** The likelihood of the formation or lack of dew should be indicated.

(g) **Drying Conditions:** Expected drying conditions should be referred to in the forecast. This information is used to determine crop-curing conditions, e.g. for Tobacco Excellent drying (more than 0.8 cm free water loss) does not favour tobacco, since the leaves dry out too fast for the necessary chemical changes to takes place. To offset this, farmers close up their curing barns.

Accuracy of Forecasts

The present (i.e. initial) weather conditions determine later plant development stages, growth and yield. Therefore observations of weather elements significant for agriculture are very useful for agro-meteorological forecasting and provide a basis for more accurate predictions than those based on regular weather forecast of these .same elements, valid sometime in the future. Long- or medium-range weather-forecasting methods have not yet reached the level of accuracy desirable for operational use.

Any deficiencies in the accuracy of agrometeorological forecasting depend on (a) how well the initial observations represent regional conditions, (b) how homogenous the regional conditions (climate, soil characteristics, etc.) are, (c) how accurate the observations themselves are, and (d) how sensitive the methods are to the variations in the agrometeorological variable being forecast.

Methods of Weather Forecasting

Methods of weather forecasting can be classified into three main types. These are:

1. Synoptic Methods.
2. Statistical Methods.
3. Physical or Numerical Methods.

Synoptic forecasting entails the diagrammatical representation of weather systems through time and the extrapolation of developments of such systems into the future (Atkinson 1968). The aim in synoptic forecasting is to produce from a synoptic chart of an existing situation, a similar chan portraying the circulation at a certain time in future. Such a chart of future surface circulation of the atmosphere is known as the prebaratic or prognostic chart.

Another technique of weather forecasting under the synoptic method uses analogues Analogues are synoptic charts of actual past situations that are similar to current situations. Future developments may be forecast if such analogues are found and the evolution of past situations carefully studied The problem with the use of analogues is that there is no perfect analogue.

Statistical methods are also used in long-range weather forecasts for a month or season. The Indian Meteorological Services for example, use linear regression equations to forecast the coming of the monsoon and the amount of monsoon rains. Statistical methods are widely employed in long-range weather forecasts and in climate forecasting.

Numerical forecasting is based on the principle that the atmospheric circulation can be treated as a problem of fluid mechanics and thermodynamics. The atmosphere regarded as a fluid is varying density that is unevenly heated and subject to the spin and frictional effects of the underlying earth (Atkinson, 1968).

Nigeria Agriculture is predominantly rainfed. So, the importance of studies on weather is paramount as regards their influences on agricultural production. It should be possible to advise farmers on when to start preparing the land, plant crop species, harvest or take new stocks of livestock. This advice would usually be based on sound climatological judgment derived form proper analysis and interpretation of available weather data. It is well known that, timeless in agricultural processes determine how well the crops/livestock would use the resources that would be available before the seasons runs out. However, this timeless will to a large extent depend on how the compromise of good weather and field activities are synchronized.

The crop production practices on which weather have significant influence mainly relate to bush cleaning, land preparation, planting, transplanting and harvesting. These will now be discussed.

Bush cleaning is normally done at the end of the rainy season. In the southern Nigeria, first the forest cleared in most cases in November-January before the advent of rains in March/April in preparation for the next cropping season. However, rainfall pattern has become increasingly inconsistent the recent past. The farmer therefore need to know from agriculture meteorologists, when to start bush cleaning.

Land preparation/planting/and or transplanting are critical operations for farmers especially at the beginning of the cropping season when farmers want to catch on the early rains to go to the field. The governing principle for land preparation and planting is timeless. This is more so because there comes a time when tractor can no longer enter the field to perform any operation. When the field is too wet, the tractor can get stuck in the mud. So, the farmer should know when to commence land preparation and planting.

In northern Nigeria, where the short spells of harmattan weather is required for wheat growing, farmers should know when to sow wheat. Targetting periods and all these operations are possible only when farmers are equipped with adequate knowledge of the weather behaviour through forecasting.

