Indira Gandhi
National Open University
School of Agriculture

MEVE 019
ENVIRONMENTAL ISSUES

Block

4
SECURITY AND DEVELOPMENT ISSUES

BLOCK 4 SECURITY AND DEVELOPMENT ISSUES

Block 4 "Security and Development Issues" discusses issues like environmental changes and nutritional security, urbanization and consumerism, multidrug-resistant organisms and Sustainable Development Goals.

Unit 13 "Environmental Changes and Nutritional Security" deals with the factors contributing to agricultural intensification; the effects of agricultural intensification; the features of food security and the challenges faced by the agriculture sector in the 21st century.

Unit 14 "Urbanization and Consumerism" discusses the pattern and causes of urbanization, issues about urbanization and challenges to sustainable urbanization.

Unit 15 "Multidrug-resistant Organisms" deals with the causes, extent and impacts of Multidrug-Resistant Organisms.

Unit 16 "Sustainable Development Goals" deals with the 2030 Agenda for Sustainable Development; the genesis of Sustainable Development Goals; SDG 13 which demands "urgent action to combat climate change and its impacts"; and India's progress and preparedness for achieving SDG 13.

Objectives

After studying this block, you should be able to:

- identify factors contributing to agricultural intensification;
- explain the effects of agricultural intensification;
- explain the features of food security;
- explain the challenges faced by the agriculture sector in the 21st century;
- explain the causes of urbanization;
- discuss the issues about urbanization;
- explain the urban sprawl and growth of slums;
- explain the sustainable cities;
- explain the causes, extent and impacts of Multidrug-Resistant Organisms.
- explain the genesis of sustainable development and sustainable development goals;
- discuss the 2030 Agenda for Sustainable Development and Sustainable Development Goals;
- recognise SDG 13- take urgent action to combat climate change and its impacts and
- review India's progress and preparedness on SDGs 13.

We hope that after studying this block, you will acquire an understanding of the security and development issues.

Wishing you success in this endeavour!

UNIT 13 ENVIRONMENTAL CHANGES AND NUTRITIONAL SECURITY

Structure

13.1 INTRODUCTION

Agriculture is older than the existence of any civilization known to mankind and its history is as old as about 11,500 years. Modern corn got domesticated about 4000years back from a wild grass called Teosintes. Similarly, farmers of various parts of the world had rich knowledge about good cultivars and

they know the importance of preserving them much before the era of Mendel and Darwin. In the post-Mendelian era, scientists helped expand awareness of the Laws of inheritance in the scientific world. The Machine got invented which has decreased both time and effort of manpower to finish the same work. Liebig invented macronutrients for plant growth in the 1840s followed by the invention of inorganic fertilizers by Bosch-Haber. Haber's breakthrough made mass production of inorganic fertilizers and so the crop production. In the late 1860s, mankind was using a chemical pesticide called Paris green against Colorado potato beetles and in 1882 the Bordeaux mixture against downy mildew on grapes in France. Later on, organo-pesticides have been manufactured and used in this sector. Some part of the world was preparing to cope with the post-world war-II crises in the first half of the nineteenth century whereas India was struggling with British rulers and famine. War already made agricultural land infertile and water stress condition was unable to support crop production. World leaders were looking at plant breeders with great hope to feed their countryperson and help developing nations with the surplus grain. Scientists across the world were working to improve varieties of maize, wheat, rice etc. Dr Norman Borlaug became successful in making a high yielding variety of wheat in Mexico called "Mexican dwarf". The Rockefeller Foundation played a very crucial role in developing high yielding rice variety at International Rice Research Institute (IRRI) in 1960 and in the early 1980s started a series of international projects. The genetic diversity of rice (*Oryza sativa*) became the key to creating an ideal type of tropical rice plant, a dream plant suitable for the agroclimatic condition of Asia. Similarly, George Harrison Shull an eminent American plant geneticist in the United States became successful in developing hybrid maize (corn) in the year 1910. The world's agricultural production became more than tripled between 1960 and 2015. The period from 1960 to 2000 became marked as the Green Revolution or agricultural intensification.

For the first time in the year 1974, The World Food Conference held in Rome declared that "every man, woman and child have the right to be free from hunger and malnutrition" and set the goal of eradicating hunger in the world within a decade. As a result, in 1974 Food and Agriculture Organization of the United Nations (FAO) first began reporting on the extent of hunger in the world. 'Triple burden' of malnutrition remains noticed as a global health emergency.

In the 20th Century, agricultural intensification was the only way to feed the troubled people because of war and famine. Many nations were dependent upon the "imported grains". To make the nation self-sufficient to feed was the topmost priority of the politicians and so this gain comes at the cost of environmental degradation that could not foresee. We have enjoyed the optimum harvest in the 20th Century by supplying the best hybrid seed, inorganic fertilizers, using groundwater and converting forests into pasture and agricultural lands etc.

In the crop year 2016/2017, a total of about 2.2 billion metric tons of grain were produced worldwide and corn shares about half of the total by producing 1.05 billion metric tons. Similarly, statistics from India show food grains produced in 2016-17 was about 272 million tonnes and wheat and rice accounted for

78% of the food grains production in the country. Worldwide, the total number of undernourished has been steadily declining, yet it is 821 million in 2017. In India too 14% of the total population remains undernourished.

Yes, we have gained production but the time has come when you have to do remedial measures for the wrong farm practices of the last century. Our soil has been eroded and sick, depletion of groundwater, and loss of agrobiodiversity are of key concern. Climate change is already at its peak and showing its impact through phenomena like El Niño that inflict both drought and flood conditions. No more soil has sufficient organic carbon and an inorganic fertilizer not only has disturbed the soil structure but excessive irrigation has disturbed the soil chemistry further. However, we expect more crop yield from agriculture in the 21st Century. To increase farm yield, we have to revisit some of the socio-ecological practices and appropriately modify them to feed the growing population. Each one has to take a proactive role in tackling the crisis of mammoth size which we have not yet thought of.

13.2 OBJECTIVES

After studying this unit, you should be able to:

- define agricultural intensification;
- identify factors contributing to agricultural intensification;
- explain the effects of agricultural intensification;
- explain the features of food security and
- explain the challenges faced by the agriculture sector in the 21st century.

13.3 AGRICULTURAL INTENSIFICATION

Agricultural production more than tripled between 1960 and 2015, owing in part to productivity-enhancing Green Revolution technologies and a significant expansion in the use of land, water and other natural resources for agricultural purposes. What new happened in the 20th century that supported agricultural intensification in the 20th century? To list important few, the invention of the machine for mechanized farming, chemical fertilizers Chemical pesticides and the availability of high yield crop seeds. FAO Ethics Paper, technically defined agricultural intensification as an increase in agricultural production per unit of inputs (which may be labour, land, time, fertilizer, seed, feed or cash). On a simpler note, it is characterised by a low fallow ratio, higher use of inputs like capital and labour, and higher crop yields per unit of land area.

13.3.1 History of Agriculture

Agriculture is the science and art of cultivating plants and livestock. The history of agriculture goes back thousands of years. It is as old as any recorded civilization. The early man survived by gathering grains from wild cultivars and around 11,500 years ago they have learnt to grow them in the field. Similarly,

animals like sheep, cattle etc. were domesticated over 10,000 years ago and used as means of transportation, food and as help in plant cultivation. People have gained knowledge about "cultivars" and varieties of food grains for more than 10,000 years ago. This knowledge was transferred from generation to generation through field observations in a more traditional way. Access to water and means of transport created different civilizations like Indus Valley, Ancient Egypt, Ancient Greece, Roman Empire, ancient china, Sumer etc. and people were living in coherence with nature. People of the Indus valley civilization (3000-1500 BC) were growing rice about 4000 years ago. Teosintes, the wild grass of the Poaceae family were native to Mesoamerica and it was already hybridized to become modern corn (Zea mays). Evidence of rice cultivation has been found at Lothal and Rangpur and later during the Harappan period as well. Later, different crop species were under cultivation on different continents of the world but people were unaware of the existence of different continents and innovations already happened in other parts. Means of transport were through sea and land, Christopher Columbus in 1492, discovered a new world, America and that's how the world came to know about crops like maize, potatoes, sweet potatoes etc. Improvement of cultivated crops and domestic animals kept practised through hereditary influence but without knowing how it happens? Scientists from across the globe have worked to improve plant and animal cultivars. Science did progress in every arena of life.

To work upon a larger patch of land, the cultivators needed help from machines. Machine decreased both the number of manpower to finish the same in much less time. We came to know how macronutrients (Nitrogen, Phosphorus, Potash) are important for plant growth and credit goes to German chemist Justus von Liebig in the 1840s, and so scientists invented inorganic fertilizers. Fritz Haber, the German chemist (1911) developed the high-pressure method of extracting nitrogen from the atmosphere that is used today to produce nearly all the nitrogen used in industry and agriculture. Carl Bosch, working for German chemical company BASF, scaled up Haber's laboratory experiment to industrial production. Pests were a problem and managing a variety of them was getting difficult and that's how experiments with inorganic chemicals started followed by the synthesis of organics.

13.3.2 Drivers of Agricultural Intensification in the 20th Century

13.3.2.1 Worldwide Plant Breeding Programmes

By 1900, cells and chromosomes were sufficiently understood to give Mendel's abstract ideas a physical context (Roberts,1929). During the first half of the 20th century, there were two separate, but not distinct, areas of genetic studies: 1) more classical genetics to study segregation and gene expression for many major genes, and 2) areas of genetics designated as quantitative genetics, biometrical genetics, and population genetics to study allele frequencies and their effects for the inheritance of complex traits.

The development of the world-famous "Marquis wheat" in Canada, released

to farmers in 1900, came about through sustained scientific effort. Sir Charles Saunders (1867 – 1937), a Canadian agronomist discovered "Marquis" wheat. He followed five principles of plant breeding: (1) the use of plant introductions; (2) a planned crossbreeding program; (3) the rigid selection of material; (4) evaluation of all characteristics in replicated trials; and (5) testing varieties for local use. Marquis was the result of crossing wheat long grown in Canada with a variety introduced from India. For 50 years, Marquis and varieties crossbred from Marquis dominated hard red spring wheat growing in the high plains of Canada and the United States and were used in other parts of the world. Early plant improvers, such as England's Thomas Knight, John LeCouteur, and Patrick Shirreff for example, had some successes in selecting and breeding new wheat varieties. Similarly, rice crop improvement work was intensively carried out at The International Rice Research Institute (IRRI).

The third grain type that contributed to the green revolution was maize. Sturtevant (1899) reported that there were 189 distinct maize cultivars in the United States at the end of the 19th century. Two scientists, Edward Murray East and George Harrison Shull independently established a sound biological basis for hybrid corn in the early 1900s. Donald F. Jones invented the double-cross in 1917, a method of hybrid seed production that made possible the practical application of the earlier discoveries of East and Shull.

So, far we have seen how plant breeders became active across the globe to enhance the food grain production mainly wheat and rice to feed the exhausted people of war and famine at the beginning of the mid-20th century.

13.3.2.2 Use of Machines and Pesticides

Intensification of land use and labour power were two important processes of change during the 19th and 20th centuries. Yields quantify the effectiveness of land intensification, which is denoted in kilograms of useful crop produced per hectare of land used. Chemical fertilizers, irrigation techniques, application of weedicides and pesticides and use of plant breeding for improved varieties for improved seed grain production can be put in class "intensification of land use". The aspect of intensification of labour-power is usually quantified by crop product produced per capita of human labour used. Mechanization provided the greatest opportunity for intensification of human labour-power.

Before 1960, mankind invented machines which have reduced the work of man in the field. Before 1840, herbal extracts like pyrethrum, nicotine etc. were used as pesticides. In the late 1860's Paris green, chemical name Copper acetoarsenite became the first chemical that become successful to kill Colorado potato beetles in the American Midwest. Later in the year 1882, the Bordeaux mixture a mixture of calcium hydroxide and copper (II) sulphate came to act against downy mildew on grapes in France and lead arsenate was used against gypsy moths (1892) in the United States. In the year 1917, Calcium arsenate, developed, was the first synthetic chemical extensively used on a field crop, cotton. Paris green, Bordeaux mixture, lead arsenate, and calcium arsenate were all based on inorganic materials and the toxicity of metals.

The use of synthetic organic chemicals came into existence in the 1950s. Para-dichlorobenzene (1-4 Dichlorobenzene) became the first organo-chemical that has acted against peachtree borer. Dichlorodiphenyltrichloroethane, having a common name DDT became the most widely used product.

13.3.2.3 Use of Chemical Fertilizers

Plants generally require soil containing high amounts of available nitrogen, phosphorus and potassium, called macronutrients as well as other micronutrients. Justus von Liebig emphasized the role of nitrogen (N), phosphorus (P) and potash (K) on plant growth and also proposed the "Law of the minimum" in 1843, i.e., crop yields are proportional to the amount of the most limiting nutrient. Jean-Baptiste Boussingault a French chemist, his works and experiments contributed to an understanding of the critical role of nitrogen in plant growth and ecological systems.

However, plant nutrients are classified into three sub-groups based on plant growth needs.

- Macro or primary nutrients: nitrogen (N), phosphorus (P), potassium (K)
- Major or secondary nutrients: calcium (Ca), magnesium (Mg) and sulphur (S), and
- Micronutrients or trace elements: Chlorine (Cl), Iron (Fe), manganese (Mn), boron (B), selenium (Se), zinc (Zn), copper (Cu), molybdenum (Mo) etc.

Later, Fritz Haber (1911) developed the high-pressure method of extracting nitrogen from the atmosphere and Carl Bosch scaled up Haber's laboratory experiment to industrial production. Fritz Haber's synthesis of ammonia from its elements, hydrogen and nitrogen, earned him the 1918 Nobel Prize in Chemistry. Haber's breakthrough made mass production of inorganic fertilizers possible and led to a massive increase in the growth of crops and crop production for human consumption. The formation of synthetic nitrogenous fertilizer involves the formation of ammonia from atmospheric nitrogen and the formation of urea using ammonia. Many modifications have been done since the inception of the Haber-Bosch process. Of the 150 million tonnes of ammonia synthesized each year, approximately 83% goes to the manufacture of fertilizers needed for the agriculture sector alone. This has contributed significantly to intensive farming in the 20th century. Sir John Bennett Lawes, produced superphosphate in England in 1842. A combination of synthetic and organic fertilizers can be used to obtain nutrient balance and optimize plant growth.

Different macro-nutrients play a specific role in the plant's growth and so its amount in the soil gets depleted with each harvest. Intensive agriculture so needed it more. The global demand for synthetic nitrogenous fertilizers is increasing year after year. The need for N, P, K varies from plant-to-plant species and nitrogen is the most important primary nutrient, accounting for more than 50% of total consumption. About 50% of the nitrogen applied to crops is absorbed while the remaining is lost to the soil.

13.3.2.5 Irrigation

Water is a critical input for agricultural production and plays an important role in food security. Irrigated agriculture represents 20% of the total cultivated land and contributes 40 per cent of the total food produced worldwide. Irrigated agriculture is, on average, at least twice as productive per unit of land as rainfed agriculture, thereby allowing for more production intensification and crop diversification. The agriculture sector alone is using the world's 70% of groundwater. The United Nations Department of Economic and Social Affairs projects that the global population to reach between 8.4 and 8.6 billion people by 2030 and between 9.5 and 13.3 billion in 2100. FAO estimates that over the last century the global water withdrawal grew 1.7 times faster than the population, which aggravates the concern over the sustainability of water use as demand for agricultural, industrial, and domestic uses continues to increase.

About 90 % of the global food production increase needed by 2050 is projected to take place in developing countries, whose share of global food production will rise to 74% in 2050 (from 67% in 2007). Agricultural output increase in developing countries will be particularly strong for livestock production, with their share in global production growing from 55 % in 2005/2007 to 68 % in 2050.

Global withdrawal of groundwater is estimated to have grown from a base level of 100–150 km^3 in 1950 to 950–1000 km^3 in 2000. 40% of actually irrigated areas in the world can be attributed to groundwater sources.

Intensive farming is credited, especially in Asia, with having jump-started economies, alleviated rural poverty, and saved large areas of fragile land from conversion to extensive farming. Over the past half-century, since the advent of the Green Revolution, the world's annual production of cereals, coarse grains, roots and tubers, pulses and oil crops has grown from 1.8 billion tonnes to 4.6 billion tonnes. Growth in cereal yields and lower cereal prices significantly reduced food insecurity in the 1970s and 1980s, when the number of undernourished fell, despite relatively rapid population growth. Overall, the proportion of undernourished in the world population declined from 26% to 14% between 1969-1971 and 2000-2002 (http://www.fao.org/ag/save-and-grow/en/1/index.html)

Through this subsection, we understood the reasons behind the agricultural intensification and some of the important processes followed to achieve it in the 20th century. Since chemical fertilizers were utilized in a big way, groundwater also got exploited to achieve production many fold by growing hybrid crop types mainly wheat, rice and maize. Surely, we have quantified the gain in terms of crop productivity. South Asia alone has seen enhance in cereal production by 50% between 1975 and 2000 and poverty declined by 30%. But, the time has come when we have to count the loss as well. As we forgot many thousands of years old practices we were following to keep good health of the soil, the

precious natural resources like water and especially groundwater and last but not the least the loss of many species and indigenous cultivars. Let's discuss how agricultural intensification has impacted soil health.

13.4 EFFECTS OF AGRICULTURAL INTENSIFIC ATION

We all know that the basic components of soil are minerals, organic matter, water and air. The typical soil consists of about 45% mineral, 5% organic matter, 20-30% water, and 20-30% air. The particle size in the range of 0.05 – 2.00 mm in diameter is called sand; 0.002 – 0.05 mm in diameter as silt and clay, the finest one has a diameter less than 0.002 mm. The percentage of sand, silt, and clay found in the soil give "texture" to the soil. Whereas, the arrangement of the solid parts of the soil and the pore space located between them give them structure". Formation of soil from parent rock takes 200-400 years in a mild climate whereas; to get soil all the virtues to sustain life may take a few thousands of years.

Factors like population explosion, war, natural hazards, urbanization, land-use change including intensive agriculture etc. have been a huge toll on soil health and are on a constant rise. The agriculture sector will further need to increase its production by 70% to feed people in 2050. So, the situation of soil can be well imagined if we continue with the practices we are following. The irreparable loss of soil already gets hit as a result of the intensification of agricultural production is irreversible. With, this background, let us study how intensive agriculture has affected soil health.

13.4.1 Soil Degradation

Soil degradation is the decline in physicochemical and biological properties of soil. It can be the loss of organic matter and the release of greenhouse gases, the over-application of fertilizers, soil erosion, soil contamination, change in pH (soil acidification and salinization), and loss of soil microbial diversity. More than 33% of global soil has already been degraded due to factors like erosion, salinization, acidification, contamination, or compaction whereas, 52% of agricultural land has been affected by soil degradation. Need not to say, both land and soil degradation will further put in toll on the food price as a result of decreased yield.

The impact of agricultural intensification on soils includes degradation by loss of soil organic matter and the release of greenhouse gases, over-application of fertilizers, erosion, soil contamination, acidification, salinization, and loss of soil genetic diversity.

