UNIT 1 FUNDAMENTALS OF ECOLOGY

Contents

Learning Objectives

Once you have studied this unit, you should be able to:

- define human ecology;
- explain the concepts and methods of studying ecology;
- describe the different ecosystems; and
- indicate the different acclamatory adjustments.

1.1 INTRODUCTION

Ecology is the scientific study of the relationships between living organisms and their environment. General ecology contains a set of concepts and principles derived from evolutionary theory that are used to explain the adaptation and evolution of animal and plant populations and communities in response to the varying conditions of resource availability presented by diverse, dynamic and changing environments. These concepts and principles pertain to other aspects such as energy flow, feeding relations, resource attainment, behaviours, materials cycles, population dynamics, ecosystem properties, population interactions and community organisation (Abruzzi, 2003).

1.2 BASIC CONCEPTS OF ECOLOGY

- Diversity of Living Things: Plants and animals exist in great variety of forms and can be classified by their structure and behaviour.
- Interdependency of Living Things: All living things rely on and are affected by other living organisms and non-living components of their environments.
- Resource and Energy Cycles: The interactions among the members of an ecological community involve the exchange of energy and resources in continual cycles.
- Nested Systems: Networks of interdependent organisms exist within other larger networks (community to bio-sphere).
- Dynamic Balance: Each ecological network regulates and organises itself by maintaining a state of dynamic balance characterised by continual fluctuations.

1.3 DEVELOPMENT OF HUMAN ECOLOGY

Human ecology is the systematic application of ecological concepts, principles, theory and research methods to study the human populations and communities. Human ecology examines the way human-resource relationships affect the human adaptation to diverse type of ecosystem such as desert, arctic, forest and others (Abruzzi, 2003). It also scrutinises the role that resource requirements needed to withstand a population play in shaping local differences in behaviour, residential distribution, household composition and structure, community, social and political organisations, inter-population relationships and other social behaviour. Human ecology also examines contemporary ecological concerns that results from population growth and industrial development (Abruzzi, 2003).

It has been known for a long time that human survivability is determined by environment. Several attempts made to understand responses of organism to critical environment can be traced back to antiquity. But the idea of contemporary human ecology has been expressed since the 18th century by Adam Smith, Malthus, Darwin and Hoppes. It is believed that the term Human Ecology was first used in geography by Huntington (1916) and later it was adopted in Sociology (1921). The history of human ecology in sociology is complex. In fact concepts of human ecology in sociology evolved from the classical concepts of competition. The social area analysis focused on the population structure (organisation) in relation to the total environment. In other words, it is the ecological analysis of social organisation. Since human ecology deals with the role of the environment in the origin and existence of man, it has engrossed many other disciplines including anthropology and medicine.

> Thus human ecology can be defined as the study of spatial and temporal relations of human beings affected by selective, distributive and accommodating forces of the environment. The definition is well adapted in sociology and other sciences.

The anthropological perspective of human ecology deals with the question "how man copes with his environment". Since human relations are not mainly biological therefore the development of culture context is necessary. Culture cannot be

understood in isolation from the environment in which it evolved. Contemporarily, social anthropology concern with the issues related to the exploitation of the environment, utilisation of resources and energy transformation in a cultural setting.

On the other hand economists view ecology as subset of economy. The economy is disrupting and destroying earth's natural system. An environmentally sustainable economy requires that the principles of ecology establish the framework for the formulation of economic policy (Brown, 2001).

It was on the basis of Malthus's concept that Darwin thought of 'struggle for existence' which result into balance between the environmental state and social activity of humans. It emphasizes on the importance of exchange system among individuals, populations and species. Theoretically, succession corresponds to accumulative increase in the human population. Practically the problem of limited natural resources is the real connecting link. This would lead to minimize consumption by consumers and to maximize the benefits by producers. It may lead to a state of balance through mutual succession. However, it has been shown that neglecting ecological and economical laws along with lack of coordination of activities, results in the destruction of natural environment and deterioration of living conditions for humans. All these ideas are typical of the initial stage of human ecology which dominated for about half century.

