Effects of Agriculture on Human Environment

Unit

4

Unit 4

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Introduction

In Unit 3 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.

Evolution of the Induced Agro ecosystems

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.

History of Land Use Pattern

The sequence of events which followed in evolution of induced agro ecosystems is outlined in Figure 4.1. 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.

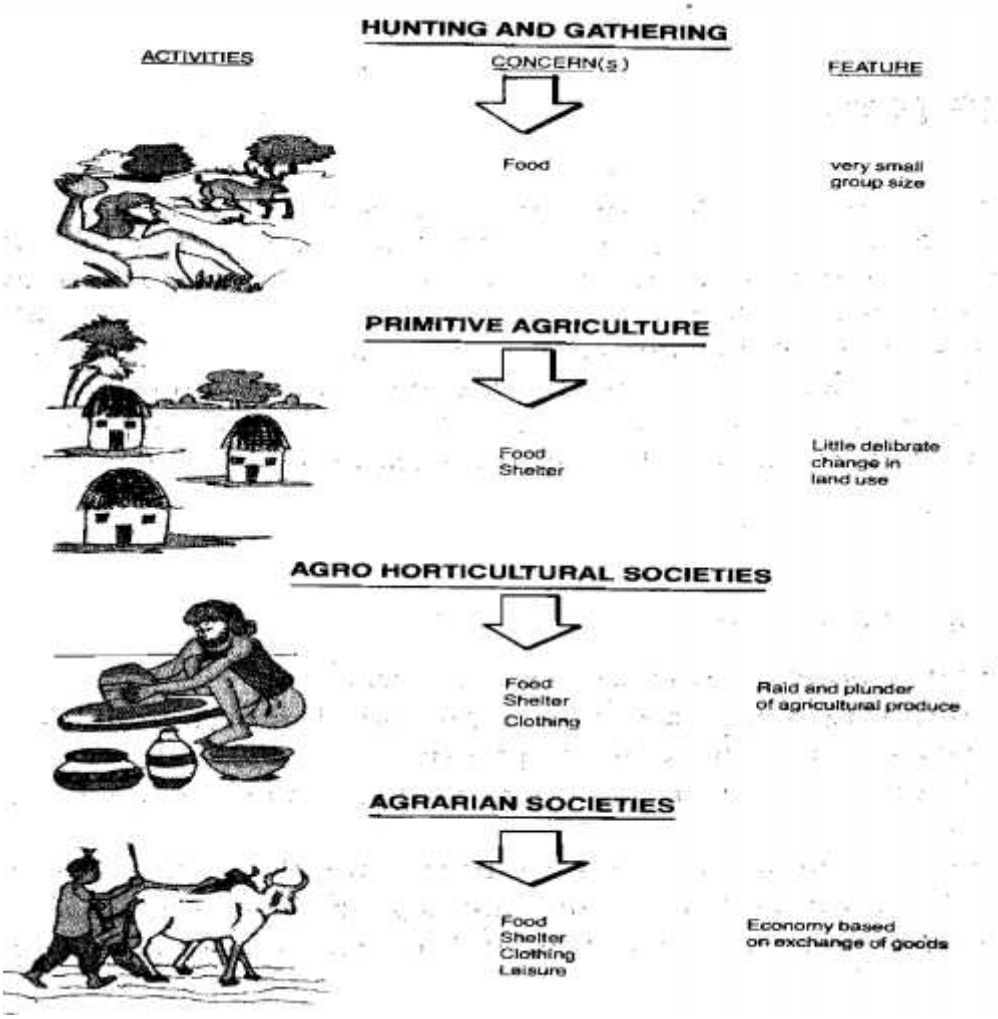

Fig: 4.1

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 urban systems.

Agrarian societies: Finally agrarian societies (AS) superseded the agro-horticultural societies. Their leisure 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 on 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 agro past oral 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. Man thus started improvising means of higher production. He designed sophisticated tools employing fossil fuel and electricity. However, the target group? Soon outgrew the production capacity of agro ecosystems (a broader term for agricultural fields encompassing the functional aspects of agriculture as a practice). Thus, more forests were cleared and dry lands 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.

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 by-products. This also meant much more inputs of energy into agricultural lands than solar energy could provide, or in other words, agriculture becomes energy intensive. The farmer became conscious of immediate returns, sometimes even overlooking the long-term 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 modem gadgets, electric-powered irrigation equipment, fossil fuel-based agro-machinery, and chemical fertiliser 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.

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 modem agriculture. The characteristics of traditional agriculture include destruction 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 by-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 help 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.

Traditional Agriculture

We shall read about the effects of traditional agriculture on environment in the following subsections.

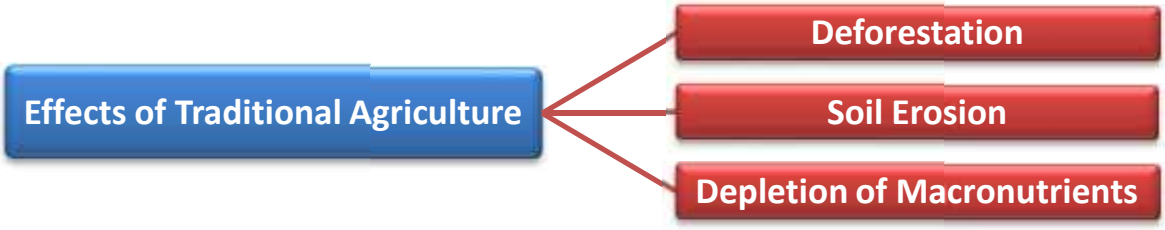

Fig: 4.2

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.

During the two World Wars, wood of certain species was extracted with felling and replacement methodology, for construction of roads and 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.

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. 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.

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, 0 , 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.**

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

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.

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 decayed matter and dead bodies. This does not happen in the case of agro ecosystems. 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 modem agro ecosystems contain macronutrients, i.e., nitrogen, phosphorus and potassium (NPK). But excessive addition of NPK to the agroecosystems causes the plants to draw more micronutrients 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.

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. The effects of nitrate are more distinct in Denmark, England, France, Germany and the Netherlands.

Plant Protection Chemicals

Toxic chemicals like insecticides, herbicides, fungicides, 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.

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:

1) 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 destruction of the natural enemies of pests. Sometimes excessive use of biocides kills the insect predators and parasites of ' sect 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.

2) 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 to replaced the original population, 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 resistance 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.

3) Contamination of food items: Now let us see how these plant protection chemicals contaminated 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 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.**

Water Logging

In his enthusiasm to provide more water to agricultural fields, man employed canal irrigation as well as tube wells 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.

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.

High Yielding Varieties (HYV)

The HYVs are manmade 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.

Effects of Overgrazing

Before we go on to discuss the changes in human environment caused by overgrazing, let us understand the position of livestock. Domesticated animal are an important source of milk and meat. They also provide fuel, organic manure and drought power. Their remains, such as hides and hoofs, provide important raw material for handicrafts, small scale industries, manufacture of bone charcoal, phosphorus fertilizers, wood and shoe industry.

Before we go on to discuss overgrazing, we would like to state another consequence of increasing livestock density. In third world countries some people 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.

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 re growth of fodder yielding biomass reduces the rate of organic recycling which plays an important role in maintaining soil fertility.

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.