UNIT 8 EFFECTS OF AGRICULTURE ON HUMAN ENVIRONMENT

Structure

8.1 INTRODUCTION

In Unit 7 you have read about overexploitation of natural resources which mainly results into deforestation, desertification and loss of wildlife. We also touched upon the effects of intensive agriculture on physical and biological environments. Intensive agriculture manifests itself in the form of increased desertification, rise in water table and soil erosion. These problems will be dealt with in greater detail here. This unit also discusses effects of overgrazing on the human environment. Use of pesticides, insecticides and herbicides is a comparatively recent development. You may be interested to know, how these chemicals have brought about unprecedented changes in the environment and altered the natural state of the environment we live in.

Objectives

After reading this unit, you will be able to :

- distinguish between modern and traditional agricultural practices
- enumerate the kinds of agricultural societies which prevailed in human history and the environmental consequences of their agricultural practices
- discuss how the use of chemical fertilisers and plant protection chemicals has affected the quality of environment
- outline the chain of events by which modern agricultural practices affect human health
- explain how overgrazing has produced environmental degradation, and
- correlate the observed environmental degradation with threats to continued human survival.

8.2 EVOLUTION OF THE INDUCED AGROECOSYSTEMS

Before you start reading about the changes in human environment caused by agriculture, we would like you to know about the history of land use patterns during different periods of

evolution of human society, so that later, you will be able to correlate and compare the kinds of damage caused by various kinds of agricultural practices. During this evolution, the modes of resource use and patterns of energy flow in agricultural practices took various shapes. This transformation from traditional to modern agriculture has brought in its wake a kind of apathy of human mind to his environs and an utter disregard for the carrying capacity of the finite resources and a habit of inflicting subtle and sometimes not so subtle, but always irreversible changes in his surroundings. Agriculture has evolved from being less energy-intensive to more energy-intensive, and from less productive to more productive. In the process, however, man chose the varieties of crops which though high yielding, were more prone to the onset of epidemic diseases. Extensive use of pesticides and insecticides also posed an ever increasing potential danger.

8.2.1 History of Land Use Pattern

The sequence of events which followed in evolution of induced agroecosystems is outlined in Figure 8.1. You will notice that these shifts in agricultural practices have brought in significant changes in land use patterns, health of resources, quantum and direction of material flow, food surpluses and livelihood patterns.

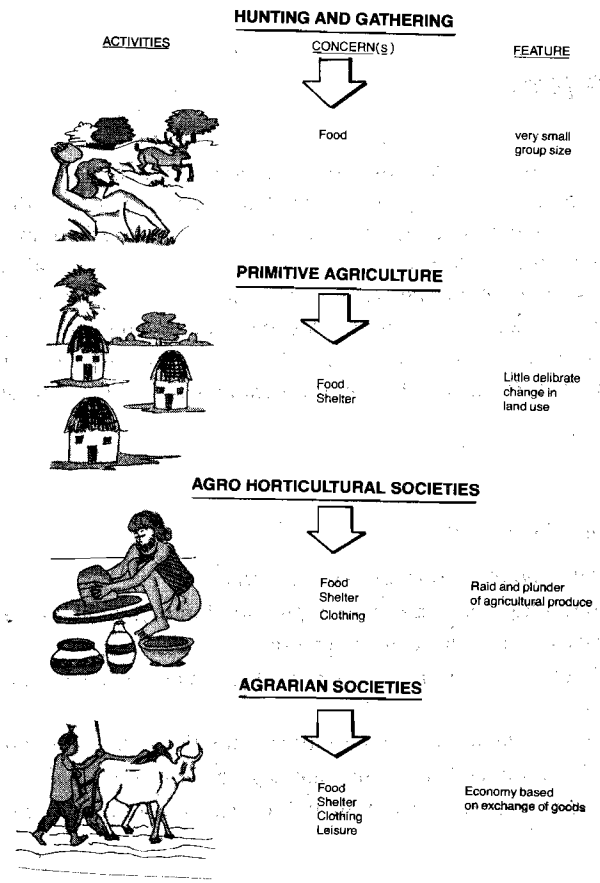

Fig. 8.1: Evolution of induced Agroecosystems

Hunting and gathering man : The early human beings depended on hunting and gathering (HAG) food for their existence. It was a kind of animal existence, but unlike animals human beings used stones and sticks. The supply of edible products was restricted. Because of limited production, the group size in HAG societies was small usually restricted to children and grand children of one family. When food supply diminished, people had to move. There were no surpluses. The regenerative capacity of the ecosystem took care of the productivity.

Primitive agricultural societies: Man's quest for stable source of living led to the emergence of first agricultural societies, about 10,000 years ago. Man started to settle sometimes and develop semi-permanent habitations. These were primitive agricultural societies (PAS). They knew only simple methods of fertility regeneration such as burning of wooden logs to increase mineral fertilisation and augmenting water to plants by artificial flooding. This gave them a degree of permanence as long as the possibility of the recurring use of the same piece of land existed. These groups were two to five times larger than HAG groups, had small economic surpluses, constructed huts made of leaf and mud and practised several rituals connected with land fertility.

Agro-horticultural societies : Then evolved the agro-horticultural societies (AHS). They used metal tools, incorporated plant and animal residues for fertilisation and practised application of water for irrigation. They learnt to acquire large number of plants from other locations and broaden their production base. According to some authorities the AHS of Africa were growing nine tenths of the known cultivated plants. This diversity helped them utilise plant products for a longer period of the year. The population density of AHS was about 200 times that of HAG societies. At this time the subjugation of one society by the other, raid and plunder of agricultural produce by mightier groups and similar lawless practices were prevalent. This led to the establishment of small fiefdoms and urban systems.

Agrarian societies : Finally agrarian societies (AS) superceded the agro-horticultural societies. Their leisures and surpluses were large. In fertile valleys, river banks and plains these centred around settled cultivation. They tilled the land and built permanent settlements around agricultural fields. In the hills, semi-arid and arid areas and other ecologically fragile regions, their activities centred around raising livestock, maintaining fisheries and management of pastures. In fertile plains of river banks economic growth brought in plantation crops and cash crops, which resulted in general depletion of natural resources. In the hills, too, devastation caused by pasturage was excessive. In both the cases non-essential consumption needs multiplied, which could only be met with by import of raw materials from other areas.