Soil degradation in India is estimated to be occurring on 147 million hectares (Mha) of land, including 94 Mha from water erosion, 16 Mha from acidification, 14 Mha from flooding, 9 Mha from wind erosion, 6 Mha from salinity, and 7 Mha from a combination of factors. Estimates of the loss of nutrients, using the annual soil specific erosion rates provided by the Central Soil and Water Conservation Research and Training Institute, ICAR, show that nearly 74 million tons of major nutrients are lost due to erosion annually in India. On average, every year, the country loses 0.8 million tons of nitrogen, 1.8 million tons of phosphorus, and 26.3 million tons of potassium.

13.4.1.1 Loss of Soil Organic Matter

Soil organic matter (OM) includes both, the plant and animal material in any form which returns to the soil through the process of decomposition. It not only provides the needed nutrients to plants but also provides shelters to a range of microbes. It further acts as a binding material to the soil, enhances the cation exchange capacity of the soil and so increases the water holding capacity of the soil. Mineralization makes nutrients available in a soluble form to plants through the process of oxidation. With each harvest organic matter gets extracted from the soil and so organic carbon gets reduced to 30-60%.

Other factors responsible for the loss of organic soil are increased activity of soil microbes, environmental conditions like increased temperature and humidity etc. Depletion of organic carbon goes hand in hand with the water availability in soil. Water stored in the soil is one of the crucial factors that decide agricultural production.

Mineralization is directly proportional to the type and duration of harvest. More number of crops per annum means more mineralization. Secondly, for intensive farming, more forest cover has also been changed to agricultural land which also led to the release of greenhouse gases.

Factors apart, global warming plays its catalytic role as well in unlocking soil organic carbon.

Now, the time has come when we have to give back organic matter to the soil through the methods of sustainable farming.

13.4.1.2 Overuse of Chemical Fertilizers

The application of nitrogenous followed by phosphatic and potash fertilizer has changed global food production. In intensive farming, overuse of these chemical fertilizers was commercially non-viable for farmers but also caused soil acidification and contamination of groundwater. Contamination does not get limited to the groundwater but it reaches farm ponds and streams, resulting in the eutrophication of water bodies. The excess loading of inorganic fertilizers perturbed the natural biogeochemical cycle and hence created contamination. Plant uptake nitrogen-fertilizer in the form of Nitrate (NO_3^-) and ammonium ion (NH_4^+).

Overuse of nitrogen-containing fertilizers combined with the high nitrate (NO_3^-) leads to increased leaching into groundwater, so causing groundwater pollution. Nitrate levels above 10 mg/L (10 ppm) in groundwater can cause "blue baby syndrome". The most common form of phosphorus fertilizer used in agricultural practices is phosphate (PO_4^{+3}). Excess use also resulted in the emission of nitrous oxide (N_2O) which has a global warming potential of 300 times that of unit CO_2 over 100 year of time scale. Loss through leaching of mineral-nitrogen became higher when nitrate fertilizer was used as compared to urea or ammonium fertilizer. So, leaching is influenced by the type of N-fertilizers and crop type as well. Hence, farmers need to know more about the application as per the soil and crop type to avoid such losses.

Practices to Enhance Fertilizer Use Efficiency

Following practices are in-use to enhance fertilizer use efficiency in India.

1. **Precision Nutrient Application:** *Precision application* of *nutrients* on a site-specific basis, is one of the key components of *precision* agriculture and governs all the major issues of improving productivity, sustainability, profitability and climate change-related turbulences.
2. **Nano Fertilizers:** *Nanofertilizers* are being prepared by encapsulating plant nutrients into nanomaterials (iron and zinc etc.)
3. **Soil Health Card Mission, India:** The scheme was launched on 19th February 2015. Under the scheme, the government plans to issue soil cards to farmers which will carry crop-wise recommendations of nutrients and fertilisers required for the individual farms to help farmers to improve productivity through judicious use of inputs.
4. **Neem Coated Urea (NCU):** C*oating urea* with *neem* seed oil ensures that all the *urea* applied is utilised by the plants.
5. **Variable Rate of Technology (VRT):** It allows fertiliser, chemicals, lime, gypsum, irrigation water and other farm inputs to be applied at different rates across a field, without manually changing rate settings on equipment or having to make multiple passes over an area.
6. **Placement of Nutrients:** *Placement of nutrients* and fertilizer rates are important factors to be considered to produce the maximum yield of crops. Fertilizer *placement* leads to higher plant *nutrient* content than broadcast. NH_4^+ + P or Urea + P placed at 10–20 cm soil depth shows the best plant growth
7. **Promotion of N Fixing Crops**
8. **Organic Farming:** As per the definition of the USDA study team on organic farming "organic farming is a system which avoids or largely excludes the use of synthetic inputs (such as fertilizers, pesticides, hormones, feed additives etc) and to the maximum extent feasible rely upon crop rotations, crop residues, animal manures, off-farm organic waste, mineral grade rock additives and biological system of nutrient mobilization and plant protection". In another definition, FAO suggested that "Organic agriculture is a unique production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles and soil biological activity, and this is accomplished by using on-farm agronomic, biological and mechanical methods in exclusion of all synthetic off-farm inputs". Conventional *farming* is no longer sustainable so India's farmers have picked up again this farming towards food safety and sustainability.
9. **Integrated nutrient management (INM):** It refers to the maintenance of soil fertility and plant nutrient supply to an optimum level for sustaining the desired crop productivity through optimisation of the benefits from all possible sources of plant nutrients in an integrated manner. 500 million tons of crop residue is available in India which can provide 200 million tons of organic carbon. Per ton of crop residue provides Nitrogen 5.5 kg; Sulphur 1.2 kg; Phosphorus (approximately 40%) 2.3 kg; Potash (approximately 10%) 25.0 kg; Organic Carbon 400 kg. So, integrating crop residue not only reduces the cost of fertilizers and strengthens the organic carbon along with other nutrients too.

13.4.1.3 Soil Erosion

Soil erosion is the removal of the most fertile top layer of soil by natural factors like water and wind or through farming activities such as tillage or overgrazing. It can be caused by natural elements such as wind, water, and glacial ice.

- Wind erosion- It is also called eolian i.e., the transport of loosened soil particles by overland flow.
- Water-
  - **i. Gully erosion:** When runoff water accumulates and rapidly flows in narrow channels during or immediately after heavy rains is called gully erosion.
  - **ii. Sheet erosion:** When water flows as a sheet down a slope and as a result, the top part of the land is washed away is called sheet erosion.
  - iii. R**avine:** Ravines are typically classified as larger in scale than gullies, although smaller than valleys. It is a landform that is narrower than a canyon and is often the product of stream bank erosion.

Intensive farming promoted monocropping, the practice of growing the same crop on the piece of land, year after year. As a result, land lost nutrients and usage of inorganic fertilizer and flooding mode of irrigation played a synergistic role to degrade the soil through depletion of the binding material i.e., soil organic carbon. These factors caused loosening of the soil and hence made topsoil vulnerable.

Box 13.1 "Dust Bowl" experienced in the United States during the early 1930s!

As a result of dependence upon inorganic fertilizer and no application of organic fertilizers led to a condition called the "Dust Bowl", in the section of the Great Plains of the United States that extended over wheat fields of Kansas, Texas, Oklahoma, and South-eastern Colorado in early 1930s. Experts assured that “rain followed the plough." But between 1933 and 1935, drought struck the area. As a result, over half a million people were left homeless when their topsoil blew away. In a single storm, beginning on November 11, 1933, topsoil from Oklahoma was blown to Chicago, where over 12 million pounds of it fell on the city like snow. Like alfalfa, guano, and nitrate in the nineteenth century, America's topsoil was travelled from west to east. On Black Sunday, April 14, 1935, dust storms were reported from the Canadian border to Texas. Visibility was less than five feet through the blowing dust. The agricultural disaster that became known as the "Dust Bowl" caused a mass departure of people from the high plains region that should never have been put under the plough. When the farms blew away the whole region was wiped out. This single incidence of soil erosion created more than 116,000 refugee families on their way into California. Only by 2012, the region was once again producing 700 million bushels of wheat with the use of irrigation.

(Source:https://mlpp.pressbooks.pub/americanenvironmentalhistory/chapter/chapter-8-green-revolution/)

Status of Soil Erosion in India

- It has been estimated that an area of over 80 million hectares or about one-fourth of our total area is exposed to wind and water erosion out of which 40 million hectares have undergone serious erosion.
- About 21 million hectares are subject to severe wind erosion in Rajasthan and adjoining areas of Punjab, Haryana, and Gujarat. Wind erosion is a serious problem in arid and semi-arid parts of North-West India.
- 34 lakh tonnes of fertile soils are removed by the wind every year in the districts of Jodhpur, Bikaner, Kota, Jaipur, Bharatpur, Kishangarh etc. in Rajasthan. These areas receive scanty rainfall, devoid of vegetation cover and have sandy soil.
- According to estimates by the Indian Council of Agricultural Research (ICAR), the loss due to water erosion is 53.34 million hectares annually. There are 39.75 lakh hectare ravines spread in 18 states, out of which 27.65 lakh hectares (or 69.55 per cent) are in the states of Uttar Pradesh, Madhya Pradesh, Rajasthan and Gujarat.
- Chambal Development Scheme has shown that the area covered by ravines up to 4.5-6.0 metres in depth is about 50,600 hectares.
- In Madhya Pradesh, about 4 to 8 lakh hectares are affected by deep gullies and ravines along the banks of rivers Chambal and Kali Sindh. Out of this, about 2.4 lakh hectares are in the districts of Gwalior, Morena and Bhind.
- States like West Bengal, Bihar and Uttar Pradesh are affected by ravines. The Ganga River alone is transporting about 30 million tonnes of eroded material per annum from the Gangetic plain to the Bay of Bengal. Similarly, the Brahmaputra is transporting about 10 million tonnes annually from the Brahmaputra valley to the Bay of Bengal.
- More than 15 lakh hectares of forest land are cleared for shifting agriculture every year. The total area affected by shifting cultivation is estimated to be 45 lakh hectares. This is causing soil erosion, especially in Assam, Meghalaya, Tripura, Nagaland, Mizoram, Kerala, Andhra Pradesh, Orissa, Madhya Pradesh, Chhattisgarh etc. It is reported that about 207,287 hectares in Assam, 41,963 hectares in Tripura and 21,862 hectares in Manipur are under shifting cultivation. In Orissa, about 33,08,502 hectares of land are subjected to shifting cultivation.

Management of Soil Erosion

Buffer Strip: Buffer strips are similar to bioswales as both control running water and contain loose sediment.

Crop Rotation: Crop rotation is growing a new type of crop in a field each year to help fight soil erosion.

Mulching: Applying a layer of mulch like wheat straw, wood chips, plastic sheet etc to the soil top prevent loss of water through evapotranspiration and restores soil pH.

Reforestation: It is the simplest way to reduce soil erosion by doing plantation.

Terracing: Turning the hill into terraces running across the slope can reduce soil erosion.

Bunding: It is a creation of obstruction on the path of erosion to slow down the motion of run-off.

Windbreakers: On the margin of crop fields, the plantation of evergreen trees slows down the wind speed by acting as windbreakers and reducing wind erosion.

Social Forestry: It can be best utilized to reduce erosion in the barren land. Through the participation of local people, the best possible barren lands like the side of rail tracks, river banks etc. can be reforested.

13.4.1.4 Soil Contamination

Soil gets contaminated because of factors like the use of pesticides and fertilizers, improper disposal of livestock waste, livestock and agricultural deforestation. Pesticides and herbicides used in the agricultural fields to control pests and weeds respectively are persistent and it gets biomagnified as we move up in the trophic levels. Contamination of food crops with arsenic (As) is widely observed in the lower Gangetic plains of India and Bangladesh due to irrigation with contaminated groundwater.

Main Sources of Contamination

1. **Fertilizers**

   Plants must get not only macronutrients (N, P, K, S, Ca, and Mg), but also essential micronutrients (Co, Cu, Fe, Mn, Mo, Ni, and Zn). Large amounts of inorganic fertilizers are regularly added to soils in intensive agriculture systems to provide sufficient N, P, and K for plant growth. The compounds contain trace amounts of heavy metals (e.g., Cd, Pb, Hg) as impurities and as a result, gets accumulated over years in the soil. Metals, such as Cd and Pb, have no known physiological activity. Application of certain phosphatic fertilizers inadvertently adds Cd including F, Hg, and Pb to the soil.

2. **Pesticides**

   Several common pesticides used fairly extensively in agriculture and horticulture in the past contained fair concentrations of heavy metals. Many insecticides and fungicides such as Bordeaux mixture (copper sulphate) and copper oxychloride contain Cu, Hg, Mn, Pb, or Zn as well. There are copper-containing fungicidal sprays in practice whereas lead arsenate was earlier used in fruit orchards to control some parasitic insects. Arsenic-containing compounds were also used to control cattle ticks and control pests in bananas and Cu, Cr, and As (CCA) are used to preserve the timber. Leaching of these compounds has enhanced the soil concentrations far more than the background concentration.

3. **Biosolids and Manures**

   Biosolids (sewage sludge) are primarily organic solid products, produced by wastewater treatment processes. Typical examples of biosolids are livestock manures, composts, municipal sewage sludge etc. These are added to land and inadvertently lead to the accumulation of toxic heavy metals such as As, Cd, Cr, Cu, Pb, Hg, Ni, Se, Mo, Zn, Tl, and Sb. In the pig and poultry industry, the Cu and Zn are added to diets as growth

promoters and As are contained in poultry health products such as roxarsone (3-nitro-4-hydroxyphenylarsonic acid). These heavy metals are potentially toxic, even get biomagnified and get transferred from soil to crops grown.

In the United States, more than half of approximately 5.6 million dry tonnes of sewage sludge used or disposed of annually are land applied whereas, in Europe, over 30% of the sewage sludge is used as fertilizer in agriculture. Heavy metals most commonly found in biosolids are Pb, Ni, Cd, Cr, Cu, and Zn, and depend upon the intensity of the industrial activity and processes involved in biosolids treatment. Applications of biosolids can be leached downwards through the soil profile and can have the potential to contaminate groundwater as well.

4. Wastewater

The use of municipal and industrial wastewater and other effluents is a common practice in many parts of the world. Worldwide, it is estimated that 20 million hectares of arable land are irrigated with wastewater. In several Asian and African cities, studies suggest that agriculture based on wastewater irrigation accounts for 50% of the vegetable supply to urban areas. Effluent treatment is still done improperly in the developing countries and these became a potential source of pollution to many rivers including the Ganga River in North India.

5. Metal Mining, Milling Processes and Industrial Wastes

Mining and milling of metal ores along with the smelting process became a potential source of metal contaminants in soil. During mining, heavier and larger particles settled at the bottom of the flotation cell. Tailings are directly discharged into wetlands and pits resulting in elevated concentrations. Industries such as textile, tanning, petrochemicals from accidental oil spills or utilization of petroleum-based products, pesticides, and pharmaceutical facilities are also sources of soil contamination

6. Air-borne Sources

Airborne sources of metals include emissions of air, gas, vapour streams etc. Metals such as As, Cd, and Pb can also volatilize during high-temperature processing, will convert to oxides and condense as fine particulates. Very high concentration of Cd, Pb, and Zn has been found in plants and soils adjacent to smelting works. Another major source of soil contamination is the aerial emission of Pb from the combustion of petrol containing tetraethyl lead; this contributes substantially to the content of Pb in soils in urban areas and those adjacent to major roads. Zn and Cd may also be added to soils adjacent to roads, the sources being tyres and lubricant oils.

Soil Remediation

Through various physical, chemical and biological processes, soil remediation can be achieved. Hybrid approaches are mostly in practice to make the process cost-effective.

A. Chemical Method

1. Solidification/Stabilization (S/S)

Solidification involves the addition of binding agents to a contaminated material to impart physical or dimensional stability to contain contaminants in a solid product by reducing access through a combination of chemical reaction, encapsulation, and reduced permeability. Stabilization also termed fixation, involves the addition of reagents to the contaminated soil to produce more chemically stable constituents. Conventional S/S is an established remediation technology for contaminated soils and treatment technology for hazardous wastes in many countries in the world.

2. Immobilization Techniques

Ex-situ and in-situ immobilization techniques are practical approaches to the remediation of metal-contaminated soils. The ex-situ technique is applied in areas where highly contaminated soil must be removed from its place of origin, and its storage is connected with a high ecological risk (e.g., in the case of radionuclides).

3. Vitrification

It is a high-temperature treatment of the contaminated area that results in the formation of vitreous material, usually an oxide solid. The increased temperature may also volatilize metal species (such as Hg) and destroy organic contaminants. It may be performed ex-situ or in-situ but in-situ processes are preferred to reduce the overall cost of energy and transport. This process can be easily applied for the reclamation of heavily contaminated soils with Pb, Cd, Cr, asbestos, and materials containing asbestos.

4. Biochar

Biochar (BC) is a charcoal-like substance that's made by burning organic material from agricultural wastes in a controlled process called pyrolysis. Pyrolysis at high temperatures generally produces hydrophobic biochars with higher surface area and micropore volume, allowing them to be more suitable for organic contaminants sorption, whereas biochars produced at low temperatures own smaller pore size, lower surface area, and higher oxygen-containing functional groups and are more suitable to remove inorganic contaminants. Nowadays both alkali modified BC and nanomaterial impregnated BC composites are highly favourable for enhancing the adsorption of different contaminants from wastewater.

B. Physical Process

1. Soil Washing

Soil washing is mainly a volume reduction/waste minimization treatment process. It is done on the excavated (physically removed) soil (ex-situ) or on-site (in-situ).

C. Phytoremediation

Phytoremediation is defined as an in-situ remediation method that uses vegetation and associated microbiota, soil amendments, and agronomic techniques to remove, contain, or render environmental contaminants harmless. Phytoremediation is energy efficient, aesthetically pleasing way

of remediating sites with low-to-moderate levels of contamination. It is more economically viable, and less disruptive to the environment using the same tools and supplies as agriculture. No disposal sites are needed. It avoids excavation and transport of polluted media thus reducing the risk of spreading the contamination etc. There are more precise ways to decontaminate soil or effluents.

a) **Phytoextraction:** It is the term given to the process where plant roots uptake metal contaminants from the soil and translocate them to their above soil tissues.

b) **Phytostabilization:** It is also referred to as in-place inactivation with the use of certain plants to immobilize soil sediment and sludges. Contaminants are absorbed and accumulated by roots, adsorbed onto the roots, or precipitated in the rhizosphere.

c) **Phytofiltration:** It is the use of plant roots (rhizofiltration) or seedlings (blastofiltration), is similar in concept to phytoextraction, but is used to absorb or adsorb pollutants, mainly metals, from groundwater rather than the remediation of contaminated soils.

13.4.1.5 Acidification

The optimal pH range for most plants is between 5.5 and 7.0. Soil acidification is the build-up of hydrogen cations (H^+) in the soil, which reduces the soil pH typically below 5.5. Soil acidification is a major problem in crop production, affecting 40% of the world's arable land and about 30% of global land surfaces. In India, out of 142 Mha of arable land, around 48 to 49 Mha is occupied by acid soils, of which 25 Mha show pH below 5.5 and 23 Mha have pH between 5.6 to 6.5.

