ABE 513 - AGRICULTURAL LAND DRAINAGE

LECTURE 1

1.1 Introduction

Literally, the word ‘drainage’ means the removal of a liquid. Land drainage is the removal of excess water through open ditches, vertical drains or through creation of dikes and pumping the water out from embarked areas. Land drainage is widely used not only in agriculture but also in forestry industry, mining industry, industrial construction, etc. Land drainage allows man to bring low productive areas (marches, waterlogged territories, etc.) into agricultural use and to enhance efficiency of farming.

Land drainage has a long history: the first drainage systems were created in Ancient Egypt, China and India as early as in third millennium BC. Since that time drainage technology has improved considerably. The current world population is roughly estimated at 6000 million, half of whom live in developing countries. The average annual growth rate in the world population approximates 2.6%. To produce food and fibre for this growing population, the productivity of the currently cultivated area must be increased and more land must be cultivated. Land drainage is one of the most important input factors to maintain or to improve yields per unit of farmed land. To enlarge the currently cultivated areas, more land must be reclaimed than the land that is lost (e.g. to urban development, roads, and land degradation). In some areas, however, land is a limiting resource.

Land drainage, as a tool to manage groundwater levels, plays an important role in maintaining and improving crop yields: It prevents a decrease in the productivity of arable land due to rising water tables; a large portion of the land that is currently

not being cultivated has problems of and the accumulation of salts in the root zone; waterlogging and salinity. Drainage is the only way to reclaim such land.

Land drainage is the removal of excess surface and subsurface water from the land to enhance crop growth, including the removal of soluble salts from the soil. Drainage of agricultural land, as indicated above, is an effective method to maintain a sustainable agricultural system. Land Drainage is used to remove excess water from fields and gardens, in fact any area where excessive water is a problem. An **agricultural land drainage system** is a system by which the water level on or in the soil is controlled to enhance agricultural crop production.

1.2 Definitions

1. Ponding is the accumulation of excess water on the soil surface.
2. Waterlogging is the accumulation of excess water in the root zone of the soil.
3. Leaching is the removal of soluble salts by water percolating through the soil.
4. Salinization is the accumulation of soluble salts at the soil surface, or at some point below the soil surface, to levels that have negative effects on plant growth and/or on soils.
5. A man-made drainage system is an artificial system of surface drains and/or subsurface drains, related structures, and pumps (if any) to remove excess water from an area.
6. Surface drainage is the removal of excess water from the surface of the land by diverting it into improved natural or constructed drains, supplemented,

when necessary, by the shaping and grading of the land surface towards such drains.

7. Subsurface drainage is the removal of excess water and dissolved salts from soils via groundwater flow to the drains, so that the water table and root-zone salinity are controlled.
8. The water table is the locus of points at which the pressure in the groundwater is equal to atmospheric pressure.
9. Agricultural drainage systems are systems which make it easier for water to flow from the land, so that agriculture can benefit from the subsequently reduced water levels.

1.3 Reasons for Drainage

1. Drainage protects the resource base for food production - Irrigation significantly contributes to meeting basic food requirements in that it is used to produce e.g. 60 percent of the rice and 40 percent of the wheat grown in developing countries as well as the bulk of food supplies in the developing countries in which the majority of the world's population lives. However, soils are the ultimate natural resource required for crop production. Reports indicate that close to 0.5 to 1.0 million hectares of irrigated land are lost annually due to soil deterioration caused by waterlogging and salinity. The FAO estimates that of the 250 million hectares currently under irrigation, about 30 million hectares are severely affected by salinity and an additional 60 to 80 million hectares are affected to some extent (FAO, 1994). In Mexico, salinity is encountered in 10 percent of the total area irrigated, in India the figure is 11 percent, in Pakistan 21 percent, in China 23 percent, in the United States 28 percent, and in some Central Asian republics it is over 50 percent.

2. Drainage sustains and increases yields and rural incomes - The effects of saline and waterlogged land on farm economics are detrimental because they cause land to be removed from production and often result in significant yield depressions. Saline and waterlogged conditions severely limit crop choice, diversification, and intensification, adversely affect crop germination and yields, and can make soils difficult to work. Although it is difficult to give general figures on overall yield depressions - they vary with salt concentration, water table depth, soil and the crops cultivated - the no-drainage case leads to income losses, reduces job opportunities, may induce migration, and has negative effects on overall food production.