The society here had divided itself into agrarian or food-producing sector and technological or commodity-producing sector. Until this point the kind of agriculture practised, was such that the requirements could be fulfilled within the frontiers of agrarian society. For the sake of convenience we will call this type of agriculture as **traditional agriculture**. It may be noted that by this time it was possible to produce enough to meet the food requirement of a much larger number of people than those directly involved in agriculture. With passage of time, the non essential consumption needs i.e. ornaments, clothes, agricultural implements, and accessories, multiplied, which could only be met with by import of raw materials from areas beyond the frontiers of agrarian societies. As a result, the size of commodity-producing sector increased. The offsite demand for agricultural produce continued to rise because people not directly involved in agriculture, continued to multiply and lean more and more heavily upon agrarian or agropastrol system for food production.

These agrarian sectors depended heavily upon agriculture for their sustenance. They had surplus crops which were used for trade or commerce. They herded animals and managed pasture ranges nearby their houses for their consumption. With the onset of small fiefdoms, alongside commodity production and ruler system, the agrarian sectors also started bartering their produce. Craftsmen were able to produce commodities played a major role in providing agricultural produce to the urban societies. These agro-pastoral societies gave way to **modern agriculture**. This system aims at meeting offsite demands i.e. meeting the needs of target groups situated far away from the site where agricultural goods are produced. Man thus started improvising means of higher production. He designed sophisticated tools employing fossil fuel and electricity. However, the target groups soon outgrew the production capacity of agroecosystems (a broader term for agricultural fields encompassing the functional aspects of agriculture as a practice). Recall Figure 6.3 from Unit 6. Thus,

more forests were cleared and drylands were put to agriculture and grassland areas were planted. This plundered forests of their fertility, stressed the grasslands to produce more, inflicting serious, irreversible changes in natural ecosystems.

You will recall from Unit 6, as shown in Fig 6.3 that population increases in spurts. The peaks in population were achieved, followed by a sudden drop in population. At the same instance, new innovations were made, to increase productivity. The production capacity rose by means of the ability to cope with the side effects of the agricultural wastes and residual bye-products. This also meant much more inputs of energy into agricultural lands than solar energy could provide, or in other words, agriculture became energy intensive. The farmer became conscious of immediate returns, sometimes even overlooking the longterm perspectives.

This speeded up energy flow, hastened the cycling of nutrients and poisoned his food with biocides. All this while he continued to be oblivious of the gradual loss of flavour and aroma of his food items, not to talk of the general reduction in quality of agricultural produce.

The mode of agriculture practised by agrarian societies has undergone many changes since the middle of this century. Addition of modern gadgets, electric-powered irrigation equipment, fossil fuel-based agro-machinery, chemical fertilisers, plant protection chemicals and high yielding varieties to traditional agriculture are some of the inputs which make it modern. **Modern agriculture** has brought in enormous increase in production on the one hand while on the other it has caused great damage to natural balance of ecosystem. We will read about the changes in human environment caused by **traditional and modern agriculture** in the following sections.

8.2 CHANGES CAUSED BY AGRICULTURE AND OVERGRAZING

The changes in environment caused by man through his agro-pastoral activities can be divided into two types for the sake of simplicity: (a) changes brought about by traditional agriculture; and (b) changes brought about by modern agriculture. The characteristics of traditional agriculture include defacement of land, deforestation coupled with loss of soil structure, soil erosion and depletion of soil nutrients. Some of these changes are also shared by overgrazing. Overgrazing, in fact, is also a bye-product of efforts to exploit the land resources for maximum livestock production regardless of the ability of ecosystem to withstand external interventions. The second type of changes are those brought about by modern agriculture. While modern agriculture continues to share the disruptive effects of traditional agriculture on environment. It also affects certain changes in environment characteristic only of modern agricultural practices. For example, i) Excessive irrigation causes twin problems of salinisation and water logging resulting from rise in water table apart from causing depletion of ground water resources. ii) Similarly, addition of chemical fertilisers increases the rate of depletion of micronutrients from soils, eutrophication of water bodies and nitrosoamenia in children. iii) And the use of plant protection chemicals poisons the food products, sometimes kills non-target friendly organisms and helps target organisms to develop immunity. iv) Likewise, use of high yielding varieties makes the agriculture market-oriented, encourages monoculture causing eruption of epidemics and depletion of genetic diversity. We shall read about this too in the following sections.

SAQ 1

1) Fill in the blanks selecting suitable words given below :

   i) Evolution of induced agroecosystems is the story of shifts in agricultural practices. These shifts have brought about significant changes in ....., ..., health of resources, ... and direction of material flow, ... and livelihood patterns.

   ii) Modern agriculture aims at meeting .... i.e., meeting the needs of target groups situated far away from the site where agricultural goods are.....

   iii) Population increases in spurts. Whenever there was a sudden drop in population, simultaneously new .... were made, technological advancements took place and ..... rose along with the ability to cope with the side effects of the .... and residual bye-products.

iv) Modern agriculture has seen enormous..... in production on one hand while on the other it has caused a great damage to ..... balance of ecosystem.

8.3 TRADITIONAL AGRICULTURE

Large agricultural tracts of Indian subcontinent are starved of fossil fuel, electricity and government subsidies. They have to depend on intrinsic resources, draught power and rain water where the farmers practise traditional methods of farming. The practice of traditional agriculture does not depend upon energy-intensive inputs nor so much on purchasable items. Traditional agriculture, which is practised in most parts of the rural India, is afflicted with low production, poor drainage and unorganised cropping pattern. The practice of traditional agriculture has caused deforestation, soil erosion and depletion of macronutrients from the soil. We shall read about the effects of **traditional agriculture** on environment in the following subsections.

8.3.1 Deforestation

Physically, the process of deforestation includes clearing of land through repeated lopping, felling of trees, browsing and trampling of seedlings, and removal of forest litter. Removal of forest cover for agricultural activities is a major cause of deforestation. Data on satellite imagery by National Remote Sensing Agency shows that, of the 3.402 Mha forest lost between 1951-72 in India, 71.4% area was deforested because of agricultural activities (Table 8.1).

