UNIT 1 AGRICULTURE

Structure

1.1 INTRODUCTION

Climate change is caused due to emission of greenhouse gases into the atmosphere. The heat trapped by the radiatively active gases causes global warming. The effects of global warming have been experienced by human, animals and plants alike. In this unit, we will deal with climate change and agriculture. There is a two way link between climate change and agriculture. While, it is well acknowledged that change in the world climate is likely to have an impact on agriculture and food security across the globe, agricultural practices are also known to have an impact on climate change. A large portion of the world's agriculture is rainfed and changes in climate play an important role in determining productivity in these regions. This unit will give you an overview of effects of agriculture on environment; and impacts of climate change on agriculture.

1.2 OBJECTIVES

After studying this unit, you should be able to:

- explain the effects of agriculture on environment;
- discuss the effects of climate change on agriculture; and
- explain the adaptation strategies to climate change.

1.3 IMPACTS OF AGRICULTURE ON ENVIRONMENT

Agriculture has a vast impact on environment through land degradation, salinisation, the over-extraction of water and the reduction of genetic diversity in crops and livestock. Thus crop and livestock have a huge impact on the overall environment. Cropping practices are the main source of water pollution by nitrates, phosphates and pesticides. Similarly, livestock is the major anthropogenic source of the greenhouse gases viz. methane and nitrous oxide, and contribute on a massive scale to other types of air and water pollution. FAO, in its summary report titled World Agriculture: Towards 2015/2030 describes about how agriculture affects environment (FAO, 2002). Some important points from the report have been summarised below:

1.3.1 Water Pollution

Pollution of water by pesticides and other plant protection chemicals is a major challenge in most of the developed and developing countries. This happens due to excessive use of plant protection chemicals. These chemicals especially nitrates and phosphates get leached into groundwater or are carried off by runoffs into waterways. This nutrient overload causes what is termed as eutrophication of lakes, reservoirs and ponds, leading to excessive growth of algae which suppress other aquatic plants and animals. Up to half the nitrogen applied in China, is lost by volatilization and another 5 to 10 percent by leaching. Pesticides and herbicides also disturb the biodiversity of an area by destroying all weeds and insects which would have formed food for birds and other animals. Though the pesticides use has reduced in most of the countries over time, the use of herbicides is still on a rise in most countries. In developed countries, their rampant use is checked by imposing regulations and taxes. These days, there is also an increase in the demand for organic crops which are produced without the use of chemical inputs.

1.3.2 Air Pollution

Agriculture is the dominant anthropogenic source of ammonia which causes air pollution. Livestock account for about 40 percent of global emissions, mineral fertilizers for 16 percent and biomass burning and crop residues for about 18 percent. Ammonia being more acidifying than sulphur dioxide and nitrogen oxides is one of the major causes of acid rain, which damages trees, acidifies soils, lakes and rivers, and damages biodiversity. Animal excreta is a predominant source of ammonia emission and is likely to continue rising in both developed and developing countries. Agriculture is also responsible for up to half of all methane emissions. Methane persists for a shorter time in the atmosphere as compared to carbon dioxide but it is twenty times more powerful in its warming effect. Current annual anthropogenic emissions of methane are around 540 million tonnes and are growing at around 5 percent per year. Livestock contributes to about a quarter of methane emissions, by way of gut fermentation and the decay of excreta. Methane emissions from livestock are likely to increase with the growing livestock numbers. Another main source of methane is irrigated rice farming, accounting for about a fifth of total anthropogenic emissions. Agriculture is also a key source of yet another important greenhouse gas i.e. nitrous oxide. Though generated naturally, it is boosted by leaching, volatilization and runoff of nitrogen fertilizers, and by the breakdown of crop residues and animal wastes. Livestock account for about half of anthropogenic emissions. Annual nitrous oxide emissions from agriculture are projected to grow by 50 percent by 2030. Biomass burning results in carbon dioxide, nitrous oxide and smoke particles which are by-products of biomass burning. Biomass burning in the form of burning forests, pastures and crop residues either to promote re-growth or to destroy pest habitats is a common activity. Projections suggest that by 2030, emissions of ammonia and methane from the livestock sector of developing countries could be at least 60 percent higher than at present.