Harvesting

Early harvesting followed by land preparation can in particular areas permit the planting in two cropping seasons. This is more critical to the second season cropping, particularly when the rain stops unexpectedly.

Late or delayed harvesting may lead to shattering of the pod in grain legumes such as cowpea and soybean. In situation where the field is ploughed immediately after the growing season in preparation for the next season, farmer should be able to know when to harvest so as to enable the preparation of the land, otherwise the ground gets too hard for ploughing.

Some processing operations like drying also need adequate knowledge of weather behaviour, for example, drying of cocoa beans, cassava flour, etc., will it rain or not? Will there be sunshine or not?

Pests and Diseases

High ambient temperatures and humidities provides a favourable breeding environment for internal and external parasites, fungi and disease vectors. The type of vegetation in a region influences the incidence of insect vectors of disease, therefore, climate has such quiet dramatic indirect effects on animal production.

Some of the common pests and diseases of major economic crops as affected by climatic conditions can be summarized as follows

Table 4: Crop common seasonal pests

Crop	Disease/Pest	When most prevalent
Cocoa	Blackpod disease	Wet season
Maize	Downey mildew	Wet season
Beans	Calosobruchus Maculators	Dry season
Yam	Tuber rot	Wet season
Banana	Sigatoka	Wet season
Cassava	Swollen Shoot	Dry season
Cereals	Zonocerus variegatus	Dry season

Agrometeorological Stations

According to the World Meteorological Organization (WMO) Technical Regulations. each agricultural meteorological station (AMS) belongs to one of the following categories:

a. A Principal Agricultural Meteorological Station

This is a station which provides detailed simultaneous meteorological and biological information and where research in agricultural meteorology is carried out. The instrumental facilities, range and frequency of observations, in both meteorology and biological field and the professional personnel are such that fundamental investigations into agricultural meteorological questions of interest to the countries or regions concerned can be carried out. These type of stations is not common, because of their requirements for trained professional, technical personnel and equipment.

b. An Ordinary Agricultural Meteorological Station

This is a station which provides, on a routine basis, simultaneous meteorological and biological information and may be equipped to assist in research into specific problems, in general, the programme of biological or phenological observation for research will be related to the local climate regime of the stations.

c. An Auxiliary Agricultural Meteorological Station

This is a station which provides meteorological and biological information. The meteorological information may include soil temperature, soil moisture, potential evapotranspiration, duration of vegetative wetting, detailed measurements in the every lowest layer of the atmosphere, the biological information may cover phenology, onset and spread of plant diseases, etc.

d. An Agricultural Meteorological Station for Specific Purposes

This is a station set up temporarily or permanently for the observation of one or several elements and/or of specified phenomena

Site Selection of a Station

The site of a station should be fairly level and free from obstructions. It should be sodded or covered by bahama grass or have natural cover common to the area. Weeds should be removed and grass in and around the enclosure should be frequently mown. The site should not be concrete, asphalt, or crushed rock. Accessibility to the weather station is highly essential.

Layout of Station Instruments

To minimize tampering by animals and people, it is very desirable to fence the weather station.