Table 8.1: The Break-up of Deforestation Due to Various Activities in India Between 1951-72

Activity	Forest Area Lost *(in ha)*
River Valley Projects	4,01,000
Agricultural Activities	24,33,000
Roads and Communication	55,000
Establishment of Industries	1,25,000
Miscellaneous	3,88,000
Total	34,02,000

Source: Satellite Imagery; National Remote Sensing Agency.

In this section we shall see that deforestation is induced by agriculture. We will support our discussion with the findings of a study conducted by the Centre for Ecological Sciences, Bangalore, shows interesting patterns of deforestation. The following study is an example of how changes in resource flow accompany banning of the access of villagers to the forest. The changes in resource flow pattern followed from decision of the Government to convert protected forest into reserve category forest. This means that the area which was earlier accessible to the villagers for non-destructive utilisation of forest resources was rendered practically out of bounds for them. This destroyed many traditional occupations such as basket making and honey collection which could be carried out on a strictly non-cultivated land, based on different forest tree species. Consequently, more people turned to the forested land for cultivation, causing serious damage to vegetation on private and community lands. Clearing the forests for agriculture continually necessitates further deforestation. Here too this happened. This ended the sustainable exploitation of village wood-lots through well defined and diversified use of forest species. As a result, teak, pine and other species have replaced the useful bamboo which provided sustainable livelihood to many of the villagers.

A cluster of villages in Tumkur district of Karnataka can be specifically cited to reveal the pattern of loss of trees following banning of the access of villagers to the resource areas. Through the earlier system the villagers had preserved good stands of trees where 60 per cent of trees comprised of peepal and papri. Today 12 per cent of the trees are being cut annually of which 7 per cent constitute the above two species. There is another ironic fact associated

with it; 78 per cent of this harvest goes to Bangalore City and only 11 per cent is retained in the village for fuel. This shows that loss of community vegetation is not due to excessive demands of villagers or their mismanagement of these resources. This was largely due to mismanagement by forest authorities, who in a mocking resemblance to British times, stressed upon meeting the offsite demand of certain groups rather than the onsite needs of the village communities.

During the two World Wars, wood of certain species was extracted with felling and replacement methodology, for construction of roads and laying of massive railway lines. This method is called **uniform system.** In this plan, bamboo trees were considered wood while overgrown coastal forests were considered as threat to teak. The case study conducted at Yakkambi-Sonda area of Karnataka showed that of the 12,134 ha area extracted, as little as 3,293 ha or about 25% area was planted with teak, which failed to establish. During the two Wars, trees along the coast or near it were removed for ease of transport. In the process, valuable mangrove forests were destroyed for building of roads ranging over extensive stretches of the east and west coasts.

8.3.2 Soil Erosion

Clearing of forest cover for cultivation exposes the land surface to abrasive agents such as rain torrents, water flow, strong surface winds and unstable atmospheric temperature. These agents cause erosion of the land depending upon direction of tilling, steepness of land slope, type of implements used and kind of crops sown. The intensity of erosion of a land mass thus depends upon agricultural practices, land use pattern and soil moisture management measures adopted. In traditional agriculture no measures are taken for soil moisture management. The losses of land can thus be enormous. The worst form of erosion prevalent in agricultural lands is wash off erosion or sheet erosion. It is a steady phenomenon and generally is not so spectacular in plains. However, when the water flows over land on the steep slopes, it becomes erosive and can cause rills. With heavy and recurring flow through rills, there develop gullies. As much as 99 M ha of cultivated land in India, which includes about 75 Mha rainfed areas, is affected by soil erosion. The rate of erosion is defined by the rate of soil lost in this process. Up and down slope cultivation of potatoes on steep; slopes in Nilgiris caused a recorded loss of 39.3 tonnes of soil per ha per annum. Jhum cultivation or shifting cultivation is also a major culprit. It causes an average soil loss of 41 tonnes per ha per annum on steep slopes in north-eastern hilly parts of India. Under worse conditions, the soil loss resulting from erosion under Jhum cultivation can be as high as 201 tonnes per ha per annum. Loss of soil in cultivated lands results in :

- Loss of finer grades of particles
- Disappearance of lattice structure
- Depletion of inorganic nutrients and organic matter
- Hydrologic degradation of the area affected.

Different crops cause different levels of soil losses. Soil erosion is the greatest danger to country's future plans of agricultural production. According to a study, if erosion is allowed to proceed at the present rate, by 2000 AD, the rainfed area in 16 south-east Asian countries, including India, will shrink by 38 per cent and production of land will decline by 36 per cent. As a result, total production for the country will fall by 12 per cent inspite of increased use of other inputs including irrigation and fertilisers.

8.3.3 Depletion of Macronutrients

The elements which are used by plants for their growth and development are called nutrients. Some of these are essential nutrients. An essential nutrient is an element which has the following attributes :

- The plant is unable to complete its life cycle without the element.
- Deficiency of an essential nutrient produces symptoms which cannot be alleviated by any other element.
- Restoration of the nutrient in physiological quantities should restore the health of the same plant.

The plant nutrients exist in soil particles in the form of inorganic salts or minerals. Minerals are prone to leaching if the soil is exposed to erosion. Traditional agricultural lands which are more exposed to onslaughts of floods are more susceptible to soil erosion. Essential elements like N, P, K, C, H, O, etc. which are needed by the plants in reasonably large quantities are called **macronutrients**; while elements such as Zn, Mo, Cu, etc. which are needed only in trace amounts are called **micronutrients.**

Estimates of loss of macronutrients such as N, P and K, through soil erosion in India ranges from 5.37 to 8.4 Mt per year. It is estimated that this represents a loss of about 30 to 50 Mt of agricultural produce per annum. However, this loss can be reduced by managing the cropping system or land use pattern. We would like you to go back to section 18.4.1 of the FST course and read if you do not already recall how nutrient loss can be reduced under different soil moisture management measures.

Let us now discuss the results of a study conducted on land under shifting cultivation. The nutrient losses under shifting cultivation or Jhuming has been compared to those under terrace cultivation. Table 8.2 shows the results of this interesting study. In this study the amount of nutrients lost per hectare land was studied under a combination of various land use patterns and soil water conservation measures, over a period of five years. You can see that shifting cultivation is a highly devastating practice. However, the loss of nutrients over a five-year period can be reduced by adopting measures such as Bench terrace, Halfmoon terrace and Contour-bund terrace cropping. You would realise that shifting cultivation is a bad practice because the land is prepared for cultivation by burning all the old vegetation which was holding soil particles together. Organic matter gets destroyed in the process. When land is left to nature's mercy to regenerate, the inorganic nutrients are also lost through soil erosion and leaching.