1.3.3 Effects on Biodiversity

One of the biggest challenges facing mankind today is to feed the ever increasing population. In their attempt to meet this challenge, human beings are resorting to activities like deforestation, field consolidation, reduction in field margins and hedgerows, and drainage of wetlands in order to bring more and more land under cultivation. This activity is causing loss of biodiversity by destroying habitats of several plant and animal species. Many species have become extinct and still many are on the verge of extinction. Besides, removing the vegetation cover also exposes the top soil to erosion. Excessive grazing lowers the richness of fodder species. Intensive agriculture and excessive use of pesticides and herbicides reduces insects and plants which would otherwise have been food for higher animals.

1.4 AGRICULTURE AND GREENHOUSE GAS EMISSION

According to FAO estimates, if steps are not taken to reduce the greenhouse gas emission due to agriculture, the emissions from agriculture, forestry and fisheries which have more than doubled during the last 50 years will increase by an additional 30 percent by 2050. The emissions from agriculture and livestock production increased from 4.7 billion tonnes of carbon dioxide equivalents in 2001 to over 5.3 billion tonnes in 2011.

1.4.1 Agriculture as a Source of Greenhouse Gases

The agriculture, forestry and other land use (AFOLU) sector is responsible for about 10–12 gigatonne of CO_2-equivalent per year. GHGs from agriculture are primarily due to land use and land use changes and forestry related activities, enteric fermentation in ruminants, biomass and biofuel burning, lowland paddy cultivation, and use of synthetic nitrogen fertilizers (Lipper et al. 2014; Smith et al. 2014; Venkatramanan and Shah 2019). Enteric fermentation is one of the largest sources of greenhouse gas emission in agriculture. During enteric fermentation, the carbohydrates are broken down by microorganisms into the digestive tract of the ruminants, producing methane as a by-product. This methane is released in the atmosphere via belches. In 2011, it accounted for 39 percent of the total GHG emission of the agricultural sector.

Soil microbes convert nitrogen rich fertilizers into nitrous oxide, a greenhouse gas which has 300 times as much heat trapping power as that of carbon dioxide. When there is an overload of nitrogenous fertilizers, the soil microbes may release high levels of nitrous oxide into the atmosphere. In 2011, emissions generated during the application of synthetic fertilizers accounted for 13 percent of agricultural emissions.

Rice farming is also one of the major contributors to greenhouse gasses. Methane is emitted in large quantities by the bacteria in the waterlogged soil from rice fields which are flooded. Nitrous oxide is another GHG that is produced by soil microbes in the rice fields. These gases generated from rice fields make upto 10 percent of the total GHG emissions from agriculture.

In 2011, 44 percent of agriculture-related GHG outputs occurred in Asia, followed by the Americas (25%), Africa (15%), Europe (12%), and Oceania (4%) according to FAO's data. This regional distribution was fairly constant over the last decade. In 1990, however, Asia's contribution to the global total (38%) was smaller than at present, while Europe's was much larger (21%) (FAO, 2014).

1.5 CHANGING CLIMATE

Climate variability has ripple effects on crop production, food prices and food security at local and global levels. Production shocks in one part of the world can have immense impact on the food prices and hence food security of various parts of the world due to the market dynamics. Sudden changes in food prices could be particularly harsh on the food security of the poor who spend a large chunk of their income on food. Understanding the nature of changing weather patterns is particularly important for this very reason.

Changing Temperatures

"*Global surface temperatures have risen by almost a degree in the last century. Sea levels have risen, while snow and ice cover has dropped significantly. Coral reefs are being destroyed and weather patterns are becoming wilder and less predictable. And the major cause of this climatic mayhem is now clear. It is the work of humans, who are burning ever increasing amounts of fossil fuel and have raised carbon dioxide levels in the atmosphere by 40% in the past 250 years*" (McKie, 2013).

The plant and animal species specific to a particular region are a reflection of the climate to which they are adapted. Once a change in their natural climate occurs, they tend to migrate to areas having more favourable environment. Species that are less mobile are the worst affected as they have to suffer a loss of their habitat combined with competition from new invading species. This results in such species becoming extinct and as a result, there is loss in biodiversity.

Changing precipitation

With increase in temperature due to global warming, the air becomes warm, resulting in more evaporation of water from the Earth's surface. Higher evaporation translates to higher precipitation. On an average, the world is already getting more precipitation now than it did 100 years ago: 6 percent more in the United States and nearly 2 percent more worldwide (US EPA, 2013). Precipitation is expected to lower in areas near equator and increase in higher latitudes. The changing rainfall pattern can cause the pests and weeds to spread to newer areas.