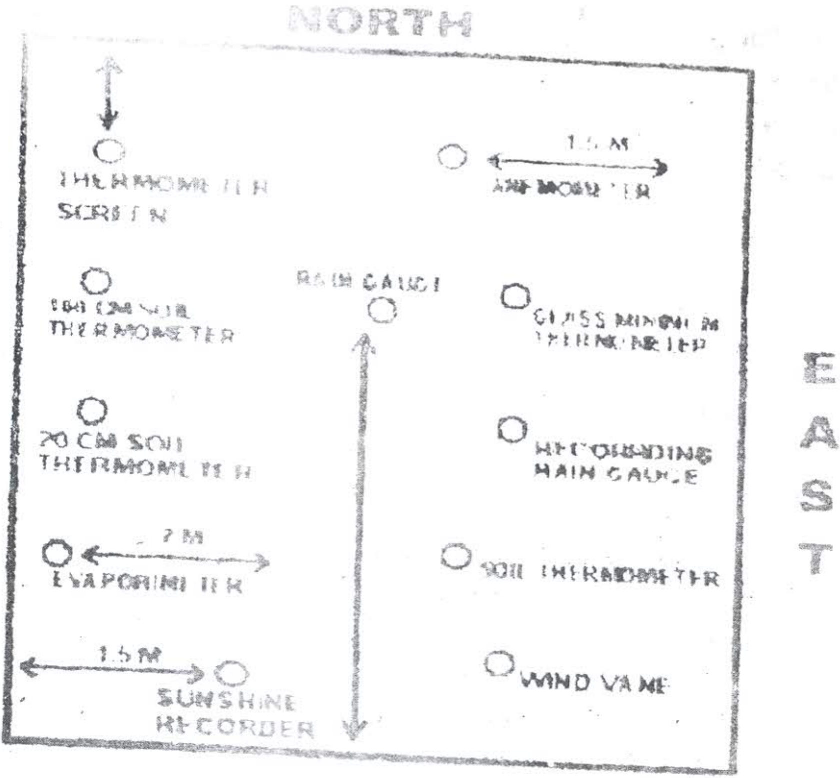


Fig. 1: Simple layout of station

Observation and Reading at Agricultural Meteorological Stations

The observing programme at an agricultural meteorological stations should include observations of some or all of the following elements characterizing the physical environment:

(a) Temperature and humidity of the air

(b) Wind.

(c) Sunshine and radiation

(d) Clouds and other water balance factors (including hail, dew, fog, soil and water evaporation, plant transpiration, run off and water table).

(e) Soil temperature and soil moisture.

These measurements refer to the programmes that should be followed for permanent or routine nation-wide observations. Nevertheless, the needs of agricultural meteorology frequently require additional specific and more restricted information as follows:

(a) Accurate physical observations on a non-routine basic (for agricultural micrometeorological research).

(b) Agricultural meso-meteorotogical surveys.

There are four standard hours that readings taken are considered important for chart making and recognized worldwide. They are called synoptic hours. They are:

(i)	Midnight	or	0000 GMT
(ii)	6 a.m	or	0600 GMT
(iii)	12 noon	or	1200 GMT
(iv)	6 p.m	or	1800 GMT

Instruments

Instruments used for measurement of weather elements should satisfy the following criteria:

(i) They should be accurate.

(ii) They should be sensitive enough for the purpose they are used for

(iii) They should be robust and durable.

(iv) They should be convenient to handle, simple and relatively cheap.

Some instruments are self-recorded. A graphic instruments and observations are usually recorded against time on graphs.

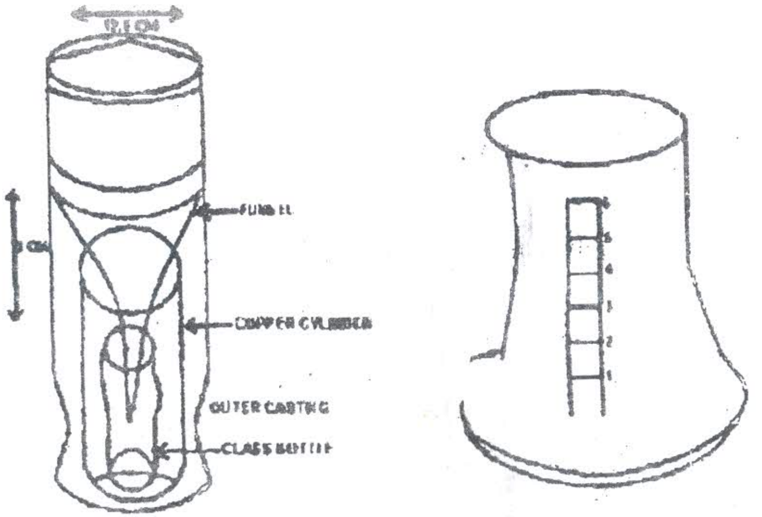
1. Measurement of Precipitation

Precipitation is defined as an aqueous deposit derived from the atmosphere. It could be in solid form such as snow, frost, glaze or liquid form such as rainfall and dew. Most of the earths precipitation is in form of rainfall (in the tropics) and snow (near the poles). Snow are melted before measuring, and conversion rate is 30 cm of snow = 2.5 of water. Rainfall is measured by the use of rain-gauge (Fig. 3a) which can be ordinary or autographic. The autographic gauge that is commonly used in Nigeria is the tilting siphon rain gauge. It works by the impact of rain drops on it over a 24 hours period by marking a chart which is dally changed. By calculating the marking on the chart, the total rainfall is recorded.