Table 8.2: Nutrient Losses Under Different Land Uses and With Various Conservations Measures in the North-Eastern Hill Region of India.

Land use	Crops grown	Soil and Water Conservation Measures	Nutrients Lost During Average of 5 years in kg/ha	
Shifting Cultivation	Paddy, Maize and tapioca, cucurbits, yam, vegetables followed by 4 years of fallowing	Nil	Org C P_2O_5 K_2O	702.9 145.5 7.1
Agriculture in 1/3 lower slope Horticulture in 2/3 of the upper slope	Paddy and Maize followed by lemon (Citrus) pineapple and cowpea	Bench Terrace Halfmoon Terrace	Org C P_2O_5 K_2O	35.1 11.2 0.5
Agriculture in entire area	Maize and tapioca on upper plane terraces followed by yam and mustard	Contour bunds on slopes	Org C P_2O_5 K_2O	260.8 95.7 3.6

Source: Shifting Cultivation in North-Eastern India, ICAR Research Project on NEH Region, Shillong, 1983.

So far we have studied the extent of loss of **macronutrients** caused by soil erosion. In section 8.4.1 we shall see how excessive fertilisation of agricultural fields with chemical fertilisers, causes widespread imbalances in **micronutrient** budgets of soil.

8.4 EFFECTS OF MODERN AGRICULTURE

In the post World War II period, new technological options, such as, chemical fertilisers, mechanisation of implements, high yielding varieties (HYV) and plant protection chemicals were open to mankind to increase agricultural productivity. These purchasable inputs made agriculture capital – and energy – intensive and market-oriented. Excessive inputs of these were made in agriculture to boost production. The outcome was two-fold: on the one hand, initially the production increased but after a certain stage the returns started diminishing;

further addition of inputs did not bring about the corresponding increase in production. On the other hand, increased use of these inputs caused multiple environmental problems, such as adverse side effects from the use of fertilisers, biocides, excessive irrigation and plant protection chemicals, eruption of diseases due to monoculture and depletion of genetic stock due to use of high yielding varieties.

SAQ 2

1) Fill in the blanks using appropriate words:

   i) Shifting cultivation is a highly devastating practice, however the loss of nutrients can be reduced by adopting soil and water ..... measures.

   ii) Elements such as Zn, Mo, Cu etc., which are needed only in .... are called micronutrients.

   iii) Removal of forest cover for ..... activities is a major cause of deforestation.

   iv) The intensity of erosion of a land mass depends upon agricultural practices, ... and .... management measures adopted.

   v) As a result of practice of modern agriculture, the returns started diminishing on the one hand, and on the other has caused ..... environmental problems.

8.4.1 Fertilisers

Minerals constitute an essential raw material for growth of plants. When present in soil, in forms available to plants, they are called **soil nutrients.** Sometimes they are present in soil particles in the form of organic matter. The organic matter is acted upon by microorganisms and is converted into inorganic minerals which act as soil nutrients. In natural ecosystems there exists a cycle of plants taking up nutrients from the soil which passes on to herbivores in the form of fodder, then to carnivores in the form of meat of herbivorous animals and back to the soil through fecal matter and dead bodies. This does not happen in the case of agroecosystems. The minerals are passed on to man in the form of agricultural produce and are disposed of into city sewage. Thus, these minerals are put out of cycle and rendered practically inaccessible to the agricultural lands.

Excessive removal of minerals by this process causes nutrient depletion. Without periodic augmentation the soil's supply of nutrients gets exhausted. We shall see as to how excessive fertilisation of agricultural fields has led to widespread imbalances in micronutrient content of soil, pollution of fresh water and contamination of underground water bodies.

Most of the chemical fertilizers used in modern agroecosystems contain macronutrients, i.e., nitrogen, phosphorus and potassium (NPK). But excessive addition of NPK to the agro-ecosystems causes the plants to draw more micronutrients as well from the soil. It may be mentioned here that in this case the rate of growth of plants often exceeds the natural ability of soils to replenish the supply of micronutrients. As a result, soil nutrient stress is caused. Thus, excessive addition of fertilisers causes micronutrient deficiency in soils. Zinc deficiency, for example, in large tracts of high yielding belt of Punjab and Haryana has depressed the productivity of the land. The main crops affected are rice, jowar, maize, cowpea, sunflower and chickpea. Similarly, iron deficiency has caused a drop in production of soybean crop.

Another adverse side effect of excessive addition of chemical fertilisers results from the fact that about one-fourth of the applied fertiliser is not used by crop plants and is leached down. These chemicals, usually nitrates, find their way into groundwater aquifers, increasing the concentration of nitrates in drinking water. This has become a serious health hazard because excess of nitrates causes methaemoglobinaemia in bottlefed infants. The effects of nitrate are more pronounced in Denmark, England, France, Germany and the Netherlands.

The loss of nitrogen fertiliser through leaching is as high as 30-45 kg per ha per annum in Europe. This amount is alarmingly high and is more than the total amount being applied in many developing countries.

The need of the day is, to develop alternate low cost methods such as **green manuring** for regenerating the biophysical status of agricultural soils and to reduce dependence of modern agroecosystems on chemical fertilisers. It may be worth mentioning here that use of bio-fertilisers can be an alternative to chemical fertilisers.

Green Manuring, ploughing the green parts of plants into the soil in order to enrich the soil with organic substances and nitrogen. Green manuring requires the cultivation of such legumes as dhencha, kesari dhal, chandani, lupin, sardella, sweet clover, lotus, lathyrus, clover, vetch and crotolaria. The plants are ploughed under the same plot of land on which they are grown and used as fertiliser or for making compost. The practice of green manuring improves the soils physico chemical properties, lowers soil acidity and increases its buffering, absorption and moisture retaining capacities. It also promotes the activity of beneficial bacteria and enriches the organic substances in ploughed layer of soil, especially in low humus, sandy and sand loam soils, increasing crop yield.

There is still another way through which excessive application of chemicals can cause environmental degradation. The fertilizers which are initially meant to increase the mineral content of agricultural fields are often not fully utilized by the plants. The extra amounts are washed down with rain water. The rain water carries extraordinarily large amounts of nutrients into water bodies causing artificial eutrophication. Eutrophication means enrichment of nutrients in a water body. You will read about eutrophication in details in Unit 11.