Causes of Soil Acidification

1. **Soil Organic Matter:** Organic matter optimal in content has positive effects on the growth of plants but the increasing amount of organic matter may make the soil more acid.
2. **Over-application of N-fertilizers:** Over-application of N-fertilizers leads to the leaching of anions like nitrate ion (NO_3^-) and the addition of lime (Ca^{2+}) both these factors contributed to the reduction of the soil pH.
3. **Excess of Rainfall:** Weather condition where rainfall exceeds evapotranspiration also makes the soil acidic.
4. **Lack of perennial grass/forest:** For intensive agriculture, perennial grass, forest etc. got cleared to make crop fields as a result, roots which were there to capture nitrate caused its leaching down the soil profile, thus leading to faster rates of acidification.

Impact of Soil Acidity on Crop Growth

1. **Poor plant growth and reduced productivity:** Plants that are sensitive to acidity will decline in growth and productivity allowing weeds to increase or reduce soil cover which can lead to soil erosion. Plants sensitive to acidity include canola, lucerne, barley, beans, peas, medics and wheat.
2. **Nutrient loss:** In strongly acid soils, potassium, calcium and magnesium can be depleted by leaching or removed in products such as hay and grain.

A lack of calcium can also contribute to soil structural problems

3. **Nutrient tie-up:** Nutrients such as phosphorus and manganese can become unavailable as soil acidity increases
4. **Phosphorus inefficiency:** Phosphorus combines with free aluminium and iron released in acid soils and becomes less available to plants. Molybdenum is also less available.
5. **Reduced microbial activity:** Microbes that fix nitrogen or decompose organic matter are less active in moderately and strongly acidic soils.
6. **Declining land values:** Loss of productive capacity due to acidity can reduce land values

Amendment/ Management of Acidic soil-

1. **Liming:** Lime (calcium carbonate) and other liming materials reduce acidity by neutralising the acid reaction in the soil. Application of lime at the rate of 2.5 t/ha of good quality lime, improves the pH of sandy loam soils to around 5.2 to 5.4 pH. The finer liming material with higher purity and higher neutralising value (NV) preferably >80% provides a quicker response. Gypsum does not neutralise acidity.
2. **Rates of N fertilisation:** High rates of ammonium (NH_4^+) fertilisers accelerate acidity.
3. **Growing leguminous crops and pastures:** Growing crops or pastures with high nitrogen requirements to utilise nitrogen produced by legume crops and pastures.

   There are many crop varieties tolerant to soil acidity such as pineapple, coffee, tea, rubber, sweet potato, cassava, potato, rice, pigeon pea, finger millet, buckwheat, rice bean, Colocasia, ginger, turmeric etc. grown in India. Acacia species are tolerant to soil acidity as well in India. Crop species such as Lupinus, commonly known as lupin, wheat, triticale, oats (*Avena sativa*) and legumes like sub clovers are commonly grown in such soils in Europe and the Mediterranean.

13.4.1.6 Salt-affected Soils

Salt-affected soils can be grouped into two categories saline soils and sodic soils.

- **Saline soil**- Saline soil is a non-sodic soil containing sufficient soluble salt like $CaCl_2$, gypsum ($CaSO_4$), magnesium sulphate ($MgSO_4$), and potassium chloride (KCl) having an electrical conductivity of the saturated extract (EC_e) being 4 deciSiemens/meter (dS/m) at 25°C.
- **Sodic soils**- Sodic soils have a pH between 8.5 and 10, having exchangeable sodium (Na) percentage (ESP) of more than 15. Exchangeable sodium percentage (ESP) is the amount of adsorbed sodium on the soil exchange complex expressed in per cent (%) of the cation exchange capacity in milliequivalents per 100 g of soil.

There are various factors responsible for increasing the extent and intensity of sodic/saline soil. Use of improperly treated industrial effluents, over-irrigation

by flooding method and cutting of native forest for making cultivable land etc. are few. Over irrigation has elevated the groundwater table and also transport of salts to the rooting zone and cutting of deep-rooted vegetation has resulted in an increased rate of groundwater recharge and so rise of the groundwater table. Salt-affected soils which include both saline soils and sodic soils, impact an estimated 1 billion ha of land, being most common in arid and semi-arid zones. Globally, salinity has made 0.3 to 1.5 million ha of farmland unfit for agriculture and also has reduced 20 to 46 million ha of cultivable land.

Management for saline soil involves "leaching" the soluble salts from the soil profile. Leaching requires the application of irrigation water at rates above and beyond the basic water needs of the crop. Leaching takes place with the percolation of soil solutes (soluble salts) under saturated soil conditions. Management of sodic soils involves replacing exchangeable sodium (Na) with a more favourable ion such as Calcium (Ca) and/or Magnesium (Mg) and leaching the soluble Na that has been replaced on the soil colloid by the application of excess irrigation water. Therefore, saline soils do not require amendments *per se*. The right choice of crops during the reclamation of sodic soils is crucial. Growing crops tolerant to excess exchangeable sodium can ensure reasonable crop yield during the initial phases of reclamation. Example: Rice (Oryza sativa) and dhaincha are more tolerant whereas wheat and bajra are only moderately tolerant. Legumes like black gram or Urd (Vigna mungo) and lentil (Lens culinaris) are relatively sensitive to excess exchangeable sodium (Na^+).

13.4.1.7 Soil Genetic Diversity

Intensive agriculture certainly limited the genetic diversity of soil as a result of using an excess of fertilizers, pesticides, excess of irrigation and mono-cropping. Any ecosystem has its resilience and so the soil ecosystem does have. To cope with these external drivers in crop production better soil management practices need to be followed in intensive agriculture too.

Every microbe has an assigned and specific role to play whether it is in nutrient cycling from breaking down of organic materials to nitrogen capture. Hence, farmers are practising back green manuring to organic farming to enhance soil biodiversity and the net yield.

13.5 LANDSCAPE CHANGE AND LOSS OF AGROBIODIVERSITY

So far, we have seen how the second half of the 20th century has greatly contributed to increased global food and fibre production, which has enabled a rapidly growing world population to be fed. To gain manifold productivity, agricultural intensification has taken the form of an increase in single-crop cultivation i.e., monocropping and chemical pesticides, weedicides and fertilizers and mechanical inputs. This has not only deteriorated the soil and water quality, and biodiversity loss but has overall negative impacts on the environment. In 9 of the 14 global biomes, 20 to 50% of the land has been

converted to croplands or grazed grassland. Tropical dry forests were impacted the most by cultivation between 1950 and 1990. Temperate grasslands, temperate broadleaf forests, and Mediterranean forests experienced 55% or more conversion before 1950 for intensive agriculture. Because of the ever-increasing population, agricultural expansion is expected to be greatest in developing countries and arid regions, while the agricultural area will decline in the developed countries. (Millennium Ecosystem Assessment, 2005). Similarly, intensive agriculture has declined thousands of plant species cultivated for food to about 200 to contribute substantially to global food output and only 9 share the 66% of total crop production (*FAO, 2019*). We can well imagine the situation when our population will be 9 billion by 2050 if we continue Business as usual.

13.5.1 Landscape Change

By 2050, food consumption must double to meet human needs. To meet this increasing demand for food, production systems are expected to become increasingly dependent on inputs of fertilizers, pesticides, and water. Irrigated lands will likely increase by 1.3-fold by 2020, and 1.9-fold by 2050. Pasture lands are also increasing, with an expected doubling in the area by 2050. In 50 years, global agricultural land area is projected to increase by 18%, with a loss of 109 hectares of natural, wildland ecosystems. These trends will further increase the pressure on biodiversity in natural ecosystems, already under stress from human disturbances such as climate change.

In the process of change from multi-cropping in the diversified landscape to the monocropping pattern, we have lost the ecosystem services offered like pollination, nutrient cycling, water purification etc. by those diversified landscapes. Pollination is particularly important for the production of fruits and vegetables. The role of ecosystem services for pollination is consistently underestimated yet is of global importance. In addition, the roles of biodiversity in nutrient and water cycling, climate regulation and other ecosystem benefit are becoming increasingly regarded as key to agricultural production. The natural resilience ie., the coping up mechanism against the external factor has declined. Diverse landscapes that incorporate agrobiodiversity and fragments of wildlands in an agroecological matrix are essential for the long-term sustainability of the food system. Hence, diversity not only at the farm but also at landscape levels is equally important to support and sustain food production.

13.5.1.1 Actions Responsible for Landscape Change in the 20th Century

1. Shift of agriculture from mixed farming/multi-cropping to monocropping
2. Converting perennial habitat (grassland) to arable fields
3. Destruction of edge habitats (hedges, field boundaries, buffer zones along creeks)
4. Reallocating land to increase field size and make farms more compact
5. Increasing landscape homogeneity by simplifying landscapes with a limited number of land-use types
6. Giving up traditional, low-intensity land-use management

7. Avoiding set-aside fallows and cultivating formerly abandoned areas (old fields, fallows)
7. Reducing resistance to the invasion of introduced species
8. Lowering landscape-wide water tables and
9. Fragmenting natural habitat

13.5.2 Loss of Agrobiodiversity

Agricultural biodiversity is the subset of biodiversity that contributes to crop and food production. It includes all the flora, fauna and microbes that support the production of food by maintaining nutrient cycling to keep the soil fertile, pollinating agents, the natural process of scavenging to the purification of water and air, and pests etc. There is some biota involved in the healthier functioning of the agroecosystem. Many tribal societies have robust traditional ecological knowledge about varieties of native plants species. It not only provided them food security but fulfilled their nutritional need as well. Under, intensive agriculture, only 9 crop species share 66% of total crop production (FAO, 2019). This worries ecologists, policymakers and other stakeholders including informed citizens to do something.

Do you remember the adoption of the Convention on Biological Diversity (CBD), 1992? CBD is an international legal framework for the conservation and sustainable use of biodiversity. The resulting "Aichi Biodiversity Targets", adopted in 2010, fully attest to the importance of mainstreaming biodiversity into development policies. As a result, in 2015, the United Nations' Sustainable Development Goals provided a renewed impetus for a focus on using biodiversity for food and nutrition and linking that to the sustainability of farming systems. Hence, there is an urgent need to plan and implement a strategy to establish the scientific basis needed to address the trade-offs between food production, biodiversity conservation, ecosystem services, and human well-being in agricultural landscapes.

13.5.3 Challenges and Opportunities

On a landscape scale, we have created homogenized farmed landscapes with the little non-crop area. Fragmentation of remaining natural habitats became a major cause of extinction of fragmented, small and isolated populations. Species losses are because of agricultural expansion and habitat fragmentation. Farmland birds are indicators of the quality of the agricultural landscape and constant decline means a lack of foraging and nesting habitat. Similar declines in insects, spiders and arable weeds etc. have been noticed. Pristine ecosystems play a central role in supporting biodiversity and so there is an urgent need to have a holistic approach towards landscape management to support biodiversity and agroecosystem functions. The percentage of pristine ecosystems is 7% worldwide but is deteriorating at a much faster rate. Losing a pristine ecosystem means the loss of habitat of most endangered species. As a result, we will force to have man-made nature reserves like central Europe which have been caused as a result of agricultural intensification and succession to forests. Overall, in the middle of the 19th century, we had a mosaic of diverse habitats created by

low-intensity agriculture; this complex rural landscape was suiting the most to sustain biodiversity.

There is a growing international awareness of threats to the sustainability of food and agriculture. The conservation efforts, both *in-situ* (e.g., protected areas, on-farm management) and *ex-situ* (e.g., gene banks, botanical gardens) are increasing across the globe, although levels of coverage and protection are often not adequate. Saving biodiversity is not only the need of the hour to sustain ecosystem services and enhance resilience but there are issues related to nutrition as well. We shall cover in the next subsection how altered landscapes i.e., from agroforestry to monocropping have forced many marginalized societies to be devoid of a balanced diet.

A case from India- ATREE

But, before we move on, you must know initiatives taken up by "Ashoka Trust for Research in Ecology, and the Environment" (ATREE), Bangalore, India. They are working on three core projects of DIVERSITAS to promote the conservation of biodiversity at multiple scales using a diverse array of approaches. One of the programs focused on conservation and livelihoods in the Biligiri Rangaswamy Temple (BRT) Wildlife Sanctuary with a prime objective to describe system parameters relating to both ecological and interacting social systems (for example, genetic, species, and ecosystem diversity; land use and land tenure; and household determinants of resource use). The second objective is to examine the impact of human societies on ecosystem structure and function (for example the effects of a collection of non-timber forest products, agricultural production for local consumption, fire, and invasive species on biodiversity at the population and ecosystem level, the impact of land-use change on ecosystem services, and the effectiveness of protected area network as well as current management practices and policies on the conservation of biological diversity). The third objective is to design and implement management and policy interventions to mitigate human impacts and promote sustainable use of resources. The management interventions consist of enhancing biodiversity and productivity in agroecosystems to reduce pressure on forest biodiversity, provision of micro-credit, and promoting micro-enterprises based on biological resources, initiating governance reforms for sustainable use of forest resources in various organizations. The project uses a participatory approach for research and action, combines principles and approaches of ecology and economics, fosters social equity in sharing biodiversity benefits, and brings stakeholders together to define and resolve conservation problems.

13.6 MALNUTRITION

Malnutrition refers to deficiencies, excesses, or imbalances in a person's intake of energy and /or nutrients. It addresses three broad groups of conditions: undernutrition, stunting and overweight. 'Triple burden' of malnutrition remains a global health emergency. The 'triple burden' of malnutrition weighing on most countries consists of undernutrition, micronutrient deficiencies, and overweight and obesity. Undernutrition is declining globally. Childhood stunting is a largely irreversible outcome of inadequate nutrition and repeated bouts of infection during the first few years of a child's life. Micronutrient deficiencies like deficiency of micronutrients like iron, zinc etc.

It has been estimated that about 2 billion people which is 29% of the world's population, faced micronutrient deficiencies in 2010. Micronutrient deficiencies are widely present in high-income countries as well. For example, in the Russian Federation and Georgia childhood anaemia in 2010 was 26%, and 16%, on average, across the European Union.

Anaemia caused due to lack of iron contributes to 20% of all maternal deaths, with about 50 000 annually. Vitamin A (retinol) deficiency remains a public health problem in more than 100 countries which causes blindness in 250 000 to 500 000 children every year. Similarly, Zinc deficiency affects about 30 % of the world's population. A similar number of children have insufficient iodine intake, which significantly impairs their cognitive development. Vitamin B12 is only found in animal source food. These nutrients are essential for a healthy immune system, which is needed to fight off infections.

Urbanization has created demand in the market to supply processed food that is easy and quick to cook as a result, lifestyles have become more sedentary. Meanwhile, changes in dietary patterns around the world have consequences for public health and sustainable development. People from around the world are now eating more meat, farmed chicken, processed red meat, processed dairy products and less than ten crop varieties as a staple food.

In 2014, some 40 % of people aged 18 and over were overweight and, of these, 13% were obese. Childhood obesity increases the threat of early onset of obesity-related health complications. Obesity is conventionally associated with the intake of food excess, but it is also associated with micronutrient deficiencies. People with obesity can be prone to deficiencies of micronutrients, such as zinc, iron, and vitamins A, C, D, and E. Caribbean islands and countries in the Middle East and Central America have reached extremely high rates of adult overweight and obesity. Some have a prevalence as high as 80%.

The economic price of malnutrition is billions of dollars in lost productivity and health care costs. Annual GDP losses due to malnutrition average 11% in Asia and Africa—greater than the loss experienced during the 2008–2010 financial crises. Though malnutrition is the outcome of many factors like food, health, and care and it's not merely only about food security but equally about public health, water, sanitation and hygiene, and social protection. Intensive agriculture was the answer to feeding people in the mid-20th century.

But, feeding safer food adequate in nutrient content has become the priority now. Ending hunger, achieving food security and improving nutrition are all key steps toward sustainable development (UN, 2016). Food safety is also a key concern, as unsafe food remains a major cause of disease and death (WHO, 2015).

Society has been transformed from a manual agrarian to a mechanised one. Monocropping has taken the driving seat of the world's economy. Without giving a second thought we have converted the diversified ecosystem into a homogenized one. Many native species and their sub-types have already been lost. Overall changes in dietary patterns are affecting public health. Dietary patterns are not only reflections of what people eat but reflect complex social behaviours as well. The following feeding trends have been observed recently.

1. **The consumption of more nutritious foods**

   Between 1990 and 2013, the consumption of more nutritious foods increased worldwide. But the situation is not uniform. East Asia consumes a fair amount of fruits whereas wholegrain consumption is on the rise in South Asia. As compared to global data, per capita fruit consumption in sub-Saharan Africa, was 16 % below the global average level in 1990 and has further gone down by 2013. Dairy product consumption is highest in North America and Europe.

2. **The daily intake of protein**

   In the last 50 years, the daily intake of protein has increased in developed countries. Per capita consumption of meat, eggs, milk and dairy products was merely 39 g per day in 1961 has improved to 52 g in 2011. Most of this increase occurred in the 1960s and 1970s. Since the 1980s, protein intake from animal sources has remained almost constant. The daily per capita availability of protein from animal products in low- and middle-income countries has almost doubled from 9 to 20 g between 1961 and 2011. Globally, fish contributes around 18% of the total animal protein intake, but in some coastal communities and small island states the percentage can reach as high as 60 % (FAO, 2009). Global per capita consumption of seafood has been increasing and currently exceeds 20 kg per year. This trend is expected to continue as incomes rise and consumers become more aware of healthy food.

   Sustainable Development Goals not only talk about healthy diets but also raises the question of the carbon footprints these foods have on the environment. Processed, packages food, dairy-based food or meat-based food have much higher carbon footprints. It means the emission of various greenhouse gases into the environment is much more in these cases as a result of enteric fermentation, processing and transport etc.

13.6.1 Challenges in Alleviating Malnutrition

A total number of 925 million people was undernourished in 2010 and the developing nations share 16%. About 75% of those worst affected live in rural areas of developing countries, with livelihoods that depend directly or indirectly on agriculture. They include many of the world's half a billion low-income smallholder farmers and their families who produce 80% of the food supply in developing countries. Together, smallholders use and manage more than 80% of farmland – and similar proportions of other natural resources – in Asia and Africa.

Though various factors contribute to malnutrition, improved water, sanitation, and hygiene (WASH) can enhance the nutritional benefits of agricultural policies by reducing disease and enhancing nutrient absorption. There are linkages between agriculture and nutrition and Gillespie and Bold, 2017 gave six pathways-

1. Agriculture as a source of food for household consumption. Farmers who grow will eat as well. It means monocropping forced them to consume few crops and hence a reason for malnutrition.
2. Agriculture became market-driven and having sufficient money to buy

other necessary items and services like health, education etc. depends upon the net yield and profit.

3. Agriculture is market-linked and various agricultural policies and food prices decide the profitability of the producer if a buyer can afford it.
4. This sector has a strong linkage with the empowerment of women. An empowered woman in the family controls the nutrition-relevant resources.
5. Intensive agriculture discouraged women's employment in agriculture because of heavy and prolonged workloads.
6. Intensive agriculture promoted heavy usage of fertilizers, pesticides etc. and as result women working in this sector were much more exposed to these chemicals. Many pesticides posed their risk as well.