Human ecology in the beginning had a monodisciplinary approach. A review of the trends in human ecology defines the scope of ecological concepts which includes basic processes like the kind of interaction between living organisms, levels of integration and functional relationship. Human ecology distinctly focuses on the interactions because organisms cannot live in isolation. Such interactions have its own dynamic structural and functional dimension. It determines the role of Homo sapiens with his own and other species. Thus the subject matter of human ecology includes systems of interactions among individuals and interrelations with the environment, niche, habitat and the ecosystem. Environment may act at three level of biological organisation: individual, population and community. Population refers to group of individuals of same species living in a given territory and is integrated by common culture. In other words human ecology deals with the matrix of nature in which each object has its own place and function.

1.4 METHODS OF STUDYING HUMAN ECOLOGY

Human ecology utilises various methods acquired from other classical disciplines that it synthesizes and incorporates. However, the methodology of human ecology is neither exclusively an analysis of individual objects nor synthesis of the problems.

The basic methods are the observation and recording of the state of nature and society which instinctively recognises the interrelationships between organisms and their environment. Monitoring is carried out at the level of the organisms, populations and environment. For instance, the inferences in epidemiology when implicit as a part of human ecology are based on healthy people rather than unhealthy people, and on populations rather than individuals. The characterisation of an event in the context of the environmental conditions provides opportunity for estimating what is the average, normal and regular.

In Anthropology, monitoring consists of recording individual responses to similar environmental conditions and intra population differences. Thus the specific response of different races or ethnic groups remains in the field of classical anthropology and the old approaches have been modernised in the light of the concepts of major genes or complex linked genes or populations.

The monitoring of the state of the environment is extremely complex, as the number of environmental factors affecting humans is almost unlimited. The physical factors include climate, nutrition, pollution of air, water, food and noise. In addition, social and economic factors indicating living conditions are also considered.

1.5 OCCURRENCE OF ADAPTATION AT DIFFERENT LEVELS

- Genetic adaptation, the evolution of advantageous characteristics,
- Developmental adaptation (plasticity),
- Long term acclimatisation acquired over the years but reversible under environmental change,
- Seasonal acclimatisation, which reverses itself during the annual cycle, and
- Short term acclimatisation, it manifests in daily or irregular responses to conditions.

1.6 DIFFERENT ECO SYSTEMS

- Deserts and dry lands
- Tropical forests
- Tropical scrubs
- Tropical grass land (Savanna)
- Temperate forests
- Mediterranean scrubs
- Temperate grass lands – short grass
- Boreal lands – coniferous forests
- Polar lands and Tundra
- Mountain habitats

1.7 HUMAN ADAPTABILITY: ADJUSTMENTS TO DIFFERENT ECO SYSTEMS

Human populations occupy a wide range of habitats, from the icy wastelands of the Arctic to the equatorial deserts of North Africa. While most animal species have become adapted to relatively narrow niches, humans have survived in far-ranging and highly diverse niches.

For the sake of discussion, two mechanisms of human adaptability may be differentiated: adaptation and adjustment. Adaptation refers to changes in gene

frequencies resulting from selective pressures exerted by environmental factors on a population. Human species is able to adjust to a wide variety of environmental conditions without undergoing major micro evolutionary changes. Such changes are termed adjustments.

However, it must be emphasised that the potentials for such non genetic adjustments are the end products of the evolutionary process. One of the major problems faced by researchers in this area is the determination of the relative importance of genetic and non genetic forms of adaptability, which we have termed here adaptation and adjustment, respectively. In fact, in most situations, both probably operate together.

1.8 BEHAVIOURAL ADJUSTMENTS

Humans are biologically tropical, better equipped to survive in hot rather than cold climate. They do not possess thick layers of subcutaneous fat or thick fur which otherwise provide insulation to body against cold. Thus, a substantial portion of cold adaptation in this hostile climate is behavioural. Behavioural adjustments are cultural responses of humans to cope with environmental stresses. These adjustments are not inherited from one generation to the other. Hence, behavioural adjustment must be made by each generation as newborn infants learn their culture. It includes seeking shelter, using protective clothing, improving housing and other technologies.