To sum up, excessive use of fertilisers causes :

- soil nutrient stress, micronutrient deficiency or depletion leading to loss in production
- leaching of toxic amounts of nitrate ions from the fertiliser applied leading to pollution of groundwater bodies
- eutrophication of rivers, lakes and other fresh water bodies.

SAQ 3

Fill the blanks with appropriate words :

i) In natural ecosystems nutrients taken up from the soil are returned back to the ecosystem through ..... matter and dead bodies. But this does not happen in the case of agroecosystems. The minerals consumed by man in the form of agricultural ..... are disposed into city sewage and are thus put ..... cycle.

ii) Excessive addition of fertilisers causes micronutrient ..... in soils, resulting from soil nutrient stress.

iii) One-fourth of the applied fertiliser is not used by crop plants and is ..... down. These chemicals find their way into groundwater, increasing the concentration of ..... in drinking water.

8.4.2 Plant Protection Chemicals

Toxic chemicals like insecticides, herbicides, fungicides, rodenticides are generally used to kill insects, weeds, fungi and rodents respectively to protect crop plants or their harvested parts against their attack. These chemicals, collectively called 'biocides', tend to remain active, long after destroying the target, i.e. pests, weeds, fungi or rodents. It is this property, which makes these chemicals dangerous to the environment. Huge amounts of different kinds of poisonous agricultural chemicals are being used these days. Total annual global production of such chemicals increased 15 fold from 0.67 in 1945 to 10.2 Mt in 1985. Their variety has also increased. Some 70,000 different biocides are currently being used all over the world. In India alone, over 80,000 tonnes of pesticides were used in 1985 as against 2,000 tonnes in mid-fifties annually. However, the average application per unit area in India is very low, 457 g/ha, as against 14,010 g/ha in Japan.

On continued application these agro-chemicals cause contamination of food materials, disruption of the natural balance of ecosystems by killing non-target organisms and gradual increase in the immunity of target organisms to these chemicals. Further, since most of these chemicals are not bio-degradable, once they enter the food chain, they persist in the plant or animal body. Their concentration in the organisms multiplies through food chain; a phenomenon known as **biological magnification** as they move up the food chain. Some of the harmful effects of the continued use of these chemicals are discussed below :

I) **Death of non-target organisms:** Plant protection chemicals are intended to kill their respective target organisms, but sometimes they kill even the useful species of insects which apart from serving as alternate food for birds, play an important role in the pollination and dispersal of wild plants and forest trees. The fungicides used to protect crop plants against fungal attack wipe out the useful group of fungi which play an important role in solubilisation of phosphates, an important plant nutrient. Use of herbicides causes the death of not only the unwanted weeds but also the sensitive, useful side crops which play an important role in protecting the crops from other diseases.

Equally serious has been the destruction of the natural enemies of pests. Sometimes excessive use of biocides kills the insect predators and parasites of insect pests. If this happens, then, several new species of crop pests may appear that previously had caused no significant damage. For example, in Malaysia so many new kinds of pests appeared in 1960 and 1961 following pesticide spraying in cocoa plantations that the use of pesticides had to be abandoned. Likewise in Nicaragua, over 15 years of heavy use of insecticides on cotton crops killed their natural enemies. As a result, the population of new pests increased and area under cotton cultivation fell by 30 per cent. In another incidence in California in 1967, bee colonies used to pollinate orchards and crops were so reduced and weakened by pesticides that they were no longer effective pollinators. A more sensible way to overcome the pests will be introduction of **biological control** methods.

II) **Immunity in target organisms:** Another problem related to excessive utilisation of plant protection chemicals is that the target organisms (pests, weeds, rodents or fungi) are gradually acquiring immunity to these chemicals by evolving pesticide-resistant strains which means that these chemicals are no more effective against target-organisms. Some of the pests have evolved mechanisms of detoxifying the chemicals designed to kill them. By 1984, nearly 447 species including major insects, mites and other pests, had developed immunity and become resistant to the chemicals used against them. Similarly, 48 weed species have gained resistance to herbicides. As a result, large tracts of agricultural land have been rendered uncultivable. Even the initial benefits brought to agriculture by biocides have backfired in many instances. For example, immune strains of insect pests have replaced the original populations, tempting agriculturists to apply even more virulent biocides, more and more frequently.

The following examples of development of immunity by target organisms illustrate the point :

- Continued use of insecticide to protect tobacco crops from tobacco bud worm, made it more resistant in north-eastern Mexico.
- Along the Saffolk County in UK, where potato is grown, the Colorado-potato beetles are reported to have developed mutant strains that are resistant to the pesticides used against them.

III) **Contamination of food items:** Now let us see how these plant protection chemicals contaminate food items. Biocides are sprayed upon food grains, fruits, vegetables and oilseeds, to protect them under prolonged storage conditions. Since these chemicals are not biodegradable they persist long after their entry into the food chain. The poisoned agricultural products are either consumed by human beings directly or reach man through milk, meat, eggs, fish products or water. The cows, goats and sheep are fed upon contaminated fodder, the fowl might eat contaminated agricultural refuse and fish may avail of planktons living in a contaminated pond. Man may sometimes consume drinking water straight from a contaminated pond, situated near agricultural fields from where these biocides are leached down to the water body. All this goes to increase the quantity of non-biodegradable chemical in their bodies. Man situated at the higher trophic level accumulates these poisons from all these sources. This phenomenon is known as **biological magnification.**

In Hyderabad, 60 per cent of the 1,284 samples of vegetables were found to be contaminated with deadly insecticides. Samples of wheat from Delhi, Haryana, Punjab and Bombay were found to contain very high levels of toxic biocides ranging from 10 to 175 parts per million (ppm) of DDT and 7–87 ppm of BHC. Cotton seeds from Punjab had DDT levels between 0.85 and 1.28 ppm and BHC between 0.56 and 0.87 ppm. This is a matter of concern because cotton seed oil is one of the basic ingredients of edible oils, and DDT being fat soluble, finds its way to lactating mothers. Thus, new born infants are likely to receive concentrated dosages of DDT through breast milk.