Another reason behind malnutrition can be the consumption of unsafe food. Some 40 % of the food-borne disease burden was among children under 5 years of age, and the highest per capita burden was in Africa, followed by Southeast Asia and the Eastern Mediterranean. Aflatoxins, produced by two species of fungi are peanut allergens. Aflatoxins are poisonous carcinogens and mutagens that are produced by mould that grows on stored grains, such as maize, as well as on groundnuts, oilseeds and tree nuts. The burden of aflatoxins is especially high in Africa, Southeast Asia and Western Pacific. Cyanide is released from natural substances in some foods and certain plants such as cassava, lima beans and almonds. *Dioxin* and related compounds (furans and polychlorinated biphenyls) are lipophilic and persist in the *food* chain. Over 90 per cent of human exposure to *dioxins* comes through *food*, mainly animal products, such as dairy, meat, fish, and shellfish. Once consumed, *dioxins* can stay in the body for a long time.

13.7 FOOD SECURITY

The World Food Conference, 1974 convened in Rome declared that "every man, woman and child have the right to be free from hunger and malnutrition" and set the goal of eradicating hunger in the world within a decade. As a result, in 1974 FAO first began reporting on the extent of hunger in the world. World Food Summit, 1996, defined food security as a condition when "all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for a healthy and active life".

The above definition talks mainly about four dimensions of food security-

1. Availability of food (supply side): Food production, stock levels and net trade
2. Economic and physical access to food: Policy focuses on incomes, expenditure, markets and prices in achieving food security objectives
3. Food utilization: Nutritional status of individuals depends upon good care and feeding practices, food preparation, diversity of the diet and intra-household distribution of food
4. Stability of the other three dimensions over time.

It is important to know the duration of the problem but knowing the intensity

or severity of the food crisis is equally important. This gives insight into the nature, extent and urgency of the assistance needed by the affected population. Food security analysts devised different indicators and benchmarks to classify food security. FAO determined undernourishment in terms of dietary energy consumption and defines it as "the proportion of the population whose dietary energy consumption is less than a pre-determined threshold". This threshold is country-specific and is measured in terms of the number of kilocalories (Kcal) required to conduct sedentary or light activities. The undernourished are also referred to as suffering from food deprivation. The severity of undernourishment indicates, for the food-deprived, the extent to which dietary energy consumption falls below the pre-determined threshold.

In India, the number of people undernourished (million) in the year 2000 was 191.20 million whereas it became 194.40 million in 2017. In Asia, the number of people undernourished (million) in the year 2000 was 634.70 million whereas it became 512.90 million in 2017 (FAO, 2020). According to 2017 data, 14% of India's population is undernourished whereas in a country like Tanzania it is 30.7% of the total population.

The dynamic nature of food security is implicit when we talk about people who are vulnerable to experiencing food insecurity in the future. There are three critical dimensions to define vulnerability-

1. Vulnerability to an outcome;
2. Vulnerability to a variety of risk factors;
3. Vulnerability because of an inability to manage those risks.

Indeed, a person can be vulnerable to hunger even if he or she is not hungry at a given point in time. Vulnerability analysis suggests two main intervention options: 1. Reduce the degree of exposure to the hazard; and 2. Increase the ability to cope.

13.7.1 Hunger, Malnutrition and Poverty

When someone is severely food insecure, they have run out of food and gone a day or more without eating. Hunger is defined as a condition in which a person cannot eat sufficient food to meet basic nutritional needs for a sustained period. Hunger can manifest itself in different ways namely undernourishment, malnutrition and wasting.

1. Undernourishment

According to the World Food Programme, undernourishment is defined as a condition when people do not take in enough calories to meet minimum physiological needs.

2. Malnutrition

Malnutrition is defined as a condition when people have an inadequate intake of protein, energy and micronutrients. Malnutrition may be an outcome of food insecurity, or it may relate to other factors, such as inadequate care practices for children, lack of healthcare services; and an unhealthy environment. This results in stunted growth in children. Further, if starvation of the right nutrition continues for long, individuals or populations can even die from common infections such as diarrhoea.

3. Wasting

Wasting, usually, the result of starvation or disease is an indicator of acute malnutrition with substantial weight loss.

Children facing hunger, food insecurity and undernutrition, today may have a higher risk of being overweight, obese and chronic diseases like diabetes later in life. In many countries, undernutrition and obesity coexist and both can be consequences of food insecurity.

The threshold for obesity is a BMI ≥30. Child obesity is of increasing concern and was included in the latest global nutrition goals for 2030 ("no increase in child-hood obesity")

The threshold for obesity is a BMI ≥30. Child obesity is of increasing concern and was included in the latest global nutrition goals for 2030 ("no increase in child-hood obesity") is characterised in many ways.

It encompasses individual sensations and household behavioural responses, food scarcity (actual or feared) and national food balance sheets that focus on the supply of energy (kilocalories) in any country in rela tion to a minimum threshold of need. The food balance sheet approach is the only standard of measurement used globally. It is based on data collated by the Food and Agriculture Organization of the United Nations. This organisation has replaced its previous use of the word "hunger" in describing this metric with the phrase "chronic undernourishment". This today is dened as "a person's inability to acquire enough food to meet daily minimum dietary energy requirements during 1 year" is characterised in many ways. It encompasses individual sensations and household behavioural responses, food scarcity (actual or feared) and national food balance sheets that focus on the supply of energy (kilocalories) in any country in rela tion to a minimum threshold of need. The food balance sheet approach is the only standard of measurement used globally. It is based on data collated by the Food and Agriculture Organization of the United Nations. This organisation has replaced its previous use of the word "hunger" in describing this metric with the phrase "chronic undernourishment". This today is dened as "a person's inability to acquire enough food to meet daily minimum dietary energy requirements during 1 year.

The proportion of people defined as hungry over the long term (usually termed "chronically undernourished") fell from 18.6% globally in 1990-2002 to under 11% in 2014-16. That was a decline of 211 million people whiles the world's population increased by 2 billion. Of the roughly 800 million undernourished, 780 million are in low-income countries, especially in sub-Saharan Africa and South Asia. The continents of Africa and Asia have the greatest number of people living in extreme poverty, and it is here that extreme hunger and poverty together present the greatest risk of famine. Famine is the most acute face of hunger. Over 70 million people died in famines during the 20th century.

Deaths from famine fell from the mid-1980s onwards. However, as of 2017 four countries were again struggling to cope: Somalia, Yemen, South Sudan, and Nigeria. In each case, instability induced by conflict, terrorism, drought and decades of failed governance has left over 20 million people facing famine, including 1.4 million children "at imminent risk of death.

A major cause of mortality in famines is children becoming severely wasted. Around 52 million children were wasted in 2016, of which around 70% (36

million) resided in Asia. Roughly 12.6% of deaths among children under 5 are attributed to wasting worldwide. Roughly 30% of stunting by a child's 3rd year can be attributed to being born small for gestational age, which is linked to nutrition before birth and health problems of the mother.

While poverty is undoubtedly a cause of hunger, lack of adequate and proper nutrition itself is an underlying cause of poverty. Food security needs a cohesive action plan by combining income growth supported by direct nutrition interventions and investment in health, water and education. Marasmus and Kwashiorkor are still prevalent in children of developing countries. Marasmus is a form of severe malnutrition characterized by energy deficiency. It can occur in anyone with severe malnutrition but usually occurs in children. On the other hand, the main cause of kwashiorkor is not eating enough protein or other essential vitamins and minerals. It's most common in developing countries with a limited food supply, poor hygiene, and a lack of education about the importance of giving babies and children an adequate diet.

A holistic approach is needed to eradicate hunger and malnutrition. It will not be just sufficient to only focus on the production end. As, in 2016, the world hit a new record by producing over 2.5 billion metric tons of cereal grains—up from 1.8 billion tons 20 years earlier. But yet hunger persists. It's good that we have set "The sustainable development goals-2030" but to achieve it holistic action of each nation and each one of us needed to make the world hunger-free and all free from all forms of malnutrition by 2030.

13.7.2 Interdepartmental approach to alleviate hunger

A few important sectors that are playing a vital role to alleviate hunger are-

Agriculture: Promotion and support of smallholder horticulture production; investments in research and extension supporting productivity gains in foods rich in nutrients; promoting food market development to increase smallholder farmer incomes and price accessibility to diets rich in nutrients.

Health: Establishment of high quality, high coverage health services, including nutrition counselling and reproductive health; effective reduction of the burden of infectious diseases; promotion of evidence-based dietary guidelines to the population.

Education: Universal enrolment and retention of girls in schools; use of schools to provide instruction on nutrition and health; promotion of awareness of a healthy diet through school gardening; enhanced curricular initiatives on diet, and physical activity.

Water and sanitation: National and local programmes that eliminate open defecation; universal provision of clean water; promotion of good sanitation and hygiene practices.

Market development: Micronutrient fortification of widely accessible foods, including salt iodisation; quality and food safety regulation.

Resilience building: Implementing effective social safety nets that smooth income flows and food consumption among vulnerable groups.

Food Saving: Loss of a kilogram of wheat and rice would mean wasting 1,500 and 3,500 litres of water respectively that goes into their production. According to Food and Agriculture Organization (FAO), every year around 1.7 billion

tonnes or almost one-third of food produced for human consumption are lost or wasted globally. The carbon value of this 1.7 billion tonne of food generation is equivalent to 0.55 billion tonnes in the world.

13.7.3 Agricultural intensification and Food Security

FAO yet measures "food security" in terms of the sufficiency of national-level food supplies relative to estimates of national-level calorie requirements, as it has since the 1970s. While this is undoubtedly an important facet of food security and useful because it is relatively easy to measure, its use has likely perpetuated the idea that to improve food security, the focus should be on the national production of more calories instead of producing a diverse range of foods to encourage diversity in diets.

So, we have already discussed how rapid population growth puts pressure on land-use change and the demand for food needs to be fulfilled. We have limited natural resources like land and water, conversion of agricultural land to housing etc. is on the rise and as a result, we are on the verge of clearing pristine ecosystems, which currently cover about 7% of the total area. Forest cover is being converted into pasture, plantations and agriculture. But, for how long and to what extent we can continue clearing these forests for other use?

So, the way to meet the food demand was intensive agriculture. In agricultural intensification, to increase agricultural production, we devised mechanisms to save labour, land, time, fertilizer, seed, feed or cash. Most of the farmers who were holding a small patch of land have increased inputs of hybrid seeds, inorganic fertilizer, chemical pesticides, exploitation of groundwater etc. to enhance the productivity i.e., output per unit area of land.

So, we have seen strategies made across the globe to meet food crises emerge as a result of war, famine and an ever-growing population. While targeting the output many lapses have been recorded and many lessons mankind have learnt. We have disrespected nature by exploiting natural resources and had used synthetic chemicals like DDT and so on without remembering the limitation of ecosystem resilience. We never counted the ecosystem services biodiversity offered us since our civilization. What we were worried about was the crop productivity and to meet per capita per day kilocalorie of energy need, we stopped counting the nutrients offered to mankind through agrobiodiversity. Hence to continue providing food supplies to feed the growing population, farmers have to intensify food production sustainably.

Forms of Agricultural Intensification

Adoption of high-yielding as well as drought, pest and disease tolerant seed varieties.

Through the increased application of nitrogen fertiliser.

Farmers adopt agricultural technology and machinery to accelerate production. Tractors for tilling the land, combine harvesters, seed planters, overhead irrigation usually replaces or substitute human labour more efficiently and the yield is higher, for instance, farm mechanization has led to increased production of soybean, maize and dry-land rice in southwestern Brazilian Amazon

Farmers adopt irrigation technology.

Apart from that water harvesting techniques that are cheap and efficient can be designed especially for small landholdings.

Farmers adopt agricultural ecological farming practices like intercropping.

Improving nitrogen uptake and fixation is another form of agricultural intensification. Nitrogen utilisation can be improved through practices like precision farming or planting nitrogen-fixing crops, for example, legume plants like beans, and soybeans amongst others.

Agriculture intensification can also be achieved through food fortification which again improves nutrition.

The second Sustainable Development Goal (SDG 2) explicitly aims at ending hunger, achieving food security and improved nutrition, and promoting sustainable agriculture, simultaneously by 2030. Let us discuss why and where hunger yet exists?

1. Countries with the highest levels of hunger are usually those with civil conflicts. Countries like the Central African Republic and Chad have a high risk of conflicts and have the highest levels of undernourishment. A civil conflict just not only creates food scarcity by lacking the ways and means to get it. But its impact can be seen as malnutrition but goes further by impacting the women and children from psychological disorders to having sexually transmitted diseases.
2. Condition of extreme poor still exists and the majority of it is still found in Asia. About three-fifths of it is concentrated in Bangladesh, China, the Democratic Republic of Congo, India and Nigeria.
3. Rising inequality within the fast-growing developing nations. Higher inequalities sabotage the resilience of societies to possible shocks in development patterns and leave larger shares of the population vulnerable to poverty. Though between 2005 and 2015, greater progress was made and double as many people escaped chronic undernutrition as compared to 1990–2005. But yet we will miss the target of eradicating hunger by 2030 if this pace of eradication continues. But the good news is that the prevalence of undernourishment went down by almost half between 1990 and 2016 in Latin America, East and Southeast Asia, the Caucasus and Central Asia, and North and West Africa.
4. Last but not least, the Gender inequality in the agriculture sector. The rural poor women became so much vulnerable. Over 60 % of people living in hunger are female. Women face challenges in accessing economic opportunities and participation in decision-making processes. Similarly, their decision-making capacity remains limited, including in community decisions over natural resources. Women's limited access to productive resources is hampering productivity growth on smallholder farms and perpetuating income inequalities. Consequently, in sub-Saharan Africa, the agricultural productivity levels of female farmers are between 20 to 30 % lower than those of male farmers because of the gender gap in access to resources.

13.7.4 Public Distribution System in India

India's Public Distribution System (PDS) is the largest distribution network

of its kind in the world. Public distribution of food grains was retained as a deliberate social policy by India when it embarked on the path of planned economic development in 1951. In the first five-year plan, the system, which was essentially urban-based till then was extended to all rural areas which suffered from chronic food shortages. By the end of the Second Five Year Plan, PDS had changed from the typical rationing system to a social safety system, making available food grains at a 'fair price' so that access of households to food grains could be improved. The concept of buffer stocks was also incorporated into the overall food policy.

By the 1970s, PDS had evolved into a universal scheme for the distribution of subsidised food. In the 1990s, the scheme was revamped to improve access to food grains for people in hilly and inaccessible areas and to target the poor. Subsequently, in 1997, the government launched the Targeted Public Distribution System (TPDS), with a focus on the poor. TPDS aims to provide subsidised food and fuel to the poor through a network of ration shops. Food grains such as rice and wheat that are provided under TPDS are procured from farmers, allocated to states and delivered to the ration shop where the beneficiary buys his entitlement. The centre and states share the responsibilities of identifying the poor, procuring grains and delivering food grains to beneficiaries. In September 2013, Parliament enacted the National Food Security Act, 2013. The Act relies largely on the existing TPDS to deliver food grains as legal entitlements to poor households. This marks a shift by making the right to food a justifiable right.

13.8 AGRICULTURE IN THE 21ST CENTURY

We have seen how the transformation began in the early years of the 20th century following several scientific discoveries including chemical fertilizers, pesticides, high yielding variety, etc. which has changed the face of agriculture to become a system of "gain" called intensive agriculture. A breakthrough registered in the second half of the twentieth century with the discovery of new plant-type genes in wheat and rice, which were instrumental in giving rise to the green revolution also called the yield revolution. The yield revolution has evolved with the birth of the new technology which is energy-intensive. So, what is needed is a new paradigm of inclusive agriculture green growth. Today agriculture shares about 40% of all liveable land areas in the world. Monocropping oversimplified the landscape and as a result, we lost ecosystem services offered by the biodiversity both at the landscape level and field level. The tropical forest is constantly under a slashing process, as a result, many endangered species are on the verge of extinction. Urbanization has already posed threat to catchments and extraction of groundwater for agricultural use has made scarce potable water. Initially, our soil responded well to the application of inorganic fertilizers and gave us a return in terms of yield. But now that fertility is no more and our sick soil needs organics and other reclamations.

So, to achieve SDG 2 on zero hunger by 2030, we need to do a lot to change our strategies to take this sector forward to become a sustainable green sector. We need to re-practice some of our old proven practices.

1. Agroecology: We have to take corrective measures and mimic nature through developing agroecological practices. A few decades back,

agronomists noticed a sharp increase in pest outbreaks in the modern monocropping system. Ecologists were trying their best to build a complex interaction system between insects and plants to understand it better. And there comes a term, agroecology which is the application of ecological science to the study, design, and management of sustainable agriculture.

The agroecological systems are based on five ecological principles: (1) recycling biomass and balancing nutrient flow and availability; (2) securing favourable soil conditions for plant growth through enhanced organic matter; (3) minimizing losses of solar radiation, water, and nutrients by way of microclimate management, water harvesting, and soil cover; (4) enhancing biological and genetic diversification on cropland; and (5) enhancing beneficial biological interactions and minimizing the use of pesticides.

So, we understood the importance of agroecology and the ecological services offered by it. Hence, we can say that simplification and monocropping are no solution if we want sustained supply. We need to revive the natural nutrient cycling and other ecosystem services through diversification of landscape by integrated landscape management and by promoting multi-cropping. We need to calculate the gains forest offers to crops.

2. Local to global: We have done enough by growing hybrid seeds to supply in the international market. But time has come when we must realise that each crop variety will not respond uniform to variable agro-climatic conditions. We must catch the local need and accordingly planning must be done to fit local priorities on land use, use of agricultural inputs, priority crops and ecosystem management. Let farmers decide whether wheat or ragi (finger millet) to be grown as per the soil type, availability of water etc. so that they will have sufficient food to eat. Let's go "local to global", only surplus food to put in the supply chain.
3. Developing sustainable cities: By 2050 two-thirds of the world's population will live in the cities. It will be highly important to make their food secure, the city must start investing in growing its food. Cities can't just expect sustained supply by doing nothing. Rather, the time has come when users will have to take the onus to support biodiversity conservation, water conservation and maintain ecosystem services. People's participation becomes a must to improve ecosystem resilience through urban-rural partnership.
4. Building cross-sector coalitions: Agencies of the United Nations act at the international level but to get those international policies translated into initiatives at the field level needs coalitions at the national level to state to the district to tehsil level. Interagency coalitions needed to translate policies through a top-down approach.
5. Financing for sustainable farming: Agribusiness needs integrated investment through various schemes and financing models like public-private partnership etc. in light of sustainable green farming and landscape management.
6. Sound science and innovation: These are the keys to sustainable agriculture. Greater investment is needed in the basics of agronomy,

biotechnology, and plant breeding to ensure that farmers and consumers everywhere benefit from science and technology. Farmers must receive support for implementing sustainability measures, especially in light of the downward trend of commodity prices. A sustained effort is needed to make this sector a net sink of greenhouse gases rather than emitters.