Or the non-recording gauge there are several makes in the country. The more common one consist of a copper cylinder with a metal funnel about 12.5-20 cm in diameter which leads into a glass bottle The hole in the funnel that leads down to the container is very small so that evaporation of the collected rain is minimized. The gauge is about 30 cm above the ground, and firmly fastened to avoid splashing.

It is usually sited well away from tall buildings, high trees and other object which would shelter it.

The measurement of the rainfall is done by removing the funnel. emptying the rainwater in the container into a graduate a cylinder.



(a) A Ram Gauge *(b) Ordinary Measurement cylinder*

Fig. 2

The reading should be done at eye level and to an accuracy of 0.25cm.

2. Measurement of Temperature

The instrument for measuring temperature is the thermometer. They are of many types: the maximum thermometer records the highest temperature of the day while the minimum thermometer records the lowest temperature of the day. Instantaneous thermometers record the immediate temperature of the atmosphere. Soil temperature may also be taken at various depths below the ground in which we may find that it varies with depth. During the day, the upper layer is warmer, but during the night the lower layers are warmer, this is because the lower layer retain the heat.

The thermometer is a narrow tube filled with mercury or alcohol working on the principle that mercury expands when heated and contracts when cooled. In most available thermometers, temperature are marked in either superscript F (Fahrenheit or superscript C (Centigrade)

To convert from one unit to another we can use this formula.

(a) To obtain °F = (1.8 x °C) + 32°F
e.g. Convert 20°C to °F
= (1.8 x 20°C) + 32°F = 36° + 32° = 68°F

(b) To obtain °C = (°F – 32) + 1.8
e.g. convert 59°F to °C
= (59° – 32°) + 1.8 = 27 + 1.8 = 15°C

3. Measurement of Humidity

The atmosphere acquires its moisture by evaporation and transpiration from the earths surface. This moisture is kept in vapour form within the atmosphere. A general term for the measurement of moisture is called Humidity.

(a) The ratio of actual moisture content of sample of air to that which the same volume of air will contain at the same temperature if saturated is called Relative Humidity. If Relative Humidity is 50%, it means that the air is half saturated at that temperature. If air sample A and B have Relative humidity of 50%.

(b) The actual amount of water vapour present in the air, expressed in gm^3 is called the Absolute Humidity. Absolute humidity is also called vapour density.

(c) Dew Point Temperature: The temperature at which saturation will occur if air are adiabatically cooled at constant pressure. The instrument for measuring Relative Humidity is the Hygrometer which comprises wet and dry bulb thermometers usually placed side by side in a Stevenson screen. The dry bulb is an ordinary thermometer while the wet bulb is kept wet by a wick that dips into a reservoir of distilled water

4. Measurement of Radiation

Measurement of radiation is not of much meteorological interest, however related phenomena such as insolation and duration of sunshine are of tremendous interest.

Insolation is the form by which radiation is measured the instrument used for measuring radiation is very expensive and in most cases the duration of sunshine is measured and values of radiation are estimated. Duration of sunshine is measured by Campbell-stokes sunshine recorder. These are spherical glass mounted on a pillar with a metal ball underneath with cardboard graduated in hours and minutes inside. The glass concentrate the rays falling on it to the metal which will burn the cardboard and the length of cardboard is measured which is the duration of the sunshine. On maps places with equal sunshine duration are joined by isohels.

5. Measurement of Pressure

Air has weight. It exerts a pressure on the earth surface which varies from place to place and from time to time. The instrument for measuring pressure is a barometer (Fig. 3).