El Nino and La Nina

El Nino phenomenon occuring in the eastern Pacific Ocean is primarily due to the build up of warm water in the eastern Pacific Ocean. The warm ocean surface enables the moisture laden winds to form rainstorms. On the other hand, La Nina occurs due to the building up of cool ocean waters in the eastern Pacific Ocean. The cool ocean surface leads to cooling of the atmosphere leading to lesser evaporation of water and making the air dry.

"*El Niño and La Niña reflect the two end points of an oscillation in the Pacific Ocean. The cycle is not fully understood, but the times series illustrates that the cycle swings back and forth every 3-7 years. Often, El Niño is followed immediately by La Niña, as if the warm water is sloshing back and forth across the Pacific. The development of El Niño events is linked to the trade winds. El Niño occurs when the trade winds are weaker than normal, and La Niña occurs when they are stronger than normal. Both cycles typically peak in December*" (NASA, 2009).

1.6 EFFECTS OF CIMATE CHANGE ON AGRICULTURE

Agriculture, livestock and fisheries are highly dependent on specific climatic conditions. Crops need specific conditions to thrive like right kind of soil, specific temperature, and enough water. Changes in climate could make it difficult for us to grow crops and rear livestock in the way and at places, we used to do in the past. Climate change and variability has potential to influence crop geography, crop production and productivity, and exacerbate the risks associated with crop farming activities (Scherr et al. 2012; Venkatramanan and Shah 2019). IPCC Assessment reports reiterate the gravity of climate change impacts on agricultural production and productivity in several agricultural regions of the world, and firmly expressed the vulnerability of developing countries and island and low-lying countries to negative impacts of climate change (IPCC 2014). Impacts from extreme weather events like droughts and floods, heat and cold waves, must be reckon with in the coming decades through devising appropriate climate resilient pathways (Venkatramanan and Shah 2019).

"Research has shown that crop yields reduce in response to extreme daytime temperatures particularly around 30°C. High daytime and nighttime temperature was reported to reduce the growth, yield and quality of rice and wheat crops which are the staple food crops of South Asia" (Venkatramanan and Singh 2009a,b; Venkatramanan and Shah 2019). "Estimated impacts of both historical and future climate change on cereal crop yields shows that yield loss can be up to 35% for rice, 20% for wheat, 50% for sorghum, 13% for barley, and 60% for maize depending on the geographic location, climate scenarios and projected year" (Porter et al. 2014; Khatri-Chhetri et al. 2017).

The negative effects of climate change on "food production, food prices and accessibility, consumption and utilization" result in marked effect on "all the dimensions of food security" (Porter et al. 2014). Further, climate change on account of its effects on "access to drinking water, income, health, sanitation, income and food supply chain" exacerbate the food insecurity. FAO (2009) reports that vulnerable, and disadvantaged group in particular the small and marginal farmers and food insecure are most likely to be the first affected from climate change (FAO 2009).

1.6.1 Monsoon Dependent Agriculture

The International Food Policy Research Institute (Gerald C. Nelson, 2009) conducted research to "*quantify the climate change impacts on agricultural production, consumption, prices and trade*". To meet this end, the study employed a "global agricultural supply and demand projection model" and "biophysical crop model" to assess the impact of climate change on five important crops: "rice, wheat, maize, soyabean and groundnut". The results of the study on various aspects of agriculture have been summarized below:

According to the study, while the crop yields in the rainfed region are influenced both by rainfall and increases in temperature, the irrigated crop yields are influenced only by temperature factor. The study further points out that in case of developing countries, while the crop yield declines are found across most crops, the irrigated crops of rice and wheat are more vulnerable to climate change. In the regions like East Asia and Pacific region, higher temperature in fact increases crop acreage as the potential temperature increase provide congenial crop growth environment than the present environmental condition. South Asian region will be affected more by climate change, as the study found yield declines for most of the crops. Nevetheless, rainfed maize and wheat crops are more vulnerable to climate change. The results for the Latin American and Caribbean region, and Sub-Saharan Africa were mixed in terms of yields of crops grown in these regions.