13.8.1 Challenges to Yield Revolution in the 21st Century

The world population is expected to reach 10-11 billion towards the end of the 21st Century. We will need at least 1billion tonnes of grain annually by 2025. So, there will be huge pressure on the available land to meet the production target. The 21st century demands substantial changes in the world's food system, including sustainable intensification to simultaneously raise yields reducing the negative environmental effects of crop production. So, our eyes shall remain on enhancing the yield by adding ecosystem services of the agro-ecosystem. M.S. Swaminathan, the architect of the first Green Revolution in India as well now advocates organic farming. Alan Savory calls the 21st-century revolution a "Brown Revolution", one that enhances soil organic matter, leading to sustainable productivity gains. Agriculture in the twenty-first century will have to respond to challenges of a different kind.

1. **Eradicating extreme poverty, hunger and malnutrition**

   We have already seen how South Asian countries including sub-Saharan countries are still facing extreme poverty. To eradicate hunger, we must succeed in building resilience to conflicts and disasters.

2. **Sustainably improving agricultural productivity and distribution system**

   There is an urgent need to make agricultural production more sustainable and food systems as a whole more efficient, inclusive and resilient. As, agriculture remains a much less capital-intensive practice in low- and middle-income countries and so, investments are required to develop new varieties and hybrids. We need to have better extension services, storage facilities, and basic rural infrastructure to access regional or local markets, insurance against weather-related risks, and support to farmers' organizations and cooperatives.

3. **Addressing climate change, hike in oil price and intensification of natural hazards**

4. **Job creation and income diversification**

   A rethinking of food systems and governance is essential for meeting current and future challenges. Social protection combined with pro-poor growth will help meet the challenge of ending hunger and addressing the triple burden of malnutrition through healthier diets. Permanently eliminating hunger, malnutrition and extreme poverty also requires building resilience to protracted crises, disasters and conflicts, and preventing conflicts by promoting inclusive and equitable global development. New job creation will further improve income-earning opportunities in rural areas and address the root causes of migration.

5. **Environmental and efficiency concerns**

   A serious effort should be initiated to develop alternative land use, farming

systems, and food systems scenarios for the 21st century. The capacity to monitor the agricultural sources and impacts of environmental change should be strengthened. The design of technologies and institutions to achieve more efficient management of surface and groundwater resources will become increasingly important. The modelling of the sources and impacts of climate change must become more sophisticated. Research on environmentally compatible farming systems should be intensified. Intermediate efforts should be made to reform agricultural commodity and income support policies. Alternative food systems have to be developed.

6. **Integration of smallholders into value chains and maintaining competitiveness in the market**

   Agriculture in the 21st century will face the challenge of integrating smallholders into value chains. We need to link up production with the market and it's an opportunity for the smallholders to get the actual price in the market with the help of technology and make their presence in the global market.

7. **Coherent and effective national and international governance**

   Various agencies of the United Nations are being engaged in framing international laws and delegations of the same at the country level. Countries are facing many challenges and at times priority gets diluted at the implementation level. So, governance plays so much importance in prioritizing the agenda to get implemented at the national level and further down at the state level to district level and so on.

13.9 INITIATIVES BY THE GOVERNMENT OF INDIA

The government of India has implemented the best possible available technologies through various governments Programs including the adoption of innovative models at various levels.

1. **Soil Health Card (SHC)**

   Soil Health Card (SHC) is a Government of India scheme promoted by the Department of Agriculture & Co-operation under the Ministry of Agriculture and Farmers' Welfare. It is being implemented through the Department of Agriculture of all the State and Union Territory Governments. SHC is a printed report that a farmer will be handed over for each of his holdings. It will contain the status of his soil concerning 12 parameters, namely N, P, K (Macro-nutrients); S (Secondary- nutrient); Zn, Fe, Cu, Mn, Bo (Micronutrients); and pH, EC, OC (Physical parameters). Based on this, the SHC will also indicate fertilizer recommendations and soil amendments required for the farm.

2. **To Improve Water Use Efficiency**

   Prime Minister Krishi Sinchai Yojana (Prime Minister Agriculture Irrigation Plan) for Improving Water Use Efficiency says "More Crop Per Drop of Water". Proven technologies such as drip irrigation, saves both water and reduce soil salinity. There is a range of improved micro-irrigation systems to increase the efficiency of water use systems. Growing more

water-efficient crops like millet and sorghum and cultivars such as water-saving rice variety. The system of rice intensification (SRI) developed in Madagascar, is showing that changing the management of rice plants, soil, water and nutrients can increase the yields of irrigated rice by 25–50% or more while reducing water requirements by an equivalent per cent.

3. Strategy for Food Saving in India

"Indian Food Sharing Alliance" (IFSA) has been formed by the Food Safety and Standards Authority of India (FSSAI) to help solve India's food waste and hunger crisis by working with various partner organizations, Food Recovery Agencies and NGOs with a mission "Save food, Share food". It facilitates the safe distribution of surplus food by connecting trained food recovery agencies with food chains (https://sharefood.fssai.gov.in/).

4. Agroforestry

About 25.32 million ha (8.2%) of the total geographical area of India are under agroforestry. It meets 50% of the overall fuel demand,70-80% wood for plywood, 60% raw material for paper pulp and 9-11% of green fodder for rearing livestock besides being a selfless giver of fruit, fibre, medicine, essential oil etc. The right selection of tree crops can be a win-win situation where farmers can maximize the benefits.

Examples:

Poplar based agroforestry systems and wood-based industries are now popular in the Indo-Gangetic region of India.

Prosopis cineraria-based agroforestry system of the arid zone of India

Khejri agroforestry in Rajasthan

Lac host Butea monosperma scattered agroforestry in Central India

Gum based agroforestry systems a) Acacia nilotica gum b) Butea monosperma gum.

Acacia leucophloea and Acacia nilotica lopped for fodder in a Ravinous tract in Madhya Pradesh, India.

5. Climate Change

a) National Innovations in Climate Resilient Agriculture (NICRA): It is a flagship project of ICAR launched in 2011. The objectives of NICRA are to a) undertake strategic research on adaptation and mitigation, b) validate and demonstrate climate resilient technologies on farmers' fields, c) To strengthen the capacity of scientists and other stakeholders in climate-resilient agriculture, d) To draw policy guidelines for wider scale adoption of resilience enhancing technologies and options. It is a unique project that brings all sectors of agriculture viz., crops, horticulture, livestock, fisheries, NRM and extension scientists on one platform.

b) Minimizing Greenhouse gas emissions through alternative technologies

Alternatives to straw burning

Baler for making bundles to biomass-based power plants as fuel

Straw chopper cum shredder zero-till sowing (ZT)

Paddy combine harvester with a straw management system (ZT)

Rotavator for incorporation of paddy straw

Reversible MB plough

Use of straw as livestock feed and bedding material

Use of straw as soil mulch in orchards

c) Micro-level Agromet Advisory Services (MAAS)

Block-level Agromet advisory bulletins are disseminated through Field Information Facilitators (FIFs) across 20 States. This helped in timely decision making for various field operations and minimizing risks.

6. Critical Role of Technology Packaging in Rainfed Drylands

Rainfed agriculture encounters several constraints on account of climatic, edaphic, and social factors. Out of the 97 million farm holdings, about 76% come under marginal and small categories. The productivity levels of these areas have remained lower across the years because of frequent droughts occurring due to high variability in the quantum and distribution of rainfall, poor soil health, low fertilizer use, imbalanced fertilization, small farm size and poor mechanization, poor socio-economic conditions and low risk-bearing capacity, low credit availability and infrastructure constraints.

a) In-situ moisture conservation Technology: In general, it could be possible to reduce soil and water losses by adopting in-situ conservation practices like dead furrows at 3.6 m intervals across the slope.

b) Land treatments Technology: Such a technology incorporates waste-water treatment, water reuse, crop utilization of nutrients and waste-water disposal. It involves the application of wastewater to vegetated land using various techniques, including sprinkling methods or surface techniques such as graded-border and furrow irrigation.

c) Farm ponds: These are considered one of the best mechanisms to mitigate drought in rainfed rural areas.

d) Community Seed Bank: It is most suitable for a dryland ecosystem where it is hard for farmers to get access to the market.

e) Community Fodder Bank- It is nothing but, a group of farmers coming together to raise multiple fodder crops consisting of trees, grasses and legumes, largely in non-arable or wastelands to meet the fodder requirement, especially during lean periods. The idea of fodder banks emerged to replenish arable lands that have lost their fertility due to continuous cropping. Thus, a fallow land is sown to leguminous perennial forages or self-seeding perennials to rebuild the nitrogen

content of the soil through biological nitrogen fixation and at the same time, for the production of high-quality dry fodder.

f) Custom hiring of farm machines- Custom hiring centres evolved as a community-led mechanism for access to costly machinery/ implements is critical for timely implementation of resilient practices in a large area.

CHECK YOUR PROGRESS 1

Note: i) Use the space given below for your answers.

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

1. What is agricultural intensification?

……
……
……
……
……...

2. What are the effects of agricultural intensification?

……
……
……
……
……...

3. What is landscape change?

……
……
……
……
……
……

4. Discuss the challenges in alleviating malnutrition.

……
……
……
……
……
……

13.10 LET US SUM UP

The 20th century will be remembered as an era of great progress especially in Asia since the 1960s. Between the 1960s and 1970s, we have seen a marked increase in grain production mainly as a result of the availability of high yielding cultivars, irrigation facilities and inorganic fertilizers. Challenges like poverty, hunger and malnutrition yet common in Asia and the situation in Africa is worrisome. In addition, 21st century has a new set of problems like climate change, water scarcity, degradation of soil, biodiversity loss etc. to

be tackled to keep producing enough to combat malnourishment. International agencies are actively engaged in taking strategic decisions to get it implemented at the national, state to village levels. Academia is actively involved in research to make resilient cultivars in the era of climate change and works with other important stakeholders like NGOs for the capacity building and dissemination of information to the village level. KVKs in India have played a great role in this as well. Tackling hunger in the 21st century will not be easy without taking small landholders in the business model from "local to global". Wiser use of natural resources is the need of the hour.

13.11 KEY WORDS

Food Security: Food security is defined as a condition when "all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for a healthy and active life".

13.12 SUGGESTED FURTHER READING/ REFERENCES

- Swaminathan, M.S. Genesis and Growth of the Yield Revolution in Wheat in India: Lessons for Shaping our Agricultural Destiny. Agric Res 2, 183–188 (2013).
- https://www.britannica.com/topic/agriculture/Scientific-agriculture-the-20th-century
- https://www.fao.org/3/i6583e/i6583e.pdf
- https://doi.org/10.1073/pnas.0912953109
- https://doi.org/10.1007/s40003-013-0069-3
- https://www.pnas.org/doi/10.1073/pnas.0912953109
- https://cas.cgiar.org/sites/default/files/pdf/Environmental%20Impacts%20of%20Ag%20Intensification%20TN9_July2020.pdf
- https://www.who.int/news-room/questions-and-answers/item/malnutrition
- https://www.fao.org/3/y4671e/y4671e06.htm
- https://www.fao.org/3/i6583e/i6583e.pdf
- https://glopan.org/sites/default/files/ForesightReport.pdf

13.13 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress 1

1. Please refer to section 13.3
2. Please refer to section 13.4
3. Please refer to section 13.5.1
4. Please refer to section 13.6.1

UNIT 14 URBANIZATION AND CONSUMERISM

Structure

14.1 INTRODUCTION

Cities or urban areas have been the centre of trade since ancient civilizations. These are the economic hub that has been the centre of trade and exchange of goods and services between rural-urban as well as urban-urban trade. In this context, the growth of cities in a region has always been an indicator of economic development. However, with the increasing population and unprecedented rate of urbanization, the land as a resource is becoming scarce to nurture the ever-rising urban population. As a result, urban areas are extending into the periphery either along the major roads leading to town- ribbon settlement; or urban sprawl where suburbs keep growing continuously. This urban sprawl costs agricultural land as it gets converted into settlements and other land-use types. Not only this, the development of slums and shantytowns also puts a blot on the development of cities. This unit emphasizes the pattern and causes of urbanization, issues about urbanization and challenges to sustainable urbanization.

14.2 OBJECTIVES

After studying this unit, you should be able to:

- describe the pattern of urbanization;
- explain the causes of urbanization;
- discuss the issues about urbanization;
- explain the urban sprawl and growth of slums and
- explain the sustainable cities.

14.3 URBAN POPULATION GROWTH AND DEVELOPMENT

All over the world, people prefer living in urban areas or cities for want of a better lifestyle, better educational facilities, infrastructural support for sanitation, transportation as well as employment opportunities. As per the UN Report (2018), the global population residing in urban areas has increased from 30% in 1950 to 55% in 2018 and is expected to increase to 60% by 2030. The annual Indian urban population growth was reported at 2.3 % in 2020 (World Bank). In 2018, Northern America was the most urbanized region in the world, followed by Latin America and the Caribbean (81%), Europe (74%) and Oceania (68%) with the lowest levels of urbanization being in Asia (50%) and Africa (43%). Also, by 2018, 13% of the world's urban population lived in 33 megacities, and this number is projected to increase to 14% of the urban population in 41 megacities by 2030. Further, it is projected that by 2050, Asia will host 52% and Africa approximately 21% of the world's urban population.

It is difficult to define the term 'urban' as the concept and definition of the term varies at the regional level; and also, from nation to nation. While in many places, population structure and density form the basis of urban characterization; others focus on administrative boundaries or employment in non-agricultural sectors or availability of health and other infrastructural facilities. However, even to this day, commonly, the number of people residing in the area forms the basis of the classification of a place into a rural or urban area. Therefore, a few criteria that can help in classifying the urban area/ urban settlement or a city are as follows:

Based on boundaries

a. **City Proper:** When an urban settlement is defined based on the administrative boundary.

b. **Urban Agglomeration:** This is larger than that of a city proper; and includes the extent of the contiguous urban area, or built-up area, to delineate the city's boundaries

c. **Metropolitan Area**: A metropolitan area is defined based on the interlinkage of a given area with its surrounding areas based on social and economic scenarios besides the presence of industries, services available and administrative functions.

Based on population thresholds

a. Small cities have a population of 1 million.

b. Medium-sized cities have a population of 1 to 5 million.

c. Large cities have a population of 5 to 10 million.

d. Megacities have a population of 10 million or more

It is assumed that urban areas or cities contribute about 80% of GDP to modern economic development. As per the UN report, currently, about 55% of the world's population lives in urban areas with these numbers rising alarmingly

by 2050. With the ever-increasing urban population, cities often face a variety of social issues such as adequate housing, hygiene and sanitation facilities, infrastructure and transport facilities, migration of rural to urban population; as well as environmental problems such as urban heat islands, environmental pollution-air, water, soil and noise; availability of fresh water and many more.

Once a city is built, its land use land cover is altered significantly leading to the conversion of pervious vegetated surfaces to impervious built-up surfaces such as roads, buildings or pavements. As a result, rainwater is unable to percolate, and issues of urban runoff and stormwater become more severe causing havoc for drainage facilities of the city. Thus, for the city to sustain its population, the rate of urban growth or urban sprawl should match the rate of growth of the urban population. However, it is generally seen that the rate of growth of people living in urban areas is almost double the expansion of land under urban sprawl; thus, leading to unsustainable growth of cities in the long run. It also imposes unnecessary pressure on the land and natural resources of the area. Further, it also exposes the population to disaster risk since, in developing countries, most of the urban expansion of built-up urban areas occurs in the hazard-prone areas in an unplanned manner. Also, cities consume about 67% of global energy and are responsible for emissions of 70% of greenhouse gases.

14.4 MIGRATION

As per UN Report, 2018, Urbanization or "urban transition" refers to "a shift in a population from one that is dispersed across small rural settlements, in which agriculture is the dominant economic activity, towards one that is concentrated in larger and denser urban settlements characterized by a dominance of industrial and service activities".

However, it becomes pertinent to distinguish between urbanization and urban population growth. Urban growth is the increase in the proportion of the absolute number of people living within defined urban areas (IOM, 2015); while urbanization refers to not only the migration of people from rural to urban areas, or an increase in urban population; but also, the process of creation of new urban centres or when administrative boundaries of urban settlements are extended giving rise to larger urban areas.

Further, IOM, 2015 iterates that "very often, urbanization is primarily the result of migration". Thus, there exists a very close-knit relationship between urbanization and migration. This migration of people could be rural-to-rural, rural-to-urban, urban-to-urban and urban-to-rural migration. Also, this migration could be within national borders or across the borders in the international domain. It is estimated that around 20% of the total population of international migrants live in about 20 cities in the world. Not only this, the proportion of foreign-born persons in some cities exceeds the global average of 3.5% (IOM, 2015).

Further, this migration plays a very important role in maintaining urban diversity

and growth. It is generally seen that international migration is more common in developed countries; while in developing countries, internal migration is more common. However, people from developing countries also migrate to developed countries in search of better opportunities.

With a greater influx of people into urban areas from rural areas in search of better amenities and employment opportunities; urban areas or cities are facing the pressure of a greater population load concerning the resources available. As a result, it becomes essential to manage data on urbanization and migration at the municipal or urban level for better management of urban resources.

14.5 ACCELERATED URBANIZATION: GROWTH OF CITIES AND SLUMS

The rapid pace of urbanization, as well as urban growth, exerts a lot of pressure on the natural resources of the region. The most affected under this sector is the housing facility. Due to the lack of adequate housing facilities as a result of unprecedented urban growth; there has been a rise in slums or squatter settlements or shantytowns in urban areas. Generally speaking, 'slums' are described as areas with multi-family dwelling houses of inadequate proportions. Another term used commonly is 'shantytown' which describes illegal settlements as a result of people moving into unoccupied lands and constructing their dwelling place. Shantytowns are synonymously called 'squatter settlements' to depict low-quality housing on the periphery of the city. A common difference between slums and squatter settlements is that slums are located in inner and older parts of cities compared to squatter settlements which are temporary and scattered in the outer periphery of cities. Shanty towns are mainly developed from rural-urban migration and the inability of city authorities to provide sufficient housing facilities and employment. The presence of these slums, shantytowns and squatter settlements has become a common feature of urban cities; especially the metropolitan cities in India and globally in regions such as Latin America, urban Africa and South Asian regions. In India, these slums have different names such as bustees in Kolkata, jhuggi- jhoparies in Delhi, Jhoparpattis or Chawl in Mumbai and Cheri in Chennai. The largest slum in Asia is the Dharavi slum in Central Mumbai of India.

Section 3 of Slum Areas (Improvement and Clearance) Act 1956 defines slums as areas or buildings unfit for human habitation and lacking basic amenities such as drinking water and sanitation facilities, adequate lighting and ventilation, faulty engineering design or dilapidated houses. Thus, the following criteria aid in classifying an area as a slum:

(i) All areas notified as "Slum" by the state government under any Act.

(ii) All areas recognised as a slum by the state government have not been formally notified as slums under any Act.

(iii) A compact area of at least 300 individuals or about 60-70 households of poorly built congested tenements such as mud or brick houses, in an

unhygienic environment with no ventilation, no proper lavatories; usually with inadequate infrastructure and lacking proper sanitary and drinking water facilities.

(iv) Social isolation from urban society with the prevalence of crime, drug abuse, alcoholism and socially aberrant behaviour.