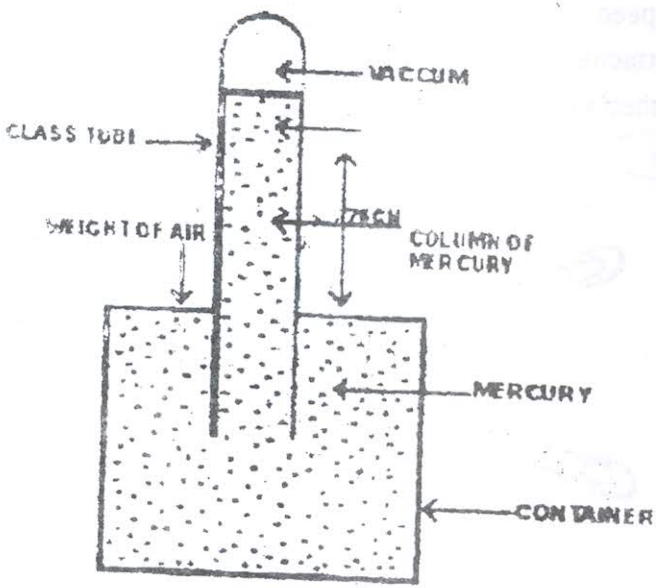


Fig. 3: An ordinary Barometer

The ordinary mercury barometer consists of a long glass tube, sealed at the upper end and open at the lower end. The lower end is inverted in a bowl of mercury whose surface is exposed to the air. Variations in the atmosphere pressure on the mercury surface are balanced by the column of mercury in the glass tube. This gives the pressure of the air and can be read off quickly from the scale on the glass lube.

6. Measurement of Wind Speed and Direction

Wind is air in motion. It has both speed and direction. It can only be felt but not seen.

The speed of wind is usually measured by an anemoter which is usually attached to the wind vane. It consists of 3 or 4 semi-circular cups attached to the ends of horizontal spokes (Fig. 4).

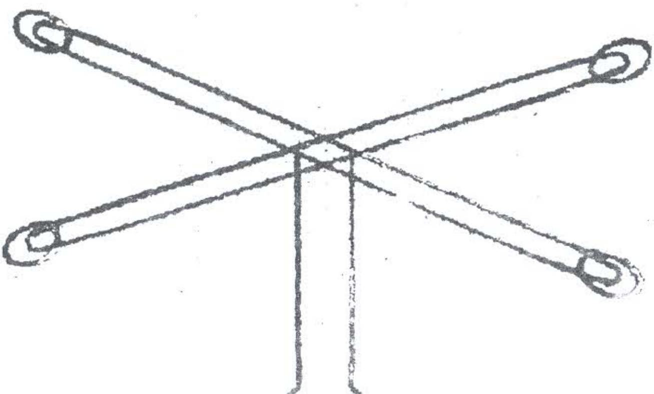


Fig. 4: An Anemometer

As the concave sides of the cups often greater resistance to the winds, the horizontal spokes will rotate moving a central rod which transmits the velocity (speed) of the wind in km/hr to an electrically operated dial.

The instrument for measuring wind direction is wind vane or weather cock (Fig. 5). It should be erected in an exposed position to get the right wind direction.

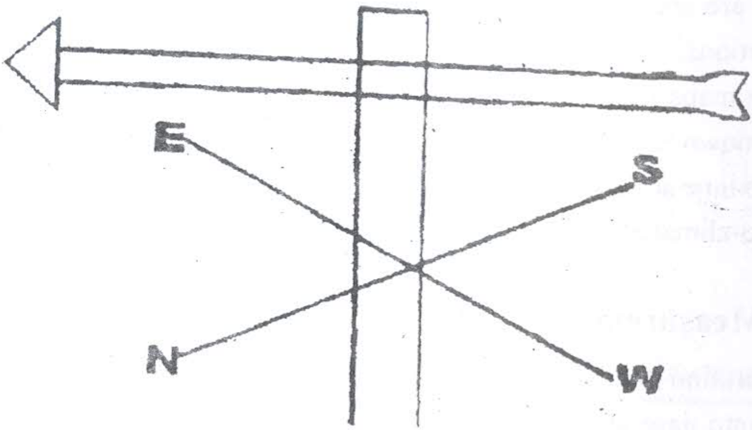


Fig. 5: A wind vane

7. Measurement of Cloud Cover

When air rises, it is cooled by expansion. After dew point has been reached, cooling leads to condensation of water vapour in the atmosphere. Tiny droplets of water vapour which are too small to fall as rain or snow will be suspended in the air and float as clouds.