The use of these deadly chemicals causes serious ailments in humans, ranging from indigestion and nervous disorders to cancer, and in many cases instantaneous death. These chemicals take a toll of 40,000 to 2 million people annually in the world. Cases of biocide poisoning in India have been reported since 1953 when 102 persons died of ethyl parathion, the first biocide to be introduced in our country. Five persons died of malathion poisoning in Indore 1967-68. Mass-poisoning of human beings as well as animals in Uttar Pradesh was reported in 1977 due to consumption of contaminated wheat.

Thus, you can see that excessive utilisation of plant protection chemicals causes

- immunity in target organisms, like pests, weeds, fungi, and rodents leading to their excessive multiplication
- death of non-target organisms which play a vital role in ecosystem functioning
- contamination of food items and drinking water causing diseases and death in human populations and livestock.

8.4.3 Water Logging

In his enthusiasm to provide more water to agricultural fields, man employed canal irrigation as well as tubewells for drawing water from deep core of the earth. Excessive irrigation without proper drainage alters the soil-liquid-air ratio and also raises the water table. As a result, soil becomes drenched with water. This is called **water logging**. Water logged soils cannot support good plant growth because they lack in air which is very essential for root respiration, causing congestion of roots. Water logged soils lack also in mechanical strength and cannot physically support the weight of plants. This causes the plants to submerge in mud. As a result, the yield is reduced. Some of the kharif crops (summer crops) like maize, millets and cotton cannot stand water logging. Water logging also damages rabi crops (winter crops) such as gram and barley. India has the largest irrigated area in the world, measuring 56 Mha, followed by China with 47 Mha, USA with 27 Mha, and USSR with 21 Mha. Review of Rashtriya Barh Ayog states that a total area of 8.50 Mha spread over 17 states in India is water logged. In three canal irrigation projects of Tungbhadra, Pochampad and Nagarjunasagar, loss of rich grain was 4,800 tonnes per annum in the recent few years. This represents about 30 per cent reduction in the total yield. Over 30 years of canal irrigation has caused water logging in an area of 33,000 ha.

8.4.4 Salt Affectation

Excessive irrigation in high temperature zones causes salt affectation of soils. Water evaporates very fast, leaving behind the traces of salt on the soil. As more and more cycles of irrigation are repeated, the left over salt accumulates and forms a thick layer of grey or white effervescence on the surface. Sometimes the salts form an impervious crust of comparatively less soluble calcium carbonate a few meters below the surface. As a result the general concentration of salts in the upper layers increases. The salt affected soils can either be alkaline or saline. **Alkaline soils** contain excessive sodium carbonate and sodium bicarbonate. These soils are dense and compact, containing a hard layer of calcium carbonate below the surface. The roots cannot penetrate the crust of carbonate lining. The **saline soils** contain soluble sodium salts such as sodium chloride and sodium sulphate.

When the salt content of the soil exceeds 2000-3000 parts per million (ppm) the water solution of soil becomes toxic for most plants. In salt affected soils, the plants fail to absorb nutrients and face simulated water stress even amidst plentiful soil moisture. Unlike alkaline soils, the saline soils are easy to reclaim, because in saline soils, salts can be leached out to recover the original fertile character. While alkaline soils need a series of treatments to remove carbonates and bicarbonates of sodium and to break the impervious calcium carbonate crust. Sometimes, sandy nature of soils along with alkalinity complicates the nature of the problem. Similarly, water logging is sometimes coupled with alkalinity in which case it becomes difficult to restore fertility of the soil.

India has a total of 3.58 Mha of alkaline soils, 1 Mha of saline soils in the arid land of Thar desert, 1.4 Mha of saline soils in the black cotton soil region and 3.1 Mha of coastal saline soils. This makes a total of 9.08 Mha of salt affected soils in India. Out of these, at least half, i.e., 4.05 Mha fall in the category of agricultural land but remain unproductive. With the national average productivity of 1.6 tonnes per ha per annum the country is losing about 6.5 Mt of agricultural produce every year because of salt affectation due to excessive irrigation. You have already read in Unit 7 that excessive irrigation deprives the area of groundwater resources and accentuates desertification as seen in the arid zones of Rajasthan.

8.4.5 High Yielding Varieties (HYV)

The HYVs are man made varieties of agricultural plants, fodder plants, forest trees, livestock and fishes which have been raised using breeding techniques, to yield more. As an outcome of introduction of HYVs, farmers were able to achieve greater output, increase in yield and greater monetary returns from agriculture. Gradually, agriculture became heavily dependent

upon research for development of new varieties and maintenance of the developed varieties. These varieties are, however, dependent upon man for their survival, because left to themselves, deprived of human protection, they are not able to compete with their wild relatives. These varieties necessitate the use of purchasable items like fertilisers, pesticides, etc. The enhanced agricultural produce has in turn to be marketed, leading to commercialisation of agriculture.

The HYVs also encourage **monoculture** which means the same genotype is sown over miles and miles of land at a stretch. One adverse aspect of this practice is that if a particular pathogen takes fancy to this crop and succeeds in infesting it, there is no way to check the disease. Whole tracts of crop will succumb to the disease leading to eruption of epidemics because the same genotype is grown everywhere else. On the other hand, if the farmer had depended on a large number of varieties he would have certainly stood a chance against eruption of the epidemic because in a mixed population there always exist combinations which can resist the onslaught of a particular pathogen. Thus, in the event of eruption of an epidemic, the farmer has nothing to fall back upon if he practises monoculture.

Use of HYVs is harmful from another point of view as well. Cultivation of HYVs necessitates greater attention from man, who unintentionally discourages the growth of wild relatives and classifies them as weeds. As a result, appearance of new combinations through cross pollination gets inhibited. Regeneration of the species and thereby evolution process, at large, is hindered. This results in depletion of crop diversity and elimination of chances for development of new varieties.

In short, we can say, that cultivation of HYVs has encouraged marketing of agricultural produce, practice of monoculture, which make the crop prone to eruption of epidemics and reduction in crop diversity. In the next section we shall see how overgrazing has caused deterioration of human environment. How about trying another SAQ, before we proceed further ?