1.6.2 Enhanced CO_2 on Crop Growth

"Crop species vary in their response to CO_2. Wheat, rice, and soybeans belong to a physiological class (called *C3 plants*) that respond readily to increased CO_2 levels. Corn, sorghum, sugarcane, and millet are *C4 plants* that follow a different pathway. The latter, though more efficient photosynthetically than C3 crops at present levels of CO_2, tend to be less responsive to CO_2 enriched concentrations. Higher levels of atmospheric CO_2 also induce plants to close the small leaf openings known as *stomata* through which CO_2 enters and water vapour is released. Thus, under CO_2 enrichment, crops may use less water even while they produce more carbohydrates. This dual effect will likely improve water-use efficiency, which is the ratio between crop biomass and the amount of water consumed. At the same time, associated climatic effects, such as higher temperatures, changes in rainfall and soil moisture, and increased frequencies of extreme meteorological events, could either enhance or negate potentially beneficial effects of enhanced atmospheric CO_2 on crop physiology". (Hillel, 1995).

1.6.3 Weeds, Pests and Diseases

Increased CO_2 leads to strong vegetative growth in both crops and weeds alike as a result of which weeds become more prolific and are expected to spread to newer places. There are also studies which prove that higher levels of CO_2 leads to herbicide resistance as a result of which more and more herbicides have to be applied. This may also have serious health implications in time to come. Besides, higher temperatures are favourable for insects and pest proliferation. Longer growing seasons will enable insects and pests to complete larger number of reproductive cycles. Changed wind patterns would lead to spread of wind borne pests and diseases to newer areas. Warmer winter temperatures may shorten the overwintering period of pest larvae resulting in higher proliferation in the next season. Thus an increase in weeds, pests and diseases could soon be a problem calling for immediate action.

1.6.4 Crop Quality

Food systems can be vulnerable to climate change. Grain quality of wheat (e.g. protein content) is highly susceptible to current variations in climate and affects the type of foods that can be produced through, for example, gluten levels and related dough strength (Porter & Semenov 2005). Other examples of the effects of climate on crop quality include pests and diseases, such as dangerous levels of mycotoxin contamination of groundnuts (Julia M Slingo, 2005).

1.6.5 Livestock

Climate change is expected to impact both crops and livestock alike. Increased temperature is bound to increase stress levels among livestock. This may result in decline in the rate of reproduction, increased incidences of diseases and also loss of appetite. Increased levels of CO_2 in the atmosphere may result in production of less nutritious feed and forage which may be required to be supplemented by additives, thus adding to the cost to the grower.

1.6.6 Prices, Production and Food Consumption

The results reveal that though, even without climate change, the prices of rice, maize, soyabean and wheat are bound to rise between 2000 to 2050, however, with climate change, there will be additional price increases to the extent of a total of 32 to 37 percent for rice, 52 to 55 percent for maize, 94 to 111 percent for wheat, and 11 to 14 percent for soybeans. Though the study does not show any direct effect on livestock due to climate change, the effects of higher feed prices caused by climate change pass through to livestock, resulting in higher meat prices. For example, the prices of beef will be 33 percent higher due to no climate change by 2050 and 60 percent higher with climate change.

Importantly, the negative impacts of climate change and variability shall be markedly observed in Sub-Saharan Africa and South Asia. The results have also shown that climate change reduces the consumption of meat slightly and of cereals substantially indicating negative welfare effects due to climate change.

1.6.7 Per capita Calorie Consumption and Child Malnutrition

The results of the study showed that without climate change, the calorie availability increases throughout the world by 2050 whereas with climate change, the calorie availability showed marked reduction relative to 2000 levels.

Further, climate change and variability encompasses increased frequency of extreme weather events like heat waves, droughts, etc. Heat waves, specially occurring during some crucial stages of plant life cycle like pollination or pod set can limit yields. Heat waves can also cause wilting due to excessive transpiration, unless they are provided with irrigation. Droughts result in long term lack of water availability to plants resulting in famines. Strong winds can damage the leaves and heavy rains can cause flooding, both of which can be detrimental to the crops.

If the temperature rise occurs in cooler areas of the world, those places will become more habitable and we may witness crops moving their ranges. In areas where crops are being grown in their warmest productive temperature ranges already, heat stress or increased disease incidence could reduce yields. When temperatures exceed the optimal for biological processes, crops often respond negatively with a steep drop in net growth and yield. If night time temperature minima rise more than the daytime maxima—as is expected from greenhouse warming projections—heat stress during the day may be less severe than otherwise, but increased night time respiration may also reduce potential yields. Another important effect of high temperature is accelerated physiological development, resulting in hastened maturation and reduced yield. (Hillel, 1995).