1.9 HUMAN HOUSING

A clear example of how culture permits people to survive in stressful habitats is housing. The oldest known human habitation structure was discovered at Olduvai Gorge, a site in east Africa that has yielded important fossil and archaeological evidence of human evolution. This structure, almost 2 million years old, consists of stones arranged in a rough circle about 360 to 420 centimeters (12 to 14 feet) in diameter. These stones most likely supported a brush structure similar to those still being built in the same area now-a-days.

Today, we are impressed by the tremendous variety of habitation structures. House form is a reflection of many variables, including the size of the household unit and availability of raw materials. It also reflects socio-cultural features such as religious beliefs, family and clan structure, social organisation, way of gaining a livelihood and social relations between individuals.

Environment plays a major role in the development of house type; its significance lies in areas under environmental stress, e.g. Igloo of the Eskimo. The igloo consists of a dome-shaped structure (Romans and Etruscans were not the only people to develop the arch) connected to the outside by a tunnel. It is made up of snow, which is an excellent insulator as it traps the air within itself. Heat is produced by a small seal-oil lamp within the structure. This melts the snow slightly during the day and refreezes at night, forming an icy reflective layer on the inner side. The reflective layers accompanied with the dome structure serve to reflect the heat throughout the igloo. Relatively little heat is lost to the outside since the dome shape minimizes the surface area from which heat can radiate. A long tunnel way helps to warm the air gradually as one enters the structure, and also block the entry of wind into the habitation area.

Habitation structure is one aspect of a human technology. There are other aspects of technology also which enable human to survive in stressful environments including, for short periods of time, outer space.

1.10 SOCIAL RESPONSE TO HARSH ENVIRONMENTS

In addition behavioural adaptation humans adjust their social organisation to their environments. For instance, Eskimos, living in extremely harsh environments use a number of strategies to reduce environmental stress. Anthropologist Knud Rasmussen during a trip to King William Island discovered that in a sample of eighteen marriages, 38 out of 96 female infants born were put to death. This strategy of female infanticide is practiced by the Netsilik Eskimos to increase the ratio of males to females. Such numerical balance between the sexes reduces stress of male hunters to support unproductive members of society. Also, in the harsh northern environments females are considered to have less survivability than males. People in these habitats also practice suicide, invalidicide, and senilicide in crisis situations. Infanticide is usually an extreme response to extreme conditions, although it has been practiced in a wide variety of human societies. All human societies in some way adjust economic, political, social, religious, and other aspects of their social systems to the environmental conditions. This socio-cultural flexibility, in part, allows humans to exist in so many habitats.

1.11 ACCLAMATORY ADJUSTMENTS

Acclamatory refers to reversible physiological adjustments to environmental stress. Instances of acclimatisation have been observed in three environments: the arctic, the desert, and high altitudes.

The Arctic, is perhaps one of the more stressful habitats occupied by humans. It was inhabited relatively late in human prehistory, and gradually human became acclimatised to the climate.

The primary environmental stress in the arctic is very low temperatures. Normal human core body temperature is 37^0C (98.6^0F). When the core temperature falls below 34.4^0C (94^0F), hypothermia occurs and at 29.4^0C (85^0F), temperature regulating ability of the hypothalamus in the brain is impaired resulting in death. Cold exposure which leads to freezing of the tissues causes frostbite. It usually occurs in exposed area of the body parts such as fingers, toes, and earlobes.

Perhaps the most important acclamatory adjustment is increase in the basal metabolic rate. The basal metabolic rate refers to minimum amount of energy required by the body to maintain body processes necessary for life and is measured as the amount of heat produced by the body per unit time at rest. This increase can be as much as 25 per cent in adults and 170 per cent in infants. The increased basal metabolic rate results in the production of additional body heat but it requires that individuals' consumption of food, high in nutritive value. The native diet in these regions consists largely of protein and fat, which provides the required types of food. People living in arctic conditions for long periods of time are less affected by the cold.