SAQ 4

Fill in the blanks using appropriate words :

i) Excessive utilisation of plant protection chemicals causes immunity in ..... organisms, death of ..... organisms and contamination of .... and drinking water causing diseases and death in human beings.

ii) Plant protection chemicals are intended to kill their respective target organisms, but sometimes they kill even the ..... species of insects.

iii) Water logged soils lack in mechanical strength and cannot ..... support the weight of plants. Such soils cannot support good plant growth because they lack in ..... which is very essential for root respiration.

iv) In salt affected soils, the plants fail to absorb nutrients and face ..... water stress even amidst ..... soil moisture.

v) Saline soils are .....to reclaim, while alkaline soils need a ..... of .....

vi) The high yielding varieties are dependent upon man for their ..... They necessitate the use of purchasable items, encourage ..... leading to eruption of epidemics and result in depletion of crop ..... eliminating chances for appearance of new .....

8.5 EFFECTS OF OVERGRAZING

Before we go on to discuss the changes in human environment caused by overgrazing, let us understand the position of livestock in India. Livestock wealth plays a crucial role in rural Indian life. Domesticated animals are an important source of milk and meat. They also provide fuel, organic manure and draught power. Their remains, such as hides and hoofs, provide important raw material for handicrafts, small scale industries, manufacture of bone charcoal, phosphorus fertilisers, wool and shoe industry.

India teems with domestic animals. The livestock population in India has been continuously increasing. A total increase of 42 per cent was registered during the thirty-year period, from 292.02 million cattle heads in 1951 and 415.94 million in 1981. The land resources available in the form of permanent pastures and grazing lands for producing fodder declined from 14545 M ha to 129.26 M ha in the same period, registering a shrinkage of habitat by 11.03 per cent. Thus, land available per animal head declined from 0.51 to 0.32 ha, a reduction of about 37 per cent. These figures show that livestock density has increased during the past thirty years. Further, though the results of 1991 Census are yet to be announced, this density is expected to increase further. The fodder producing lands are under a greater pressure today than they were, forty years ago.

Under normal grazing conditions one ha of pasture or grazing land can support on an average 3 livestock heads in rainfed areas and 6 livestock heads in extensively irrigated areas. As against this, the actual number of animals which depend on each ha of such lands is much higher — anything from 2.4 to 4.5 times their carrying capacity. In Jammu and Kashmir, for example, 16.8 animals are supported by each ha of grazing and foraging land. The grazing and foraging lands are thus being over-grazed. You will see the effects of overgrazing in the next section.

Before we go on to discuss overgrazing, we would like to state another consequence of increasing livestock density. More and more families are forced to share their shelters with their domestic animals. Since these animals act as host for many viruses, pests and bacteria, there is increasing danger of infection and direct transfer of disease. Animal excreta are finding easier paths to ground and surface waters which form major sources of drinking water for a large section of human population.

Equally serious has been the fact that domestic animals which are a source of milk are carrier of dangerous chemicals like DDT also, which they consume with their fodder inadvertently. DDT tends to be deposited in fatty tissues. It is not metabolised and it remains in most animals in their fatty tissues for life, leading to its bioaccumulation. You have read about **biological magnification** in section 8.4.2. During starvation or debility, these chemicals come out of the fatty tissue and are released into the blood stream causing general poisoning of the organism.

Now, let us see what are the effects of overgrazing on human environment.

8.5.1 Land Degradation

Under heavy grazing pressure the quality of land deteriorates because overgrazing leads to compaction of soil, reducing the operative soil depth, viz., the soil depth in which plants can take root and regenerate. The amount of soil moisture, which can be stored for the regeneration needs of the desired plant species is thus reduced. Fall in total regrowth of fodder yielding biomass reduces the rate of organic recycling which plays an important role in maintaining soil fertility.

As a result of overgrazing microclimate becomes drier, mulch cover or humus decreases, and is heavily trampled producing puddling of surface layer, which in turn, reduces the infiltration of water into the soil and accelerates its run off. This exposes the land to erosion by rain torrents and surface runoff. This causes heavy soil losses through wash off resulting in the formation of rills and gullies. Consequently, silt loads to streams and rivers increase thus resulting in relatively much larger inputs into the reservoirs. This is specially true of Indian, Pakistani and Nepali catchment areas subject to overgrazing. You will read more about this in Unit 12 on Soil Erosion and Soil Degradation.

8.5.2 Loss of Water Points

Water points have been a crucial factor for livestock maintenance whether it is pasture-based, migratory or a part of settled farming system. In Rajasthan, for example, as a result of overgrazing, water points in some of the villages silted up, reducing their number to almost half between 1953-54 and 1973-74. People living in the neighbourhood started cultivating these new-found areas. Though initially they got some returns, these lands were rendered barren within 4-5 years because they were not viable as an agricultural land. Since the cultivation of such lands was practised by a few individuals nearby, this also resulted in large scale conversion of public land into private property.

8.5.3 Loss of Vegetal Cover

Excessive utilisation of land for cultivation and overgrazing have adversely affected composition of plant populations and their regeneration capacity. Areas cultivated for agriculture lose all natural flora except for the few which are weeds from the point of view of agricultural production. As a result, nutritious and juicy fodder-giving plant species are gradually replaced by unpalatable thorny plants such as lantana, parthenium, eupatorium, and the like, over extensive areas. This is especially true of areas where the dry period stretches for more than 5 months in a year for reasons of rainfall, topography and soil-temperature, etc.

In Western Rajasthan, where rainfall is less than 200 mm per annum and dry periods extend over 10 to 11 months, sparse annual grass species are found in steppe formations. In other parts of the state with rainfall of 500 mm and dry season extending between 5-6 months, tall grass species grow under the light shade of khejiri tree, forming savanna grass ecosystems. As a consequence of overgrazing, the production of biomass has gone down, leading to disappearance of juicy, fodder plant species which are gradually being replaced by unpalatable thorny weeds and shrubs. As a result of overgrazing vast areas of Arunachal Pradesh and Meghalaya are getting increasingly invaded by trees, bushes and weeds low in fodder value.

You will read more about land degradation and replacement of vegetal cover by thorny xerophytic plants in Unit 12. In the next unit you are going to read about another interesting aspect, namely, urbanisation and its impact on human environment. Well, how about solving a set of questions now?