Since agriculture is dependent on rainfall, any change in its pattern or total precipitation will significantly affect agriculture. Moisture stress, especially during important stages of plant growth like pollination, flowering and grain filling is harmful. Increase in temperature may lead to higher rates of transpiration causing moisture stress in plants and would call for increased need for irrigation. In coming years, the demand for water for irrigation may increase due to warmer climates and agriculture may have to compete with other industries for water. Less rainfall also results in falling water tables which would also increase the energy needed to pump underground water. Scientists and plant breeders are working towards developing new drought resistant varieties of various crops.

Check Your Progress 1

Note: 1. Use the space given below for your answers.

2. Check your answers with those given at the end of the unit.

Q1. What are the effects of changing climate on livestock?

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Q2. What are the effects of changing rainfall pattern on agriculture?

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1.7 AGRICULTURE AS A SINK FOR GREENHOUSE GASES

Agriculture sector can also act as a sink to GHG. Firstly, agricultural sector can reduce its own emission. Plants use CO_2 for photosynthesis. Hence they have the ability to offset emissions from other sectors by reducing CO_2. The biomass generated in agricultural sector can be used to produce biofuels which can be a substitute to fossil fuels which are currently used for energy. Improved management practices in agriculture can help in storage of carbon in plants and soils. Every tonne of carbon added to, and stored in, plants or soils removes 3.6 tonnes of CO_2 from the atmosphere (Paustian et. al, 2006).

Agriculture can increase soil carbon by the following:

1. Cropland Management: Several management practices can increase cropland soil carbon. Carbon inputs to soil can be increased by increasing crop productivity, growing crops that produce large amounts of residues, doing away with the practice of fallow periods between crops, efficient use of fertilizers, manures and irrigation and use of zero tillage or low tillage practices.

2. Management of Grazing Land: Soil carbon of grazing lands can be increased by improved management practices. These management practices include use of proper fertilization, irrigation, cultivation of legumes, improved grazing and use of improved grass species.

3. Changes in land use can also help to increase carbon in soil. Conversion of crop lands to forests or grasslands can increase soil carbon. Highly degraded areas like reclaimed mines, saline soils and eroded lands have high potential of carbon sequestration, if a productive plant cover with high rates of carbon inputs from residues can be achieved.

1.7.1 Mitigation of GHG Emissions from Agriculture

Nitrous oxide and methane are two important greenhouse gasses emitted as a result of both crop and livestock operations. There is a large amount of nitrogen that is supplied to the soil in the form of nitrogenous fertilizers and also from legume crops which fix atmospheric nitrogen. The emission of nitrous oxide is largely influenced by the amount of nitrogen present in the soil. Hence the mitigation rests in efficiently using the soil nitrogen. A proper check on the rate and time of use of nitrogenous fertilizers could help in reducing the nitrous oxide emissions from croplands.

Methane emission through agriculture is largely restricted to flooded soils specially in case of rice cultivation and cultivation of other wetland crops. Mitigation options include choosing rice varieties that have high resistance to methane transport. Also, under aerobic condition, the soil bacteria use methane and convert it into carbon dioxide. This process is known as methane oxidization. Highest methane oxidization occurs in undisturbed soils. Thus use of zero till methods and conservation agriculture will help in creating methane sink on agricultural soils.

Mitigation of methane emitted from animal wastes can be done by capturing and burning the methane emitted from animal wastes which also helps in generation of renewable energy. Similarly, manures produced by livestock also emit nitrous oxide and methane. The nature of emissions from manure depends on the nature of storage practices. While anaerobic storage conditions will produce methane and suppress nitrous oxide emissions, piled storage which is mainly aerobic will suppress methane and increase nitrous oxide emissions. Proper storage preferably anaerobic which will suppress nitrous oxide production and using of the methane produced as a source of energy is one of the ways of mitigating GHG emissions. The methane emission from enteric fermentation is dependent on the type of feed and digestive efficiency of the animals. Incorporating feeds like grain, silage and legume hay which are easily digestible can reduce methane emissions.

Conservation agriculture to mitigate climate change

The spread of Resource Conservation Technologies (RCTs) like conservation agriculture/zero tillage will help to improve soil structure and reduce erosion. Integrated Pest Management which uses the information on life cycle of pests and their interaction with environment in combination with the available pest control methods to manage pests will reduce pesticide use. Use of pesticides should be subjected to more rigorous testing, and residue build up should be more closely monitored.