3. Drainage protects irrigation investment - Irrigation has been the largest recipient of public agricultural investment in the developing world.

4. Drainage infrastructure serves rural and urban residents as well as industry - In many countries, off-farm drainage infrastructure is also used by rural settlements, cities, and industry to dispose of waste water - a benefit rarely considered in planning drainage projects. In Nigeria, almost all industries, e.g. textiles, paint, plastic bottles, grease, oil etc., discharge untreated waste water into the main drains that were constructed for agricultural effluents. Slaughterhouses, chicken factory-farms, and wholesale vegetable markets use the main drains as dumps. The untreated wastewater of half a million residents of a major city is also released into a main drain.

While the volume discharged does not create a capacity problem and does not diminish the system's function for agricultural beneficiaries, non-agricultural usage causes a considerable increase in maintenance requirements and requires hazardous maintenance work in the drains for the working personnel and seasonal workers

who live near such drains. Near Faisalabad (Punjab/Pakistan), a fertilizer plant releases its effluents into a main drain that provides water directly used for irrigating vegetables, and in all canal commands main drains are used by industry and settlements for wastewater disposal. This obviously creates health and environmental problems and requires regulation, though it is undoubtedly beneficial to non-agricultural user.

5. Drainage protects human lives and assets against flooding and high groundwater levels - Well-drained areas and drainage infrastructure provide a buffer (retention area) for torrential rainfall. In the humid tropics monsoon flooding and waterlogging are part of natural conditions, but irrigation has altered the hydrology of the soils and thus aggravated the problem. Agricultural land no longer has the capacity to cope with the high, and highly intense, rainfall. Tremendous losses of human lives and damage to assets occur periodically through uncontrolled floods e.g. in India and Bangladesh.

6. Drainage services improve health conditions - The FAO (1997) estimates that five million people die annually from water-related diseases, i.e. water-related vector-borne diseases (malaria: schistosomiasis. or bilharzasis; Guinea worm infection; lymphatic filariasis, or elephantiasis): water-borne diseases that are of a gastro-intestinal nature (diarrhea), caused by fecal matter, and orally transmitted, as well as diseases related to the transmission of pesticides and pesticide residues in drainage water (non-communicable). Stagnant water on inadequately drained land and in poorly maintained, silted-up drains contributes to the transmission of diseases and escalates their incidence, causing human suffering, health costs, and incalculable costs in terms of unavailable or weak labor forces.

In the absence of domestic water supply and sanitation facilities, drainage water is often used for drinking purposes, washing, bathing, etc.; drainage infrastructure transports untreated wastewater, waste, and human excreta. It is estimated that access to safe water and adequate sanitation could result in two million fewer deaths from diarrhea among young children. With properly designed and maintained drains, vectors could be controlled. Sanitary conditions improve when stagnant water in and near villages is reduced, and pit latrines may work properly if the surrounding area has low water tables. Apart from the positive effects on human health, land drainage is also beneficial to animal health.

7. Drainage and protection of water quality - Irrigated agriculture inevitably produces emissions, and in many countries agriculture is the largest polluter of water bodies as a result of unsustainable land management practices.

Even if water is used efficiently, irrigation uses entail a leaching fraction which contains salt. Water quality problems increase with repeated reuse, disposal in closed basins, and injections and percolation into deep wells, where groundwater is contaminated.

Properly designed and maintained drainage facilities contribute towards controlling effluents from agricultural land. Pollutants like pesticides and fertilizer are conveyed through the drainage systems to receiving water bodies such as rivers or lakes. Water quality problems can be minimized if drainage water is channeled to large open surface water systems with significant dilution or assimilative capacity. However, conveyance may not be the ultimate solution: while it may reduce health and environmental costs on-site, it externalizes problems entailing social costs off-site. These costs can only be reduced and internalized if drainage becomes a part of integrated water resources management.