The form, shape, height and movement of clouds tell us a great deal about the sky condition and the weather we are likely to experience. The amount of cloud cover In the sky is expressed in eights or okta's for example:

2/8 is $\frac{1}{4}$ covered

4/8 is $\frac{1}{2}$ covered

6/8 is $\frac{3}{4}$ covered, and

8/8 is completely overcast.

Oktas are shown on weather maps by discs, shaded in the correct proportions.

On maps places with an equal degree of cloudiness are joined by lines known as isonephs. However, because clouds vary so quickly from time to time at any particular place, isoneph maps have little significance in agro-climatology.

8. Measurement of Evaporation

Evaporation involves a change of a state of water from liquid to solid form into gaseous forms and it is the term used to describe water lost from water surface and ground surface.

Evapotranspiration is the term used to describe loss of water from vegetated surface where transpiration is of major importance.

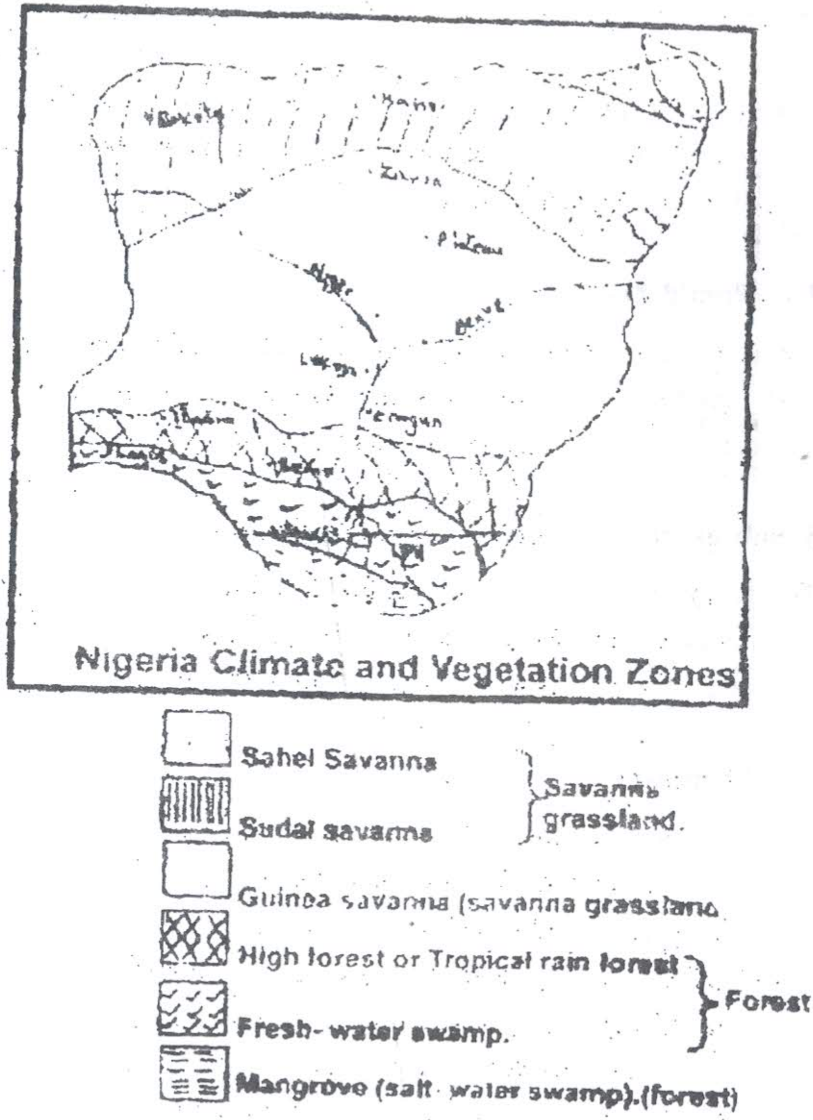
Methods of measuring evaporation include:

(a) Use of Riche 'Evaporation'.