(v) Prevalence of water-borne diseases such as diarrhoea, blood dysentery, malaria, typhoid as well as jaundice due to contaminated groundwater,

The causes of urbanisation are manifold, the chief being:

- Rapid urbanisation and industrialisation
- Shortage of land for housing facilities
- Exorbitant prices of land
- The influx of rural migrants to the cities in search of employment

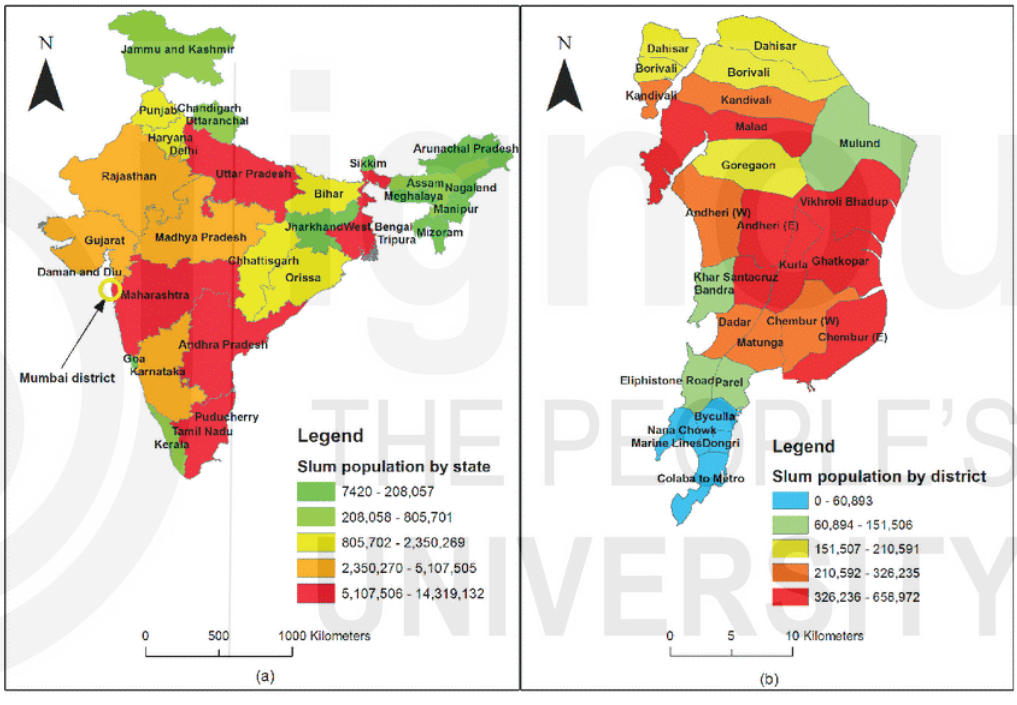

Fig. 14.1. Geographic distribution of slum population of (a) India (b) Mumbai (Mahabir et. al., 2018)

CHECK YOUR PROGRESS 1

Note: i) Use the space given below for your answers.
ii) Check your answers with those given at the end of the unit.

1. Describe the classification of urban areas.

……
……
……
……
……

2. Discuss the causes of rural to urban migration.

……
……
……
……
……

14.6 PRESSURES ON URBAN RESOURCES

Some of the problems that arise due to pressure on urban resources are the following:

1. **Lack of Adequate Housing:** It was estimated in 2011 that about 100 million people around the world have become homeless. Thus, the lack of adequate housing is a glaring problem in urban cities. With rising rural to urban migration, the housing problem has further aggravated.

2. **Inadequate Sewage System:** Insufficient sewage system is another major problem faced by growing cities as the population size far exceeds the sewage systems in most unplanned urban cities. Currently, not a single city in India is fully sewered. It is believed that only 35-40% of the urban population has access to an adequate sewage system. Most of the cities do not have proper arrangements for treating the sewerage waste and thus it gets drained into a nearby river (for example, Delhi) or into the sea (for example - Mumbai, Kolkata and Chennai); thereby, polluting the water bodies. Further, in most Indian cities, water pipes run close to sewer lines. Any leakage leads to contamination of water that has repercussions for water pollution which would eventually lead to an outbreak of water-borne diseases such as cholera, dysentery and typhoid.

3. **Overcrowding:** With the rising population in urban cities due to growth in the service sector and migration of people from rural to urban areas as well as across the borders, the overcrowding of urban cities is a common phenomenon. If we look at the example of Mumbai, the Master Plan of Greater Mumbai suggests four acres of open space per thousand population; while in reality, it has one-sixth of an acre of open space per thousands of people. Delhi has the highest population density of 9,340 persons per square kilometre as per Census 2001.

4. **Decline in Agricultural Productivity:** Rural to urban migration leads to lesser availability of people in the agricultural sector which causes a reduction in agricultural production and poses a major threat to food security. As per UN World Migration Report, 2020, 3.5% of the world's population, i.e., close to 272 million people have migrated globally in 2019; with 52% of international migrants being males and 48% being females. Out of these, 74% of migrants are in the working-age group lying between a band of 20-64 years. Further, in terms of international migrants, India continues to be the number one nation with 17.5 million migrants living abroad followed by Mexico and China. Also, there has been observed a pattern that varies from region to region. While most international migrants born in Africa, Asia and Europe reside within their regions of birth, the majority of migrants from Latin America and the Caribbean and Northern America reside outside their regions of birth.

5. **Rise of Slums and Squatter Settlements:** With rising urban sprawl and the inability of urban cities in nurturing the huge population load, the migrants and lower-income groups are forced to settle in slums or squatter settlements to carry on with their employment and support their families either living with them or sending money to the ancestral villages.

   It is imperative to mention that the central districts of the city bear the greatest pressure from the immigrating population as the immigrants throng their relatives' and friends' places before searching for their housing. This situation has been described by Brush (1968) as *"urban impulsion"* which results from the concentration of people in the centre of the city close to their friends/relatives and workplace. The four metropolitan cities of India-Delhi, Mumbai, Kolkata, Chennai and a few other cities such as Bangalore and Hyderabad act as magnets for migration and present a very good example of urban sprawl. Besides, another glaring problem is the unemployment of urban youth. It is estimated that about half of all educated urban unemployed are concentrated in the four metropolitan cities. Also, although urban incomes are higher than rural incomes, the high cost of living compensates for the comparatively higher income of the urban population.

6. **Traffic Congestion:** Another issue of increasing urbanization is the rise in the automobile sector which has led to increased traffic congestion. These transportation-related problems increase and become more complex as the town grows in size. As a result, tremendous pressure is exerted on public transport and causes much longer journey periods with buses and trains crammed to capacity, overcrowded roads and very slow movement of traffic. This leads to increased commuting time by people as well as increased fuel consumption. This has a bearing on air pollution as well as respiratory issues. In the Indian scenario, Mumbai has the best city transport system besides Chennai, Ahmedabad and Pune having well established local transport systems. Delhi despite having a well-developed road network and metro rail systems, still has congested and slow-moving traffic which is believed to worsen by the guidelines for Delhi Master Plan 2021, which would allow mixed land use, multi-storeyed structures and regularisation of 24 industrial estates.

7. **Water Scarcity:** The problem of water scarcity in urban areas is a common phenomenon. No urban city in India is self-sufficient in providing drinking water to its dwellers. In many Indian cities, the municipal supply of drinking water ranges from half an hour to two hours daily which is not sufficient to meet the family requirements. This scarcity aggravates during the summer months. The gap in demand and supply of water in four metropolitan cities in India varies from 10 to 20 % which widens further in smaller towns and cities. As a result of increased demand, Central Public Health and Environmental Engineering Organisation (CPHEEO) fixed 125-200 litres of water per head per day for cities with a population of more than 50,000, 100-125 litres for the population between 10,000 and 50,000 and 70-100 litres for towns with a population below 10,000. However, the target achieved is uncertain.

   To tackle the issue of water scarcity, a programme known as the Accelerated Urban Water Supply Programme (AUWSP) was launched

to provide water to towns with a population of less than 20,000. Also, the Zakaria Committee recommended the water requirement per head per day 204 litres for cities with a population between 5 lakh and 2 million and 272 litres for cities with a population of more than 2 million.

8. **Urban Pollution:** With the growth of Indian cities, managing solid and liquid waste dumping is a crucial issue. Most Indian cities lack adequate garbage disposal facilities and the capacity of existing landfills far outweighs the incoming solid waste. Thus, wastes are scattered in the open, forming leachate, attracting rodents and flies, and presenting a scary picture of urban cities. Besides leachate contaminating the groundwater, the open water bodies and rivers face the brunt of urbanization in the form of stormwater runoff; defaecation, discharge of sewage and industrial effluents in water bodies as well as inadequate management practices.

9. **Urban Crimes:** The social fabric of urban cities is very diverse due to people with different cultural backgrounds co-existing together. However, the problem of urban crimes is rampant that disturbs the peace of the cities and makes it unsafe for the inhabitants; particularly the women and children being most vulnerable. Increasing consumerism, materialistic lifestyle, socio-economic disparities, unemployment and growing loneliness lead to increased crime in urban cities. In India, the two metropolitan cities of Delhi and Mumbai have a high crime rate in terms of theft, robbery, sexual assault, rape and kidnappings to list a few.

14.7 CHALLENGES TO SUSTAINABLE URBANIZATION

It is pertinent to mention that all the above factors listed in the above section such as adequate housing and sanitation facilities, availability of drinking water, urban sprawl, urban slums as well as pollution pose a significant challenge to sustainable urbanization. The pace of urbanization is also causing changes in land use landcover of urban areas where pervious vegetated surfaces are being converted to impervious concrete surfaces for housing, roads, and flyovers as well as commercial centres. The influx of people from rural to peri-urban and urban areas and the emergence of new activities-be commercial or labour-driven occupational activities, is continuously changing the urban landscape with lesser and lesser availability of land as a resource in megacities.

Besides these issues, another aspect of urbanization is the role played by cities in tackling climate change. The LULC conversion has a bearing on the local micro-climate of the region with the formation of urban heat islands that exhibit elevated temperatures in the city centre compared to peri-urban and rural areas. Also, the exposure of cities increases the risk of climate change and disaster risk as the city grows in size. The coastal cities are particularly vulnerable to storm surges, tsunamis, cyclones as well as coastal floods besides the rise of sea level.

Not only this, but cities have also played a crucial role in combating epidemics as the recent example of the COVID-19 pandemic that has hampered public health as well as the economic and social structure of urban areas. The preparedness of cities in tackling the pandemic world over has been an eye-opener, as it required a massive overhaul in the structure of the health sector with the involvement of all the components of the urban governance and the public at large. Thus,

building healthy and resilient cities is the need of the hour that provides a haven for its citizens against epidemics, pandemics and other challenges such as migration. The FAO Framework for Migration proposes to minimise the causes of migration and offer lucrative alternatives in rural areas to curb migration besides promoting the well-being of migrants. Not only this, but the Government of India has also launched major development programmes such as Urban Basic Services for the Poor (UBSP), Environmental Improvement of Urban Slums (EIUS), Integrated Development of Small and Medium Towns (IDSMT), Housing and Urban Development Corporation (HUDCO), Mega-Cities Project, and Integrated Urban Poverty Eradication Programme (IUPEP).

14.8 SUSTAINABLE BUILDINGS

The growth of sustainable cities is dependent on sustainable buildings. India is among the fastest-growing economies of the world with projections that seventeen of the twenty fastest-growing cities of the world between 2019 and 2030 will be from India (Oxford Economics' Global cities report). This poses challenges to urban governance, livelihood, water supply, sanitation as well as liveability conditions for urban citizens. Most of the urban cities in India have grown in an unplanned manner with larger clusters of urban agglomerations in the centre of the city and less congested in the outskirts. Hence, Jawaharlal Nehru National Urban Renewal Mission (JNNURM) was launched in 2005 to reform the cities through planned development initiatives. It was later replaced by Atal Mission for Rejuvenation and Urban Transformation (AMRUT). Later, many other schemes such as Smart Cities Mission, Pradhan Mantri Awas Yojana – Housing for All (Urban) (PMAY-U), and Swachh Bharat Mission (Urban) (SBM-U) were launched to improve the quality of life in urban cities.

Sustainable buildings are also known as 'Green Buildings' that focus on environmental conservation besides construction safety. This is achieved by focussing on energy-efficient architectural design, recycling of grey wastewater, using solar and other renewable sources of energy, reducing the burden on fossil fuels and cutting down on the demand of electricity. GRIHA norms help in ratifying or certifying the housing settlements for a better quality of living. In India, various government and corporate housing are increasingly implementing the concept of "Green Buildings" and trying to increase the green cover of urban settlements. This also has a bearing on climate change as there has been a shift in mindset from excessive consumerism and lifestyle demands to climate-conscious green consumerism.

CHECK YOUR PROGRESS 2

Note: i) Use the space given below for your answers.
ii) Check your answers with those given at the end of the unit.

1. Enlist the major challenges of urbanisation.

……
……
……

……
……

2. What policies have been launched by the government of India to combat the issue of housing facilities in urban areas?

……
……
……
……
……

14.9 LET US SUM UP

In the present unit, urbanisation and its impacts, the challenges posed have been discussed in great detail. Thus, at the end of this chapter, the students would be well-versed with the following concepts:

- Pattern of urbanization
- Causes of urbanization
- Issues about urbanization
- Urban sprawl and growth of slums
- How to develop sustainable cities and sustainable buildings.

14.10 KEY WORDS

Migration: Environmental migration refers to human migration where environmental risks or environmental change plays a significant role in influencing the migration decision and destination. Migration may involve distinct categories such as direct, involuntary, and temporary displacement due to weather-related disasters; voluntary relocation as settlements and economies become less viable; or planned resettlement encouraged by government actions or incentives. All migration decisions are multi-causal, and hence it is not meant to describe any migrant flow as being solely for environmental reasons.

Green Building: A green building is "designed", "constructed" and "operated/ maintained" to reduce greatly the environmental impacts and augment the resource use efficiency and at the same time factor in the "cultural and community sensitivity". Use of energy-efficient equipment aid in attaining higher efficiency in performance. The green buildings are constructed in such a way that it uses less electrical energy, but use more natural sunlight for operation.

Acronyms:

- GDP: Gross Domestic Product
- IOM: International Organization for Migration
- UBSP: Urban Basic Services for the Poor
- EIUS: Environmental Improvement of Urban Slums

- IDSMT: Integrated Development of Small and Medium Towns
- HUDCO: Housing and Urban Development Corporation
- IUPEP: Integrated Urban Poverty Eradication Programme
- JNNURM: Jawaharlal Nehru National Urban Renewal Mission
- AMRUT: Atal Mission for Rejuvenation and Urban Transformation
- PMAY-U: Pradhan Mantri Awas Yojana – Housing for All (Urban)
- SBM-U: Swachh Bharat Mission (Urban)

14.11 SUGGESTED FURTHER READING/ REFERENCES

- Duncan, H. and Popp I. 2018 World Migration Report 2018, Chapter 10: Migrants and Cities: Stepping Beyond World Migration Report 2015, IOM, Geneva.
- United Nations 2018 Sustainable cities, human mobility and international migration: Report of the Secretary-General, UN, New York.
- Charles, A., Galal H., and Guna D. 2018 Preparing Cities to Manage Migration, A policy brief from the Think20 Migration Task Force, CARI and CIPPEC, Buenos Aires.
- Jansen, K. et al. 2018 Economic Migration and the Role of Cities – Ensuring Social Cohesion, A policy brief from the Think20 Migration Task Force, CARI and CIPPEC, Buenos Aires.
- United Nations Department of Economic and Social Affairs (UN DESA) 2018 World Urbanization Prospects: The 2018 Revision, UN DESA, Population Division.
- World Migration Report, 2020; IOM UN Migration, Published by International Organization for Migration (IOM), Switzerland. ISSN 1561-5502; e-ISBN 978-92-9068-789-4.
- Mahabir, Ron & Crooks, Andrew & Stefanidis, Anthony & Croitoru, Arie & Agouris, Peggy (2018). A Critical Review of High and Very High-Resolution Remote Sensing Approaches for Detecting and Mapping Slums: Trends, Challenges and Emerging Opportunities. Urban Science. 2. 10.3390/urbansci2010008.

WEB LINKS

- https://www.worldbank.org/en/topic/urbandevelopment/overview (Accessed on 23 December 2021)
- https://mohua.gov.in › cms › urban-growth (Accessed on 23 December 2021)
- https://www.migrationdataportal.org/themes/urbanisation-et-migration (Accessed on 23 December 2021)
- https://www.migrationdataportal.org/themes/urbanisation-et-migration (Accessed on 23 December 2021)
- https://rosanjose.iom.int/site/es/blog/el-complejo-punto-de-encuentro-

entre-la-migracion-ambiental-y-la-covid-19 (Accessed on 23 December 2021)

- https://habitat3.org/the-new-urban-agenda/
- https://www.iom.int/
- https://worldmigrationreport.iom.int/2015
- https://www.weforum.org/reports/migration-and-its-impact-on-cities
- https://indianexpress.com/article/india/india-news-india/rural-to-urban-migration-in-india-why-labour-mobility-bucks-global-trend/ (Accessed on 23 December 2021)
- https://economictimes.indiatimes.com/news/economy/policy/view-indias-urbanisation-challenges-and-the-way-forward/articleshow/79443872.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst

14.12 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress 1

1. Please refer to section 14.3
2. Please refer to sections 14.4 and 14.5

Check Your Progress 2

1. Please refer to section 14.7
2. Please refer to section 14.8

UNIT 15 MULTIDRUG-RESISTANT ORGANISMS

Structure

15.1 INTRODUCTION

Due to the increasing menace of multidrug-resistant organisms (MDROs), WHO in the year 2011 emphasized combating drug resistance (Sharma, 2011) that has led to increased morbidity, mortality and economic losses to the nation due to increased antimicrobial resistance (AMR) (Cohen, 2000; Rosenberger et. al., 2011; Morales et. al. 2012). Antimicrobial resistance refers to the ability of a microbe to resist the effects of a drug and may continue to multiply even in the presence of drugs. Antimicrobial-resistant germs are not killed by the drugs that are typically used against them and may continue to multiply (*cdc.gov.in*).

Historically speaking, the problem of MDROs is not a recent one, with the first antibiotic resistance being reported in *Staphylococcus aureus towards penicillin resistance. With the increasing use of antibiotics, the number of MDROs has increased manifold throughout the world.* This unit emphasizes the causes, extent and impacts of Multidrug-Resistant Organisms.

15.2 OBJECTIVES

After studying this unit, you should be able to:

- define Multidrug-Resistant Organisms;
- explain the Emerging Infectious Diseases and
- explain the causes, extent and impacts of Multidrug-Resistant Organisms.