SAQ 5

Fill in the blanks using appropriate words :

i) Domestic animals which are a source of milk are also a ..... of dangerous chemicals like DDT, which they consume with their fodder inadvertently. DDT tends to be ..... in fatty tissues. It remains in most animals for life, because it is not..... .

ii) As the livestock density increases, more and more families are forced to ..... their shelter with their domestic animals. There is increasing danger of ..... and ..... transfer of disease, since these animals act as ..... for many viruses, pests and bacteria. Animal excreta are finding easier paths to ground and ..... waters.

iii) Under ..... grazing conditions one ha of pasture or grazing land can support on an average 3 livestock heads in ..... areas and 6 livestock heads in .... areas.

iv) Effects of overgrazing on human environment are a) .... , b) .... and c) ....

v) Overgrazing leads to compaction of soil, reducing the ..... soil depth, viz., the soil depth in which plants can take root and regenerate. The volume of soil moisture, which can be stored for meeting the ..... needs of the desired plant species, is thus reduced.

vi) As a result of overgrazing, nutritious and juicy ..... giving plant species are gradually replaced by unpalatable ..... plants.

8.6 SUMMARY

In this unit we have tried to trace the changes brought about by agricultural practices in the human environment. We have started from tracing the course of evolution of agro-ecosystems. To begin with, man's tools were simple and techniques were not sophisticated.

- His tools went on becoming more and more powerful. This accompanied by his devastating activities and the extent of damage caused by agricultural practices to the human environment also kept increasing.
- For the sake of convenience we have classified agriculture into two categories — traditional agriculture and modern agriculture.

- The practice of traditional agriculture causes deforestation, soil erosion and depletion of macronutrients.
- Since World War II electric powered implements, chemicals and HYVs were introduced into practice of agriculture. Modern agriculture changed its priorities side by side. For example, it became market-oriented, quantity-dependent and energy intensive.
- Excessive use of fertilisers depletes the soils of their micronutrients, accumulation of nitrates in groundwater and eutrophication of rivers, lakes and fresh waterbodies.
- Use of biocides causes death of useful non-target organisms and acquisition of immunity by target organisms and poisoning of food items with DDT, BHC and malathion etc.
- Waterlogging and salt affectation result from excessive irrigation of agricultural fields especially in dry areas. Excessive irrigation depletes groundwater resources, and raises the water table.
- High yielding varieties necessitate the use of purchasable items. They tend to encourage monoculture and reduce plant diversity. This leads to eruption of epidemics, inhibiting the process of natural evolution of species.
- Increasing agricultural productivity has resulted in increased density of livestock and domesticated animals. We have seen that animals are carriers of pathogens and deadly chemicals like DDT.
- Increased density of domesticated animals has put fodder-producing pastures and forage lands under stress. This has resulted in defacement of land, soil erosion and disappearance of palatable plant species.

8.7 TERMINAL QUESTIONS

1) How does modern agriculture differ from traditional agriculture?

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2) List the changes caused by modern agriculture in the space given:

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3) What are the main aspects of traditional agriculture?

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4) What are the three basic attributes of an essential nutrient?

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5) State in 4-5 lines how nitrosomaenia is caused in children.

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6) What is artificial eutrophication, and what are the results of eutrophication of water bodies?

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7) Give two examples of insects or pests which have become immune to biocides.

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8) How does overgrazing lead to land degradation?

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8.8 ANSWERS

SAQ 1

i) land use patterns, quantum, food surpluses

ii) offsite demand, produced

iii) innovations, production capacity, agricultural wastes

iv) increase, natural

SAQ 2

i) conservation

ii) trace quantities

iii) agricultural

iv) land use pattern, soil moisture

v) multiple

SAQ 3

i) fecal, produce, out of

ii) deficiency

iii) leached, nitrates

SAQ 4

i) target, non-target, food items

ii) useful

iii) physically, air

iv) simulated, plentiful

v) easy, series, treatments

vi) survival, monoculture, diversity, combinations

SAQ 5

i) carrier, deposited, metabolised

ii) share, infection, direct, host, surface

iii) normal, rainfed, extensively irrigated

iv) land degradation, loss of water points, loss of vegetal cover

v) operative, regeneration

vi) fodder, thorny

ANSWERS TO TERMINAL QUESTIONS

1) **Modern agriculture** depends on modern gadgets such as electric-powered irrigation equipment, fossil fuel-based agro-machineries and purchasable inputs such as chemical fertilisers, plant protection chemicals and high yielding varieties. It is an energy intensive practice. Modern agriculture produces more quantity of agricultural products on a unit area basis.

2) a) Excessive irrigation leads to depletion of groundwater resources and twin problems of salinisation and water logging resulting from rise in water table. b) Addition of chemical fertilisers causes micronutrient deficiency, eutrophication of water bodies and nitro-somaenia. c) Use of plant protection chemicals poisons food products, kills useful non-target friendly organisms which are beneficial to agriculture, and helps the target organisms to develop immunity over extended periods of time, resulting in arrival of new group of organisms capable of harming the crops or agricultural produce. d) High yielding varieties make the agriculture market-oriented, encourage monoculture, leading to eruption of epidemics and depletion of genetic diversity.

3) The practice of **traditional agriculture** makes use of intrinsic resources, draught power and rain water. It does not depend upon energy intensive inputs nor upon purchasable items. In India traditional agriculture suffers from low production, poor drainage and unorganised cropping pattern.

4) An **essential nutrient** is an element which has the following three attributes.

- The plant is unable to complete its life cycle without the element.
- Deficiency of an essential nutrient produces symptoms which are not alleviated by any other element.
- Restoring the nutrient in physiological quantities restores the health of the plant.

5) Chemical fertilisers in excess of the needs of crop plants are leached down to ground water aquifers. These chemicals, usually nitrates, when ingested along with drinking water, cause methaemoglobinaemia. Children are especially sensitive to nitrates.

6) The extra amounts of chemical fertilizers from agricultural fields are washed down with rain water. This surface run off carries nutrients to water bodies, causing artificial eutrophication. This causes, undesirable blue-green algal growth, rise in biological oxygen demand, impedence in navigation and imparts obnoxious character to water bodies. You will read about this in Unit 11.

7) Tobacco bud worm in north eastern Mexico has developed resistance to insecticides. Continuous use of pesticides has made the Colorado-Potato beetles more resistant in Saffolk county in UK.

8) Overgrazing leads to compaction of soil, leading to reduction in volume of soil moisture and operative soil depth. Also the microclimate of grazed land becomes more dry and prone to soil erosion as a result of puddling.