Farming as a sink for carbon

Soils act as sink which can store carbon in the form of soil organic matter from crop residues and manure. Though, soils have an inherent upper limit for storage, the total amount that can be stored is crop and location-specific and the rate of sequestration declines after a few years of growth before eventually reaching this limit. Some changes like restoration of saline soils could boost the total carbon storing capacity of the soils. However, if the soil reclamation practices are discontinued, the sequestered carbon would be released over a period of a few years.

Agroforestry

Agroforestry is a practice in which woody perennials are deliberately integrated with the farming systems. This helps in improving soil structure and organic carbon content, improving land productivity, increasing infiltration and enhancing fertility and thus reducing the need for fertilizers.

1.8 ADAPTATION TO CLIMATE CHANGE

UNCCD policy brief (UNCCD, 2009) talks about adaptation approaches to climate change, especially drought. These strategies can be extended to other climate change scenarios also.

- ✓ Early Warning Systems: If the possibility of a potential disaster is known in advance, communities can be motivated to establish safeguards particularly at household levels.
- ✓ Strengthening coping mechanisms: New adaptive mechanisms need to be designed based on indigenous knowledge and traditional practices. This would strengthen the capacity of local people to address the issue of climate change within their own communities and social structure.

- ✓ Mitigation activities to support adaptation: Actions promoting sustainable land management improve the natural resource base of a region by restoring soil fertility, improving water availability, etc.
- ✓ Joint Forest Management: Conserving and establishing forests by the communities can help in checking moisture and soil loss and improving soil quality.
- ✓ Diversification of Livelihoods: Studies assessing the diverse systems of a region supporting the local livelihoods and their resilience to climate change will help in determining viable new options that provide innovative solutions.
- ✓ Local Governance: Participation of local communities in policy formulations and project development is very essential. The ability of these communities to develop the rationale for new technologies is crucial to their ability to be flexible when there is great uncertainty.
- ✓ Climate Insurance: Financial instruments on which the communities can bank upon at times of unanticipated risks are a priority.

Check Your Progress 2

Note: 1. Use the space given below for your answer.

2. Check your answers with those given at the end of the unit.

1. Enlist 5 strategies to adapt to climate change.

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1.9 LET US SUM UP

Climate is an important factor of agricultural productivity. Climate change is likely to impact agriculture and food security across the globe. In this unit, you read about the various affects of climate change on agriculture. You have also read about how agriculture affects the environment and the remedial measures that can be under taken to combat the ill effects of agriculture on environment. Towards the end, you read about adaptation strategies that can be used to combat climate change.

1.10 KEYWORDS

Resource Conserving Technologies : Resource Conserving Technologies refer to those practices that enhance resource- or input-use efficiency. Few examples of RCTs are: New varieties that use nitrogen more efficiently; Zero or reduced tillage practices that save fuel and improve plot-level water productivity; Land leveling practices that help save water.

Conservation Agriculture: Conservation agriculture practices involve the characteristics: Soil cover, particularly through the retention of crop residues on the soil surface; Sensible, profitable rotations; and a minimum level of soil movement, e.g., reduced or zero tillage.

1.11 SUGGESTED FURTHER READING/ REFERENCES

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1.12 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress 1

1. Climate change is expected to impact both crops and livestock alike. Increased temperature is bound to increase stress levels among livestock. This may result in decline in the rate of reproduction, increased incidences of diseases and also loss of appetite. Increased levels of CO_2 in the atmosphere may result in production of less nutritious feed and forage which may be required to be supplemented by additives, thus adding to the cost to the grower.

2. Moisture stress, especially during important stages of plant growth like pollination, flowering and grain filling is harmful. Increase in temperature may lead to higher rates of transpiration causing moisture stress in plants and would call for increased need for irrigation. In coming years, the demand for water for irrigation may increase due to warmer climates and agriculture may have to compete with other industries for water. Less rainfall also results in falling water tables which would also increase the energy needed to pump underground water.

Check Your Progress 2

1. Five strategies to adapt to climate change are:
   - ✓ Early Warning Systems
   - ✓ Strengthening coping mechanisms
   - ✓ Mitigation activities to support adaptation
   - ✓ Joint Forest Management
   - ✓ Diversification of Livelihoods