1.12 ACCLIMATIZATION AND EXTREME COLD

The nude human body at rest begins to combat against hypothermia at the air temperature of approximately 31^0C (87.8°F). This temperature is known as the critical temperature. Consequently, the individual reduces the loss of heat from body to the environment and produces heat to increase body temperature.

A major mechanism for conserving heat is peripheral vasoconstriction. Constriction of the capillaries below the skin prevents warm blood from reaching to the surface of the skin, where much of the body's heat would be lost to the air. Additional body heat is produced voluntarily by exercise and involuntarily by shivering. A high degree of muscle activity yields heat. However, exercise can be performed only for limited periods of time depending on the physical fitness of an individual. More important is shivering. Low body temperature causes the hypothalamus of the brain to stimulate increased muscle tone, which results in shivering. At the peak of shivering, the increased muscle metabolism can increase the rate of heat production five times than that of the normal.

1.13 MECHANISMS OF HEAT LOSS

Humans survive more efficiently in the hot and arid climates than in the arctic regions of the world. This is generally due to lack or scant presence of body hair, which otherwise act as insulating material. Also, humans have a greater capacity to sweat than any other mammal.

In the hot climate as in desert it is essential for the human body needs to get rid of excess heat that is being absorbed by the body. In general, heat can be lost in any one of the four ways:

Conduction: It occurs when heat move from a warmer object to a cooler object by direct contact. Thus, if you stand barefoot on a hot pavement, the soles of your feet will heat to an uncomfortable temperature because of conduction.

Convection: Heat is transferred from warmer to surrounding cooler fluid, either liquid or air. Returning to our hot pavement, the heat from the pavement is transferred to the cooler air. As the air warms up, it expands, and expanding air rises above. Cooler air flows down to replace it. Thus currents set up in the air carry away heat.

Radiation: Heat is given off by an object as electromagnetic waves of a characteristic wavelength. Other forms of electromagnetic waves include visible light, ultraviolet radiation, and radio waves.

Evaporation: The heat is lost from the skin by evaporation of sweat as when water converts into vapor; a certain amount of energy is required in the form of heat. Therefore, when you get out of the swimming pool on a warm day, you feel cool because some of your body heat will be used up in the process of transforming the pool water left on your skin into water vapor.

Human body gets rid of excess heat in warm climates by all four methods, but at air temperatures above 35°C (95°F) evaporation is much efficient. Therefore,

sweating is the most important method of controlling body temperature in warm climates. Humans have a high density of sweat glands over their bodies, although the number per square centimeter does differ in different parts of the body. An adult male averaged 206 sweat glands per square centimeter on the hand and 69 on the trunk; these numbers are greater than in any other mammal. The number of sweat glands does not differ significantly between desert- and non desert-dwelling populations.

1.14 ACCLIMATIZATION TO DESERT HABITATS

Acclimatising to desert life is not well understood, but within a few weeks of exposure to hot and arid climates individuals acquire some adjustments. Meanwhile, the sweat glands become sensitive and produce sweat. Sweat also contains salts, and much sodium is lost through sweating. With time, the concentration of salt in sweat is reduced, although the relatively high salt concentrations found in desert water easily compensate for salt loss. Urine volume also reduces, thus conserve water in the body. This same acclimatisation ability has been found in peoples from all parts of the world, so it appears to represent a basic ability of the human species instead of an adaptation of certain populations.

In addition, there are short-term reactions to increased heat loads. The physiological response involves vasodilatation of the capillaries under the skin. In vasodilatation, the bloodstream brings heat to the body surface, and is lost to the environment by conduction, convection, radiation or evaporation. Acclimatisation escalates the ability to work longer and more efficiently in hot climates.

People also adopt various behavioural adjustments to the hot climates. In desert regions people tend to reduce physical activity during the heat of the day, thereby reducing heat production by the body. Also, assume a relaxed body posture that increases the surface area of the body from which sweat may evaporate.