15.3 DEFINITION

Multi-Drug Resistant Organisms (MDROs) are microorganisms, particularly bacteria, that have become resistant to one or more classes of antimicrobial agents or antibiotics. This implies that antibiotics become ineffective in controlling such bacteria (IOM, 1998; https://www.cdc.gov/infectioncontrol/guidelines/mdro/background.html). These MDROs deserve special emphasis in the healthcare sector since these MDROs are resistant not just to one antimicrobial agent, but a broad spectrum of antimicrobial agents which may be antibacterial, antifungal or antiviral. Examples include certain bacteria such as *Escherichia coli, Klebsiella pneumoniae, Acinetobacter baumannii, Stenotrophomonas maltophilia, S. pneumoniae* (MDRSP), vancomycin-intermediate *S. aureus* (VISA) and vancomycin-resistant *S. aureus* (VRSA), *Pseudomonas aeruginosa*, Methicillin-resistant *Staphylococcus aureus* (MRSA), Enterococci especially Vancomycin-Resistant Enterococci (VRE), and other organisms such as *Burkholderia cepacian* and *Ralstonia pickettii*. Generally, MDROs are present in hospitals and long-term healthcare facilities and affect old or sick people.

Further, European Centre for Disease Control (ECDC) and Centre for Disease Control & Prevention (CDC), Atlanta, have extensively defined the multidrug-resistant (MDR), extensively drug-resistant (XDR), and pandrug-resistant (PDR) organisms based on antimicrobial agents and antimicrobial categories (Magiorakos et. al., 2012). While multidrug-resistant organism (MDRO) refers to acquired non-susceptibility to at least one agent in three or more antimicrobial categories; Extensively drug-resistant organism (XDRO) was defined as non-susceptibility to at least one agent in all but two or fewer antimicrobial categories. Pandrug Resistant Organism (PDRO) was defined as nonsusceptibility to all agents in all antimicrobial categories. Another term defined by CDC in this context is Multidrug-resistant (MDR) isolate which is defined as an isolate that is resistant to at least one antibiotic in three or more drug classes. Further, non-susceptible isolate refers to an isolate that is either resistant or not completely susceptible to one or more antibiotics.

15.4. CAUSES OF ANTIMICROBIAL RESISTANCE

The causes of antimicrobial resistance could be many. A few of them are listed here:

- **Over-prescription of Antibiotics:** It is well known that antibiotics have been used for a long to treat various diseases; however, overuse of antibiotics has its challenges. It is observed that micro-organisms that were effective in treating disease have become resistant, and are no longer responding to antibiotics. Sometimes, the doctors prescribe antibiotics for a condition, such as a throat infection; when test results are awaited and doctors are not sure if the sickness is caused by bacteria or virus. It is pertinent to mention that antibiotics are effective only against bacteria, and not viruses; therefore, over-prescription must be avoided.

- **Patients not finishing the entire antibiotic course:** Many times, it is seen that patients who are on a dose of antibiotics, leave it midway once they feel relaxed; however, the illness may resurface. Prescribing antibiotics again to cure the same disease may involve a higher dosage of antibiotics to achieve the desired results. Thus, it leads to developing resistance in the long run if such practice continues.
- **Antibiotics being taken longer than necessary or when not needed:** It is common knowledge that antibiotics dampen the action of bacteria by limiting their growth and reproduction. However, an overdose of antibiotics or antibiotics once taken longer than when they are needed often results in developing resistance against the antibiotics and is ineffective.
- **Overuse of antibiotics in livestock and fish farming:** In developing countries, there has been an increasing demand for animal protein, which has resulted in intensive cultivation of livestock. This has resulted in an increase in residues of antibiotics in animal-derived products which eventually leads to antibiotic resistance. This is a matter of concern as regards public health concern because the antibiotic-resistant bacteria associated with the animals may be pathogenic to humans, that can be easily transmitted to humans via food chains. This would be widely spread in the environment via the food chain and food web that can ultimately lead to human infections. The increased use of antibiotics is so complex that it can lead to increased healthcare as well as implications for human life. Thus, these challenges cannot be isolated by geographic boundaries and are of local, national, regional, and international dimensions.
- **Poor infection control in healthcare settings:** In healthcare settings, preventing infections will aid in minimising the burden of MDROs and thus limiting antimicrobial resistance. This can be achieved by implementing appropriate clinical practices such as management of vascular and urinary catheters that are a part of routine patient care, accurate diagnosis of infections to avoid an overdose of antibiotics, prevention of infection, judicious use of antimicrobial agents and controlling transmission of these MDROs.
- **Poor hygiene and sanitation:** In healthcare settings and patients recovering at home infected by MDROs, maintaining proper hygiene and sanitation is of utmost importance as poor sanitation would be conducive to the growth and transmission of MDROs. The burden of MDROs due to poor hygiene and sanitation can be minimized by training the medical/technical staff (or, attendants at home) and making them aware of the importance of proper hygiene in the healthcare sector and also at home.

15.5 Extent

Studies prove that the MDROs can spread from person to person through direct contact; or via medication cart handles, bed rails, intravenous poles, and catheters. Many times, it is observed that MDRO may be present in the human body, but may not cause any sickness, a process known as “colonization”. For example, the presence of Staphylococcus aureus on the skin may not always fall sick; and those falling sick may be elderly people, children or people with decreased immunity on account of acute diseases, autoimmune diseases or

patients who underwent surgical procedures. Patients hospitalized in clinical facilities, especially Intensive Care Unit (ICU) patients, tend to have more risk factors than non-hospitalized patients and have the highest infection rates.

Another concept that the readers need to be aware of is 'decolonization'. This term indicates treatment of MDRO caused infections in patients by controlling the carriers of MDROs so that the infection in patients can be curtailed. However, this method has its limitations, as it is not easy to study decolonization and the efficacy is difficult to determine.

15.6 EMERGING INFECTIOUS DISEASES

The occurrence of emerging infectious diseases has increased over the world in the last three decades with 30 new agents discovered worldwide, and this trend is expected to continue in future. India, being a developing country also has been a hub of emerging infectious diseases due to its geographical location, prevailing climate, the socio-economic structure of the society and, most importantly, the environmental factors. In recent years, there has been the emergence and re-emergence of various infectious diseases, most of which are of zoonotic origin. Emerging infectious diseases (EIDs) include new, previously undefined diseases as well as old diseases with new features, such as the introduction of a disease to a new location or a new population, an increase in the incidence and spread of the disease, or new features such as resistance to available treatments. Re-emerging infectious disease is a disease that was once endemic, and had been eradicated, but has again reappeared after that.

This is a challenging situation for the healthcare sector that has repercussions for economic development as well. The distribution of emerging and re-emerging pathogens by groups shows that 37 per cent of emerging and re-emerging pathogens are viruses and prions followed by protozoa (25%). This indicates that emerging and re-emerging pathogens are disproportionately viruses (Woolhouse et. al., 2005). For example, the first severe infectious disease to emerge in the 21st century is the SARS (Severe Acute Respiratory Syndrome), which was first reported in Guangdong province of China in 2003 and thereafter spread to 30 countries in the world. The SARS virus is reported to originate possibly from civet cats, caused thousands of deaths within a short period and caused a loss of 10-30 billion USD in Asia alone (WHO, 2007). Besides, H1N1 influenza, another EID, was reported in March 2009 from Mexico, which had spread to the entire world including India by September 2009. World Health Organization (WHO) had reported more than 17,000 deaths worldwide; of which the United States alone witnessed 12,000 deaths.

The complete picture of EID in India from 1990 to 2011 can be understood in Figure 15.1. Some of these EIDs include the epidemic cholera of 1992 caused by Vibrio cholerae O139. The epidemic originated in southern peninsular India and spread both inland and along the coastline of the Bay of Bengal. The epidemic Plague outbreak of 1994, 2002 and 2004 in India are other examples of EIDs. The National Centre for Disease Control (NCDC) has identified the junction of Karnataka, Andhra Pradesh and Tamil Nadu; the Beed belt in Maharashtra, Rohru in Himachal Pradesh and Uttarakhand as focal points of the plague outbreak in India; with the worst affected being 1994 plague outbreak of Surat in Gujarat.

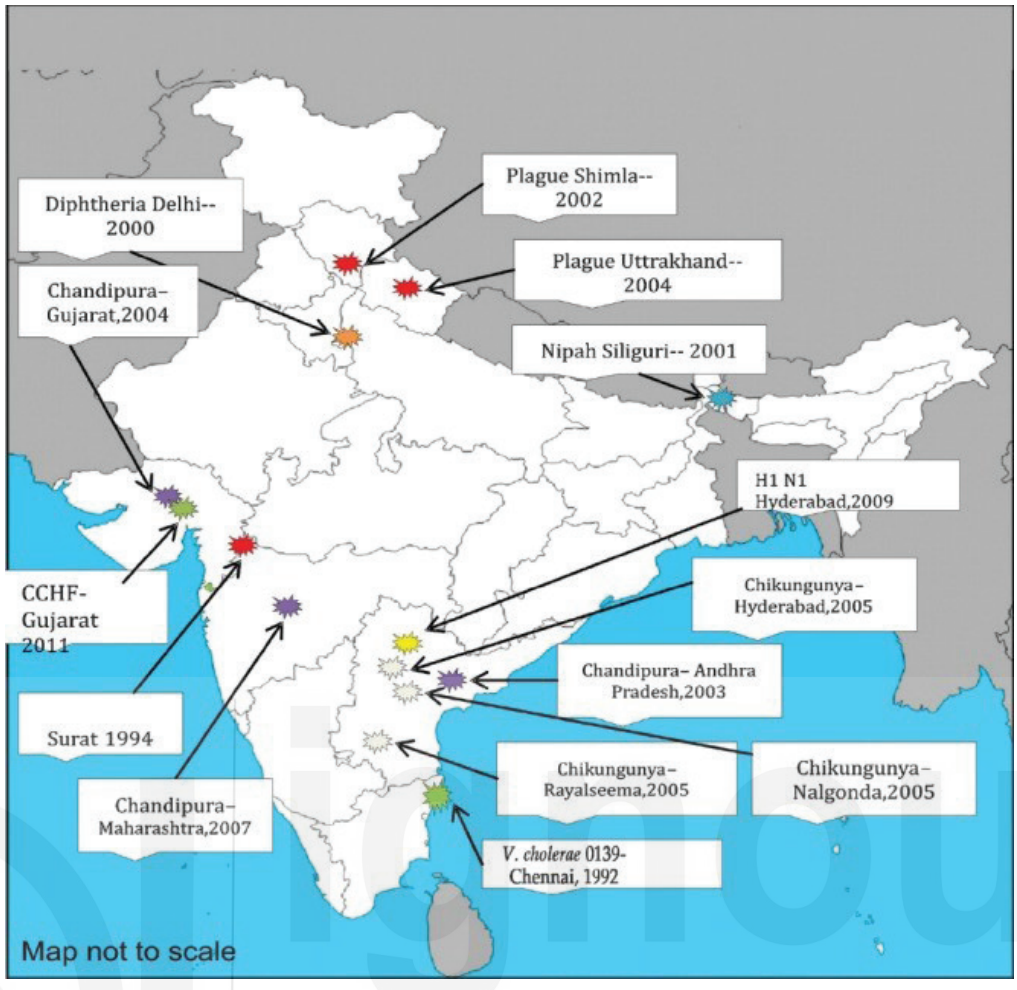

Fig. 15.1: Recognized site(s) of emerging and re-emerging infections in India, 1990-2011 (NCBI, 2013).

The incidence of diphtheria, a vaccine-preventable disease during 1980 was later reduced. However, diphtheria outbreaks from various States including Delhi, Andhra Pradesh, Assam, Maharashtra and Gujarat have been reported due to inadequate vaccination/booster doses.

The Nipah virus was first recognized in 1999 during an outbreak among pig farmers in Malaysia. Since then, there have been 12 additional outbreaks, all in South Asia. Fruit bats of the *Pteropodidae* family are the natural hosts for the Nipah virus. Evidence shows that the geographical distribution of Henipavirus (Nipah and Hendra) overlaps with that of *Pteropus*. Over the years, the epidemiology of Nipah appears to have changed. Evidence of person-to-person transmission and a high case fatality rate (60-70%) were some of the alarming developments seen in Nipah outbreaks in India (2001) and Bangladesh (2001, 2006). Nipah virus has also been categorized as a foodborne disease from eating dates contaminated with urine or saliva of infected bats.

The Nipah virus led to a high fatality in India in 2001, which was first recognized in 1999 during an outbreak among pig farmers in Malaysia. Fruit bats of the *Pteropodidae* family are the natural hosts for the Nipah virus. Later, *Rhabdoviridae* led to an outbreak of febrile illness in 1965 in the Chandipura (Nagpur) region and was named as Chandipura (CHP) virus and is transmitted to humans by sandflies. CHP virus outbreaks have been reported in Andhra Pradesh (2003), Gujarat (2004) and Maharashtra (2007). Chikungunya fever,

caused by the chikungunya virus, was first reported in Tanzania in 1953; which was later reported in India again in 2006. Almost 22 States and Union Territories of India have reported cases of chikungunya over the years.

Avian influenza is an infection caused by Influenza A (H5N1) viruses, usually infecting poultry animals and pigs. Bird flu was first reported in Navapur *tehsil* of Nandurbar district of Maharashtra, and at many places in India in 2002-03. The pandemic HINI influenza virus emerged in humans in early April 2009 in Mexico and California which later spread worldwide by human transmission.

Another EID that deserves a mention is Crimean-Congo Haemorrhagic Fever (CCHF) caused by CCHF virus that circulates in an enzootic tick-vertebrate-tick cycle. A rapid outbreak of CCHF virus was reported in Gujarat in 2011 that spread via human transmission. Early laboratory diagnosis and containment measures helped in combating the disease promptly.

Acute Encephalitis Syndrome (AES) characterized by fever and seizures affects children below 10 years of age and the states affected most by it include Uttar Pradesh, Bihar, Assam and West Bengal. AES often occurs in outbreaks during summer or following the rains.

Kyasanur Forest Disease (KFD) or Monkey Fever Disease was first discovered in 1957 in the Kyasanur forest of Shimoga district, Karnataka. Later, in 2016, it was reported in Sindhudurg, Maharashtra, where about 650 people were affected.

Further, Integrated Disease Surveillance Programme (IDSP) in 2017 reported a total of 1683 outbreak of Emerging Infectious Diseases, out of which 71% of these EIDs was caused by viral pathogens while the remaining 29% were by non-viral pathogens. It was also observed that 30% of the outbreaks were febrile rash syndromes such as measles, rubella and chickenpox, while gastroenteritis and arboviral diseases contributed 20 and 17%, respectively.

CHECK YOUR PROGRESS 1

Note: i) Use the space given below for your answers.

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

1. What are Multidrug-Resistant Organisms?

……
……
……
……
……
……
……

2. What are Emerging Infectious Diseases? Give a few examples.

……
……
……
……
……
……
……

15.7 MECHANISM

The mechanism of spread of MDROs infections is by direct contact- either with an infected person's body fluids- such as blood, drainage from a wound, urine, bowel movements (stool), or sputum (phlegm). They can also be spread by contact with equipment or surfaces that might be bearing germs. However, it is to be kept in mind that contact, such as touching or hugging, will not spread MDROs.

The chances of MDRO infection are higher in elderly people or people who underwent surgery recently. Also at risk are people with chronic illness or people hospitalized for a longer duration. Further, if a person has a weakened immune system or open wounds/sores or tubes/drains in the body, he is more likely to be infected with MDROs.

15.8 IMPACTS

MDROs cause infections in almost any part of the body.

A. **Bloodstream:** MDROs in the bloodstream may lead to serious infection, which at times can be life-threatening. The epidemiology of MDROs during bloodstream infection (BSI) and associated risks of MDROs among patients with spinal cord injury (SCI) in France was studied by Dinh et. al. (2016) and it was observed that the occurrence of MDROs in BSI in an SCI population is quite frequent; however, no associated risks were identified that would aid in optimizing antibiotic treatment.

B. **Lungs:** Infection of MDROs in the lungs can lead to pulmonary infections, pneumonia and tuberculosis and treatment is based on a combination of various antibiotics.

C. **Urinary tract:** The most common causal organism for urinary tract infections (UTIs) by MDROs is Enterobacteriaceae. Infectious Diseases Society of America has issued guidelines that for patients suffering from MDROs induced UTIs, antibiotic therapy should be based on data about local resistance data, supply/ prevalence of drugs and antibiotic intolerance history of treated patients.

D. **Wounds:** In various studies, MDROs are aggravating the infections, especially in patients having open wounds or sores.

E. **Skin:** MDROs are most likely to enter the human body if there is an open wound, sore or boils in the skin. An example of the same is Methicillin-resistant Staphylococcus aureus (MRSA) bacteria that causes infections in different parts of the body once it enters through the skin.

F. **Surgical site:** Surgical sites are very much prone to infections by MDROs, especially people who have undergone recent surgery, or are having tubes and drains in the body, are at higher risk of contracting MDROs based infections.

15.9 MANAGEMENT AND POLICY

Management of MDROs is a challenging domain due to their limited ability

to respond to common antibiotics. However, it is seen that a combination of antibiotics is many times successful in treating MDROs based infections. Various agencies such as the Centre for Disease Control and Prevention (CDC) suggest following strictly the prescription of antibiotics by doctors and not leaving it mid-way.

Another approach is handwashing – one of the most effective methods to limit the spread of MDROs. Healthcare professionals are trained to wash their hands with soap and warm water for at least 20 seconds or use an alcohol-based hand sanitizer before and after treating each patient. Besides, all healthcare personnel are trained to clean their hands after touching any surface, patient care items, equipment, and room surfaces and after removing protective clothing. This can also be corroborated by preparing a checklist to ensure all areas were cleaned. This approach has been very significant during times of the COVID-19 pandemic to control the spread of coronaviruses as well. Further, vaccination against resistant micro-organisms will also be effective in combating infection against MDROs.

However, outside a healthcare setting, it is essential to wash hands properly with soap and water on coming in contact with such person and wash clothes/towels etc. that were used during contact with the person. In case, a patient infected with MDRO needs care at home, the attendant or caretaker needs to follow a similar procedure of washing hands with soap and water before and after coming in contact with the sick patient infected with MDROs. Not only this, bedsheets, towels, gloves and the room of the patient should be cleaned and disinfected regularly. Also, care should be taken to use disposable gloves, gowns or masks and other materials as much as possible, that can be disposed of safely. Further, it becomes essential to notify the healthcare professionals monitoring the patient about his/her infection with MDROs. Further, patients with an MDRO infection are usually isolated or share a room with other patients having similar infections by MDROs. Control of MDROs in a healthcare setting requires a different set of protocols; e.g., on visiting a patient in a hospital, it is advisable to wash hands before entering/leaving the room and wearing disposable gloves or gowns.

It is pertinent to mention that the primary responsibility for spreading awareness about MDROs and infection thereof lies in hospitals and other healthcare facilities. These monitor the spread of MDROs and educate technical staff and caregivers on the best ways to prevent it. The training is provided for maintaining adequate hygiene, daily cleaning, use of antibiotics and use of protective clothing.

Further, there are various control interventions, that include the following:

1. **Administrative Support:** It is believed that for successfully controlling the MDROs, the most important step is administrative support and involvement which requires committed human resources. Examples include:

    - Ensuring effective communications by implementing system changes. This includes computer alerts to identify patients with a history of MDROs infections.
    - Providing appropriate facilities for reducing infections due to direct contact. This includes installing washbasins/sinks for washing hands with soap and water or sanitizers/alcohol-based handwash dispensers.