(b) Evaporation Pans and Tanks.

The Major Agroecology Zones in Nigeria

The ecological zones in Nigeria are shown in the figure below.



Nigeria Climate and Vegetation Zones

1. Equatorial/Rain Forest Zone

It has lots of evergreen species which do not shed their leaves because of its year-round rainfall with 2000-4000 mm of annual rainfall. There is forage throughout the year but due to the density of trees, the forage species grows sparsely under the tree. There are many ectoparasites and diseases in this zone, e.g. Trypanosomiasis. The zone is good for cash crop production – oil palm, rubber, cocoa.

2. Humid Zone

In this zone plants growth is very vigorous and annual rainfall exceeds 1000 mm. Forage availability is seasonal. Good for root and tuber crop production. Cereals can also be grown in this zone.

3. Sub-humid Zone (Derived Savanna and Guinea Savanna)

This zone has many species of grasses and fewer trees. The area is good for nomadic rearing. Cereals and grain legumes can be profitably cultivated in this zone. Annual rainfall is 600-1000 mm.

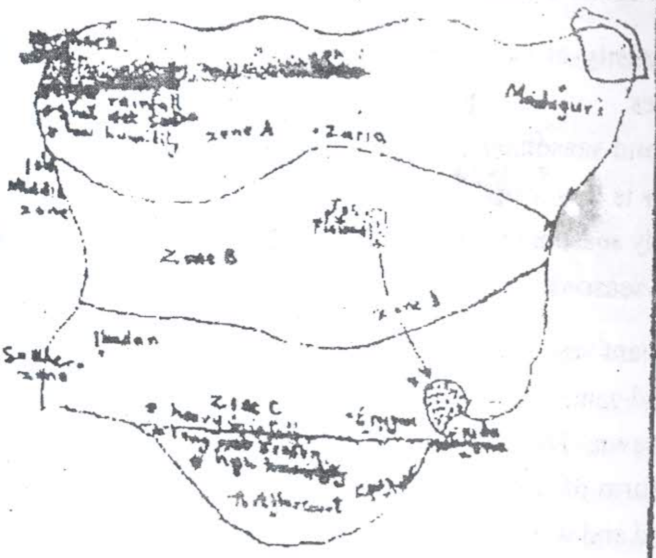
4. Semi-arid Zone

This has short rainy season, low humidity, there is open sky, annual rainfall less than 600 mm. The area is best suited for animal husbandry such as sheep, goats and camel but not cattle; the area is called thorn bush and is found in Kano and Sokoto states. The common problem is that of feed and water. To survive animals feed on low quality feed and very little water and therefore experience a lot of stress. Short duration cereals and grain legume (cowpea) crops can be cultivated in this zone.

5. **Arid Zone**

In this area, there is hardly any rainfall, so plants are ephemeral (available only when there is moisture).

Livestock and Crop Ecological Zones in Nigeria



Nigeria Crop Ecological Zones.

Zone A	–	*Northern*
Zone B	–	*Middle zone*
Zone C	–	*Southern zone*
Zone D	–	*High altitude zone*

The domestic livestock and food crop zones can be divided into four zones:

Zone A

This is the modern zone comprise the Sudan and Sahel savanna regions. This climatic region is characterized by the following:

i. High intensity of solar radiation due to the dry atmosphere and clear skies.
ii. Diurnal and seasonal temperature fluctuations are very wide.
iii. Humidity is low from most of the year.
iv. Extremely seasonal conditions with relatively low rainfall and very long dry seasons.