Adjustment to hot climates is aided by cultural factors such as clothing and shelter. Desert dwellers cover their bodies to protect the skin from ultraviolet radiation as well as to reduce the amount of heat from the sun which otherwise is absorbed by the body. Such clothing is designed to permit the free flow of air between the clothing and the body. This airflow is necessary to carry off the water vapor formed by the evaporation of sweat.

Interestingly, the color of clothing does not seem to make much difference in hot climates. An experiment conducted on black and white Bedouin robes shows that black robes gain about 2 ½ times as much heat as white robes. Yet the temperature of the skin under black robes is the same as that under white robes. Most likely, the greater convection currents between the black robe and the skin are responsible for this phenomenon.

In addition to physiological and cultural factors, psychological elements appear to play major roles in adjustments to intense heat. Some Europeans adapt quickly to desert life, others never seem to adjust to changing conditions of life. In an emergency, the European, anxious to do something, is active, gets hotter and uses up his limited supply of water. In contrast, the nomad, secure in the will of Allah, tends to relax and behave more calmly.

1.15 ADJUSTMENTS TO HIGH ALTITUDES

When a person travels into the mountains on vacation, he or she may experience high-altitude or mountain sickness. The symptoms include shortness of breath, respiratory distress, physical and mental fatigue, rapid pulse rate, interrupted sleep, and headaches intensified by activity. Slight digestive disorders and in some cases a marked loss of weight may also occur. In other cases the individual may feel dyspnea, nausea, and vomiting. Although most people eventually become acclimatised to high altitude, many do not. They will continue to suffer from chronic mountain sickness as long as they remain at high altitude.

Less than 1 percent of the world's population lives at high altitude, yet these populations are of great interest to anthropologists. High-altitude environments exert multiple-stress on human population. These stresses include low oxygen pressure, intense solar radiation, cold and dry wind, rough terrain, and relatively limited plant and animal life.

High-Altitude Hypoxia: As already known, the arctic and desert environments lay emphasis on culture as an efficient means of adjustment to stressful environments. Culture plays a pivotal role in high altitudes as well except in hypoxia. Hypoxia refers to low oxygen pressure, which occurs when relatively low levels of oxygen are supplied to the tissues of the body. Hypoxia may result from disease as well as environmental factors. High-altitude hypoxia represents one of the few environmental stresses that cannot be adjusted to by some cultural means. Although the use of oxygen tanks provides limited adjustment, this solution is available only in high-technology cultures and is practical only for short periods of time.

The earth's atmosphere exerts an average of 1 kilograms of pressure on every square centimeter (14.7 pounds per square inch) of surface area at sea level. This pressure is able to raise a column of mercury (which has the chemical symbol Hg) in a closed tube to an average height of 760 millimeters (29.92 inches). Therefore, we say that the average air pressure at sea level is 760 millimeters (29.92 inches) of mercury.

The atmosphere is composed of many gases and approximately 21 per cent of air is oxygen. The portion of the total atmospheric pressure due to oxygen is the partial pressure of oxygen, which measures 159 millimeters (6.26 inches) of mercury at sea level. At altitude, the partial pressure of oxygen decreases. At 4500 meters (14,765 feet) the partial pressure of oxygen is decreased by as much as 40 per cent, thus substantially reducing the amount of oxygen that can reach the tissues of the body.

The oxygen enters into the bloodstream via approximately 300 million alveoli of the lungs. The alveoli are small air sacs that are richly endowed with blood capillaries. Although the partial pressure of oxygen at sea level is 159 millimeters (6.26 inches) of mercury, the partial pressure of oxygen in the alveoli at sea level is 104 millimeters (4.16 inches) of mercury. This is due to the fact that not all the air in the lungs is replaced with each breath. The partial pressure of oxygen in the arteries and capillaries of the circulatory system is 95 millimeters (3.80 inches) of mercury, and in the tissues it is 40 millimeters (1.60 inches) of mercury.

As gas moves from higher to lower partial pressure, oxygen diffuses from the blood to the tissues. At high altitudes, the partial pressure of oxygen in the blood would be too low to permit diffusion of oxygen from the blood to the tissues unless certain physiological adjustments take place. These adjustments make high-altitude environments a possible human habitation.