1.4 Benefits of Drainage

One of the benefits of installing a drainage system to remove excess water is that the soil is better aerated. This leads to a higher productivity of crop land or grassland because:

i. The crops can root more deeply.
ii. The choice of crops is greater.
iii. There will be fewer weeds.
iv. Fertilizers will be used more efficiently.
v. There will be less denitrification.
vi. A properly designed and constructed drainage system removes excess water from the land lowering the water table. It permits aeration of the root zone and warming of the soil when temperatures rise. One of the main reasons for this excess water is when precipitation is far in excess of crop requirements. Crop growth requires drainage

Other benefits of well-drained soils are:

The land is more easily accessible.

1. The land has a greater bearing capacity.
2. The soil has a better workability and tilth.
3. The period in which tillage operations can take place is longer.
4. The activity of micro-fauna (e.g. earthworms) is increased, which improves permeability.
5. The soil structure is better, which also improves permeability.
6. Soil temperatures are higher, so that crops (particularly horticultural crops) and grasses can be grown earlier.

When drainage makes it possible to control the water table, the benefits that follow are:

1. The root zone cannot become salinized by the capillary rise of saline groundwater.
2. Leaching is made possible.

In its turn, the benefits of leaching are:

1. It prevents increases in soil salinity in the root zone, thus making irrigated land use sustainable in the long term.
2. By removing salts, it allows salt-sensitive crops, or a wider range of crops, to be grown.
3. It makes it possible to reclaim salt-affected soils, thus bringing new land into cultivation.

There are four basic requirements for plant growth.

In areas of with excess rainfall or spring runoff, good soil drainage is required to ensure the right amounts of each of these:

1. Food - Plants require the right nutrients in sufficient amounts to grow. Manure and inorganic fertilizers are normally used to supply this need. Nutrients are better utilized by plants in well drained soils.

2. Air - Air is required in the soil for seed germination, growing roots and for the growth of microorganisms and worms that result in good soil structure. Air is not available in poorly drained soils.

3. Water - Plants require the right amount of water for growth. Too much will limit root and plant development, as well as, result in poor trafficability for fieldwork. Too little water will likewise limit crop growth.

4. Warmth - Plants need heat to germinate and to develop to full potential. Well-drained soils warm up more quickly, resulting in earlier, more productive growth.

In areas with excess rainfall or spring runoff problems, a well-planned drainage system will help to meet these requirements. Benefits to expect include the following:

1. Increased crop yield - It is a fact that plants use fertilizers more efficiently in well-drained soils. In addition, drainage allows the root system to develop properly. The plants are able to draw moisture from a larger volume of soil and are therefore better equipped to withstand drought. Well drained and aerated soils are less prone to plant diseases.
2. Longer growing season - A drainage system allows you to get on to your fields sooner in the spring. Tillage and seeding operations can start earlier. As well, the basic crop requirements discussed earlier are available sooner, giving the plant a better chance to reach its potential during the growing season. Weed control is easier since the crop is planted earlier in the spring.
3. Longer harvest season - A drainage system allows you to get on to your fields for longer periods in the fall. This gives a better chance to harvest late crops. Trafficability is increased and there is more opportunity for fall fieldwork.
4. Greater cropping choice & flexibility - Well-drained soils offer greater choice and flexibility of crops. Land previously suitable to only moisture resistant crops may now be suitable for other higher value crops.

5. Potential for sub-irrigation - In relatively flat lands, water control structures to augment the drainage system can be used to raise the water table for sub-irrigation. Water can be backed up to the ditches and subsurface drains and be carried into the root zone by capillary action. Water control structures are essential to limit decomposition in organic soils.
6. Control of erosion by water - When rain falls on poorly drained waterlogged soils; it runs off overland and may carry soil particles with it. Well-drained soils have a capacity to absorb rainfall and runoff resulting in some control of erosion by water.
7. Less soil damage - Soil structure describes how soil particles are arranged. Good soil structure occurs in well-drained soils. A drainage system should, with time, improve soil structure. Soil structure can be easily destroyed by compaction and smearing from farm machinery. Surface crusting from ponded water results from and compounds poor soil structural conditions. Soil structure damage is less likely to occur in well drained soils.

KEY POINTS:

1. Agricultural drainage systems usually increase crop yields on poorly drained soils by providing a better environment for plants to grow, especially in wet years.

2. The systems generally help improve field conditions for timely tillage, planting and harvesting.