The dominant vegetations are tall grasses and are Acacia trees. Grain crops, irrigated cane sugar, market garden crops around large towns are commonly grown. This zone is more suited for livestock production than for any form of agriculture. The major constraints to productivity are lack of feed and water with consequent nutritional and climatic stress. Internal and external parasite can be controlled with relative ease, but the control of epizootic diseases is more difficult. Examples of animals found in this climatic condition are long legged sheep and goats, Red boraro, White Fulani cattles, carmel, etc.

Zone B

This is the guinea and derived savanna of middle belt, which is a belt o. deciduous trees mixed with grasses. The dry season varies from about

80 days in the Southern half to about 140 days in the Northern half. Wet season last for about 6-8 months. Characteristics of this climate are the following:

i. The climate is more seasonal with a relatively short rainy seasons.
ii. Temperature variations are much wider with hotter dry season due to a high intensity of radiation combine with a longer day.
iii. The vegetation of savanna area is an open grassland with various combinations of high, medium and low/trees and short grasses.

Generically the climatic conditions, i.e. temperature, rainfall, relative humidity, radiation and so on are intermediate values between the Northern and Southern zones. This is a mixed crop zones. The seed culture cultivation which characterizes. Savannah farming is based on the highly productive combination of cereals, leguminous, grains, cotton, roots and tubers and a host of other crops.

The dominant domestic live stocks are some indigenous breed, cross breeds cattles (such as zebu, muturu), N'dama cattle, white Fulani and short legged sheep and goats. Climatic stress on livestock is less intense than in the Northern zone, but forage production is very seasonal and nutritional stress can be a major problem.

Zone C

Which is the Southern region composing mangrove and tropical rain forest areas. The forests contains evergreen trees of different types with no grass except in open patches were it grows as secondary vegetation.

The characteristics of the forest zones are the constant heat, rainfall and humidity. Solar radiation and temperature are usually low. It is not usual for rainfall to be evenly distributed throughout the year, in some areas one season is slightly wetter, while in others, there are two wetter seasons.

The farming systems of the forest zone is considered to be ecologically more balance than those of the savannah. This is partially true of the food production system. In this zone, vegeculture farming, which is predominant and characterized by vegetables, roots and root crops with cereals playing a secondary roles in cultivation.

In the forest zone, the common domestic livestock are the short legged sheep and goats and N'dama cattles which are resistance to Trypanozomiasis diseases that caused by tse-tse fly. Climatic stress on domestic livestock is considerable in this region and generally indigenous domestic breeds of livestock are not numerous. The climate favours plant grown so that forage could be plentiful and available all year round. Internal and external parasites are favoured by the climate and animal products rapidly deteriorate when stored.

Zone D

This is the high altitude or montanc region which covers a very considerable area of land in the tropics. In Nigeria, the altitude zones are found in Jos Plateau and Mambila Plateau. These zones are cooled with lower mean, annual temperature and atmospheric pressure. Rainfall is usually greater at higher altitude and there are more cloudy days.

The decrease in mean annual temperature and increase in diurnal temperature variation and a higher rainfall are likely to assist in the production of temperate and sub-tropical crops at top altitudes and in the improvement of livestock productivity.

Generally, the crop ecological zones in Nigeria can be summarized as follows:

Table 5: Ecological zones and crop distribution

Sociological Region	**States**	**Ecological Crop Specialization**
1. Sudan Savannah	Sokoto, Kaduna, Bauchi, Borno.	Cerelas, Grains, Legumes, L/S Vegetable Seeds and Nuts
2. Guinea Savannah	Niger, Kaduna, Benue, Plateau, Kwara, Oyo North	Cereals, Grain, Legumes, Root Crop, Tubers, Seed nuts, Livestock
3. Forest Savannah	Kwara, Delta, Edo, Anambra (North)	Root Crops, Tubers, Cereals, Vegetables, Grain, Legumes
4. Tropical Rainforest	Oyo, Ogun, Ondo, Edo, Anambra, Imo, Cross River (North)	Tree crop, Root crops, Vegetables, Fruits, Grain, Legumes, Pisciculture, Poultry, Piggery

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