When an individual inhabiting near sea level migrates to high mountains, he or she will probably notice an increase in the breathing rate, which may reach twice that of at sea level. The increased breathing rate brings more oxygen in the alveoli, and increases the partial pressure of oxygen in the blood.

This hyperventilation, or increased breathing rate, eventually reduces, to normal level as the person becomes acclimatised to the high altitude.

About 97 per cent of the oxygen in the blood is carried in chemical combinations with hemoglobin in the red blood cells; the other 3 per cent is dissolved in the plasma and may be ignored. The chemical association of oxygen and hemoglobin is loose and reversible. When the partial pressure of oxygen in the alveoli of the lungs is higher than that of blood, oxygen diffuses into blood vessels and combines with hemoglobin. When the hemoglobin molecule reaches the capillaries, oxygen diffuses into the cells where the partial pressure of oxygen is lower than blood.

When the blood leaves the lungs, the hemoglobin is about 97 percent saturated with oxygen. Some of the oxygen is then utilised by the tissues. As a result, the hemoglobin in the veins returning to the heart and lungs is only about 70 per cent saturated. At high altitudes, several factors operate to alter these percentages, thereby permitting the hemoglobin molecules to carry more oxygen to the tissues. As a result of hyperventilation, the concentration of carbon dioxide in the blood is decreased, thus altering the blood chemistry in a way to increase the amount of oxygen carried in the blood.

Other acclamatory changes include increase in the number of blood capillaries, thereby improves the diffusion of oxygen by shortening the distance between the cell and capillary. Increased number of red blood cells enhances oxygen carrying capacity due to elevated amount of hemoglobin. Therefore, although the partial pressure of oxygen as it enters the lungs differs at sea level and at high altitude, the partial pressure of oxygen in the blood is not very different by the time it reaches the capillaries. Many changes also occur at the cellular level that enables cells to carry out their metabolic functions at lower oxygen levels.

While the factors discussed above and many more, permit humans to live at high altitudes, people cannot overcome all the negative biological effects of high-altitude. For example, high altitude affects reproduction; birth weights are lower and infant mortality is higher. In addition, the growth and development of children are slower. A good example of developmental adjustment is found among the children of high altitudes. During growth the native develops greater chest circumferences than do those growing up at lower elevations.

1.16 GENETIC AND NON-GENETIC FACTORS IN CLIMATIC ADJUSTMENTS

Twin studies indicate that variations in body-shape, size, fat deposition, growth pattern, skeletal and physiological maturation are all determined by genetic constitution to a larger extent than by totally environmental factors. Population

differences rest undoubtedly on distinct genotypes or multifactorial recombination, e.g. nose-shape or the ratio of limb length to trunk length remains unaffected by change in environment. The situation is, however, more complicated, because of the action of climate on body-weight and growth rate of non-indigenous peoples. Europeans in the tropics possess body-weights lower on the average than those in colder environments.

1.17 SUMMARY

In physical anthropology, ecological study plays an important role as always human beings have been studied in relation to their environment. The ecological concepts and principles permit a better understanding of the individual. Ecology is systematically studied by applying different methods and techniques. The subject matter include: genetic adaptation, developmental adaptation, seasonal acclimatisation, etc. Human beings have been distributed in different ecosystems namely, tropical, subtropical, temperate, semi-temperate and artic regions and have adjusted to these ecosystems in order to survive in a successful manner. Bodily and physiological adaptation has enhanced tolerance to extremes cold and hot climates. Behavioural adjustments are in coordination with cultural characteristics of a particular community or populations. At the same time, role of the genetic and non-genetic facts in climatic adjustments cannot be ruled out.

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Suggested Reading

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Sample Questions

1) Explain the different basic concepts of ecological studies.
2) Discuss the different methods of studying human ecology.
3) Write an explanatory note on behavioural adjustments in ecological studies.
4) Briefly explain the role of genetic and non-genetic factors in climatic adjustments.