- Maintaining adequate staff for proper care of patients hospitalized with MDROs.
- Enforcing mechanism to implement adherence to recommended infection control practices.
- Administrative interventions in controlling transmission rates of MDROs.
- Participation in local, regional, national or global collaborations for combating MDROs caused infections.

2. **Judicious Use of Antimicrobials:** The CDC Campaign to Prevent Antimicrobial Resistance was launched in 2002 to emphasize on judicious use of antimicrobials. This aspect focuses on the effective antimicrobial treatment of infections, use of narrow-spectrum agents, avoiding longer duration of therapy, educating about side-effects of MDROs; academic interventions to counteract pharmaceutical influences on prescribing patterns; computer-assisted management programs; and active efforts to remove redundant antimicrobial combinations.

3. **Surveillance:** Surveillance is a critically important component of any MDRO control program, and is of both routine and enhanced surveillance nature. This allows early identification of newly emerging pathogens, monitoring epidemiologic trends, and measuring the effectiveness of interventions. The simplest form of MDRO surveillance is the monitoring of clinical microbiology isolates resulting from tests ordered as part of routine clinical care for detecting the emergence of new MDROs not previously detected. Another aspect is determining MDRO incidence based on clinical culture results.

4. **Standard and Contact Precautions:** CDC has recommended the use of Standard and Contact Precautions for MDROs since 1996 to prevent MDROs transmission. Standard precautions are significant in preventing MDRO transmission, even in facilities that use Contact Precautions for patients with an identified MDRO, i.e., from potentially colonized patients, because many times, colonization with MDROs can go undetected due to lack of sensitivity, or intermittent colonization due to antimicrobial therapy. Therefore, Standard Precautions must be used to prevent transmission. Hand hygiene is an important component of Standard Precautions. On the other hand, contact precautions are intended to prevent the transmission of infectious agents, which are transmitted by direct or indirect contact with the patient or the patient's environment.

5. **Environmental Measures:** The potential role of environmental reservoirs, such as surfaces and medical equipment, in the transmission of VRE and other MDROs has been reported in several studies, which has led to interventions such as dedicated cleaning staff and increased cleaning and disinfection of frequently touched surfaces. Therefore, monitoring for adherence to recommended environmental cleaning practices is an important determinant for success in controlling the transmission of MDROs and other pathogens in the environment.

6. **Decolonization:** Decolonization is a concept that implies the treatment of persons colonized with a specific MDRO, usually MRSA, wherein

the carrier organism of MDRO is eradicated. Most healthcare facilities have limited the use of decolonization to MRSA outbreaks, or other high prevalence situations.

7. **Need for Coordinated Action:** The above facts indicate that combating MDRO calls for a coordinated action plan and following a multisectoral approach by engaging stakeholders from the health sector, policy formulation, researchers and academicians to attain better public health outcomes. The launch of various programmes such as the Global Action Plan on Antimicrobial Resistance (GAP), the Antimicrobial Resistance Multi-Partner Trust Fund (AMR MPTF), and the Global Antibiotic Research & Development Partnership (GARDP), AMR Action Fund and other initiatives could bridge the existing gap in MDRO studies. The **Global Action Plan on Antimicrobial Resistance (GAP)** framework was set out in the Global Action Plan (GAP) on AMR during the 2015 World Health Assembly and committed to the development and implementation of multisectoral national action plans to slow the emergence and reduce the spread of AMR. Besides, **Tripartite Joint Secretariat on Antimicrobial Resistance was declared by** United Nations General Assembly in New York in September 2016, which also emphasized on multisectoral approach by engaging human resources as well as environmental health sectors. The Interagency Coordination Group on AMR submitted its report "No time to wait: Securing the future from drug-resistant infections" to the UN Secretary-General in April 2019.

   Not only this, **World Antimicrobial Awareness Week (WAAW),** previously called World Antibiotic Awareness Week is celebrated since 2015 to include all antimicrobials including antibiotics, antifungals, antiparasitic and antivirals and encourages best practices among the general public, health workers and policymakers.

   Further, WHO launched the Global Antimicrobial Resistance and Use Surveillance System (GLASS) in 2015 to continue filling knowledge gaps by collecting, analysing, interpreting and sharing data by countries. It monitors the status of existing and new national surveillance systems, provides technical support to countries and facilitates enrolment into GLASS. The **Global Research and Development priority setting for AMR was again set up in** 2017, to guide research and development into new antimicrobials, diagnostics and vaccines by the WHO. **Global Antibiotic Research and Development Partnership (GARDP)** is a not-for-profit global partnership developing treatments for drug-resistant infections that pose the greatest threat to health.

CHECK YOUR PROGRESS 2

Note: i) Use the space given below for your answers.

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

1. Describe the spread of infection by MDROs.

……
……
……
……
……

2. What is decolonization?

……
……
……
……
……
……

15.10 LET US SUM UP

For a developing country such as India, the emerging infections, particularly due to MDROs remain a real challenge due to its large population structure, geographical location and limitations in the healthcare sector. Thus, combating MDRO caused infections calls for a multi-pronged strategy for combating emerging and re-emerging infections. Centre of excellence and high-end research facility should be set up to develop partnerships between public health organizations and research institutes to improve their scientific capacity, share best practices and expand the knowledge domain as far as MDROs are concerned. Besides, adequate efforts are also needed to develop surveillance tools, diagnostic tests, vaccines and therapeutics through basic as well as applied research. Fast diagnosis and appropriate treatment call for the appointment of well-trained and committed staff. Besides, commitment and comprehensive efforts are also necessary at all levels of health services to meet the threat of emerging and re-emerging infections. This calls for appropriate policy formulations keeping scientific temperament and spirit of enquiry among the healthcare workers and researchers.

15.11 KEY WORDS

Multidrug-resistant Organisms (MDROs): In general, bacteria (excluding M. tuberculosis) that are resistant to one or more classes of antimicrobial agents and usually are resistant to all but one or two commercially available antimicrobial agents (e.g., MRSA, VRE, extended-spectrum beta-lactamase [ESBL]-producing or intrinsically resistant gram-negative bacilli).

Abbreviations

AMR MPTF: Antimicrobial Resistance Multi-Partner Trust Fund

AMR: Anti-Microbial Resistance

CCHF: Crimean-Congo Haemorrhagic Fever

CDC: Centre for Disease Control and Prevention

ECDC: European Centre for Disease Control

EIDs: Emerging Infectious Diseases

GAP: Global Action Plan on Antimicrobial Resistance

GARDP: Global Antibiotic Research & Development Partnership

IDSP: Integrated Disease Surveillance Programme

KFD: Kyasanur Forest Disease

MDR: Multidrug-Resistant

MDROs: Multidrug-Resistant Organisms

MRSA: Methicillin-resistant Staphylococcus aureus

NCDC: National Centre for Disease Control

PDRO: Pandrug Resistant organisms

SARS: Severe Acute Respiratory Syndrome

XDRO: Extensively Drug-Resistant Organisms

15.12 SUGGESTED FURTHER READING/ REFERENCES

- Cohen M. L. Changing patterns of infectious disease. *Nature.* 2000;406(6797):762–767. doi: 10.1038/35021206.
- Dinh A, Saliba M, Saadeh D, Bouchand F, Descatha A, Roux AL, Davido B, Clair B, Denys P, Annane D, Perronne C, Bernard L. Bloodstream infections due to multidrug-resistant organisms among spinal cord-injured patients, epidemiology over 16 years and associated risks: a comparative study. Spinal Cord. 2016 Sep;54(9):720-5. doi: 10.1038/sc.2015.234. Epub 2016 Feb 16. PMID: 26882486.
- Hall KK, Shoemaker-Hunt S, Hoffman L, Richard S, Gall E, Schoyer E, Costar D, Gale B, Schiff G, Miller K, Earl T, Katapodis N, Sheedy C, Wyant B, Bacon O, Hassol A, Schneiderman S, Woo M, LeRoy L, Fitall E, Long A, Holmes A, Riggs J, Lim A (2020). Making Healthcare Safer III: A Critical Analysis of Existing and Emerging Patient Safety Practices. (Prepared by Abt Associates Inc. under Contract No. 233-2015-00013-I.) AHRQ Publication No. 20-0029-EF. Rockville, MD: Agency for Healthcare Research and Quality.
- Integrated Disease Surveillance Programme, Ministry of Health & Family Welfare, Government of India. [accessed on June 5, 2018]. Available from: http://idsp.nic.in/index4.php?lang=1&level=0&linkid=406&lid=3689.
- IOM (1998), eds. Harrison, P. F. Lederberg, J. (National Academy Press, Washington, DC), pp. 8-74.
- Jane D. Siegel, MD; Emily Rhinehart, RN MPH CIC; Marguerite Jackson, PhD; Linda Chiarello, RN MS; the Healthcare Infection Control Practices Advisory Committee. Management of Multidrug-Resistant Organisms In Healthcare Settings, 2006. https://www.cdc.gov/infectioncontrol/guidelines/mdro/
- Magiorakos A.-P., Srinivasan A., Carey R. B., et al. Multidrug-resistant, extensively drug-resistant and pandrug-resistant bacteria: an international expert proposal for interim standard definitions for acquired resistance. *Clinical Microbiology and Infection.* 2012;18(3):268–281. doi: 10.1111/j.1469-0691.2011.03570.x.
- Morales E., Cots F., Sala M., et al. Hospital costs of nosocomial multi-drug resistant *Pseudomonas aeruginosa* acquisition. *BMC Health Services*

Research. 2012;12(1, article 122) doi: 10.1186/1472-6963-12-122.

- NCBI (2013). https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3767269/
- NCMH Background papers - the burden of disease in India. New Delhi: National Commission on Macroeconomics and Health & Family Welfare, Ministry of Health, Government of India; 2005. Disease burden in India: estimations and causal analysis.
- Rosenberger L. H., Hranjec T., Politano A. D., et al. (2011). Effective cohorting and 'superisolation' in a single intensive care unit in response to an outbreak of diverse multi-drug resistant organisms. *Surgical Infections.* 12(5):345–350. doi: 10.1089/sur.2010.076.
- Sharma A (2011). Antimicrobial resistance: no action today, no cure tomorrow. *Indian Journal of Medical Microbiology.* 29(2):91–92. doi: 10.4103/0255-0857.81774.
- Woolhouse ME, Gowtage-Sequeria S. (2005). Host range and emerging and reemerging pathogens. *Emerg Infect Dis.*11:1842–7
- World Health Organization. Geneva, Switzerland: World Health Organization; 2007. World Health Report 2007

Web Links

- *cdc.gov.in* (Accessed 28th December 2021)
- https://portal.ct.gov
- https://www.cdc.gov/infectioncontrol/guidelines/mdro/background.html
- https://www.cdc.gov/nhsn/pdfs/ps-analysisresources/phenotype_definitions.pdf
- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3767269/ (Accessed 06 February 2022)
- https://www.who.int/antimicrobial-resistance/global-action-plan/development_process/en/ (Accessed 05 February 2022)
- https://www.who.int/antimicrobial-resistance/global-action-plan/en/ (Accessed 08 February 2022)

15.13 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress 1

1. Please refer to section 15.3
2. Please refer to section 15.6

Check Your Progress 2

1. Please refer to section 15.7
2. Please refer to section 15.9

Unit 16 SUSTAINABLE DEVELOPMENT GOALS

Structure

16.1 INTRODUCTION

We can recall from the previous units and can categorically state that climate change challenges the existence of humanity; it is a reality and calls for urgent action at the global and national levels. According to UNFCC, "the global nature of climate change calls for the widest possible cooperation by all countries and their participation in an effective and appropriate international response, to accelerate the reduction of global greenhouse gas emissions." In this context, the year 2015 marked a milestone in humanity's efforts towards building a better and more sustainable future for everyone. In 2015 "the Sustainable Development Goals (SDGs)" were agreed by 193 member states of the United Nations and complemented by commitments made in the Paris Agreement which map out a broad spectrum of economic, social and environmental objectives to be achieved by 2030. "The 2030 Agenda for Sustainable Development having 17 interconnected Sustainable Development Goals (SDGs) and 169 targets is a global plan of action for people, planet and prosperity". Among the 17 Sustainable Development Goals (SDGs) specified in the 2030 Agenda for Sustainable Development, climate change is not only one of the SDGs, but it impacts most of the other SDGs as well. It is a threat enhancer, with the potential to negatively affect humanity's greatest challenges including health, poverty, hunger, inequality and ecosystem preservation, among others. Addressing climate change also offers humanity's greatest chance to positively impact these goals.

India also adopted two transformative agreements within the span of a few months: the 2030 Agenda for Sustainable Development and the Paris Climate Change Agreement. The 2030 Agenda and the Paris Agreement share the

purpose of creating a more resilient, productive and healthy environment for present and future generations. These two agreements though adopted separately, nevertheless, share the common goal of building a climate-safe future that is more sustainable, resilient and prosperous for all. The SDGs are global goals and they are built upon the erstwhile Millennium Development Goals. These goals are exhaustive, universal and integrated and emphasize core areas of poverty and inequality, economic growth, innovation, sustainable consumption and production, climate change, peace and justice and partnerships. In this unit, we will discuss the 2030 Agenda for Sustainable Development; the genesis of Sustainable Development Goals; SDG 13 which demands "urgent action to combat climate change and its impacts"; and India's progress and preparedness for achieving SDG 13.

16.2 OBJECTIVES

After studying this unit, you should be able to:

- explain the genesis of sustainable development and sustainable development goals;
- discuss the 2030 Agenda for Sustainable Development and Sustainable Development Goals;
- recognise SDG 13- take urgent action to combat climate change and its impacts; and
- review India's progress and preparedness on SDGs 13.

16.3 THE CONCEPT OF SUSTAINABLE DEVELOPMENT

The term "Sustainable Development" was first coined in 1972 at the United Nations Conference on Human Environment in Stockholm. The most important publication on "Sustainable Development" is the publication by the World Commission on Environment and Development (WCED) or the Bruntland Commission report in 1987 titled "Our Common Future". The World Commission on Environment and Development was initiated by the General Assembly of the United Nations in 1982, and its report, Our Common Future, was published in 1987. It was chaired by then Prime Minister of Norway, Gro Harlem Brundtland, thus earning the name the "Brundtland Commission." The report was published to link the issues of economic development and environmental stability and the oft-cited definition of sustainable development was provided as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations General Assembly, 1987, p. 43). In other words, it is improving the quality of life of the present generation without excessive use or abuse of natural resources, so that they can be preserved for the next generation. Its roots were in the 1972 Stockholm Conference on the Human Environment where the conflicts between environment and development were first acknowledged.

The United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992 (the so-called "Earth Summit") issued a declaration of principles, a detailed Agenda 21 of desired actions, international agreements on climate change and biodiversity, and a statement of principles on forests. Ten years later, in 2002, at the World Summit on Sustainable Development in Johannesburg, South Africa, the commitment to sustainable development was reaffirmed.

Box 16.1: Sustainable Development: From Our Common Future (WCED, 1987)

- "Humanity can make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs. The concept of sustainable development does imply limits - not absolute limits but limitations imposed by the present state of technology and social organization on environmental resources and by the ability of the biosphere to absorb the effects of human activities. But technology and social organization can be both managed and improved to make way for a new era of economic growth. The Commission believes that widespread poverty is no longer inevitable. Poverty is not only an evil in itself, but sustainable development requires meeting the basic needs of all and extending to all the opportunities to fulfil their aspirations for a better life. A world in which poverty is endemic will always be prone to ecological and other catastrophes".
- "Meeting essential needs requires not only a new era of economic growth for nations in which the majority are poor but an assurance that those poor get their fair share of the resources required to sustain that growth. Such equity would be aided by political systems that secure effective citizen participation in decision making and by greater democracy in international decision making".
- "Sustainable global development requires that those who are more affluent adopt lifestyles within the planet's ecological means - in their use of energy, for example. Further, rapidly growing populations can increase the pressure on resources and slow any rise in living standards; thus sustainable development can only be pursued if population size and growth are in harmony with the changing productive potential of the ecosystem".
- "Yet in the end, sustainable development is not a fixed state of harmony, but rather a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are made consistent with future as well as present needs. We do not pretend that the process is easy. Painful choices have to be made".

16.4 GENESIS OF SUSTAINABLE DEVELOPMENT GOALS

In 2000, the Millennium Summit was held in New York, which resulted in the UN Millennium Declaration. The Millennium Declaration resulted in a set of targets to be achieved by 2015 that included environmental sustainability, the eradication of extreme poverty and equality for women, now known as

the Millennium Development Goals. In 2000, 189 countries agreed under the umbrella of the United Nations on the Millennium Development Goals (MDGs) by signing the Millennium Declaration. According to the UN Declaration, the MDGs were to be achieved in a timeline of 15 years and, thus, they expired in 2015. The MDGs were composed of eight goals: seven social goals (namely eradicating hunger, promoting education and gender equality, reducing child mortality, improving maternal health, combating HIV/AIDS, creating a global partnership for development) and one environmental goal (ensuring environmental sustainability). The MDGs reflected, indeed, the idea at that time that health and education were crucial drivers of development, thus sustainability and development were to be achieved by goals mostly focused on the improvement of individuals' conditions. The era of the Millennium Development Goals (MDGs) which mobilized attention on addressing the challenges of extreme poverty, hunger, illiteracy and disease came to an end in 2015.

World Summit on Sustainable Development which was held in Johannesburg renewed international commitment to the pursuit of sustainable development with the Johannesburg Plan of Implementation (JPOI); 2012 resulted in an outcome document "The Future We Want". In the document, the States reaffirmed the commitments to all previous sustainable development agreements, plans and targets. They also committed to developing a suite of Sustainable Development Goals (SDGs) building on the priorities identified in Agenda 21 and the JPOI and decided to replace the Commission for Sustainable Development with a 'high-level political forum' to progress implementation of Agenda 21 and the JPOI, and the achievement of the SDGs. The Sustainable Development Goals (SDGs) were agreed upon at the United Nations in New York in September 2015.

16.5 2030 AGENDA FOR SUSTAINABLE DEVELOPMENT

Since its inception in 2015, the 2030 Agenda for Sustainable Development has provided a blueprint for shared prosperity in a sustainable world. The 17 Goals of the 2030 Agenda for Sustainable Development came into force on 1 January 2016. These SDGs are a "universal set of goals and targets agreed by 194 UN member states to guide their development policies and initiatives over the next 15 years". The 2030 Agenda focuses on the "elimination of hunger and reduction of poverty and inequality (opportunity, resource access, gender, and youth) in all their forms". The 2030 Agenda also buttress the Paris Agreement on climate change by "promoting and facilitating energy efficiency and clean energy". It also aims to augment the resilience to extreme weather events and climate change; protect the habitat and ecosystem; enhance resource use efficiency; and enable sustainable production and consumption.

If we look at the history of SDGs, the Heads of State and Government representatives, held a meeting at the United Nations Headquarters in New

York from 25-27th September 2015 and they agreed upon a new 2030 Agenda for Sustainable Development, which was built around 17 goals and 169 targets (UN, 2015). The 2030 Agenda and its seventeen Sustainable Development Goals (SDGs) build on the Millennium Development Goals (MDGs), are much broader in scope and ambition, encompassing the eradication of poverty and hunger and improved health and nutrition; reduction of inequality; the building of peaceful, just and inclusive societies; the protection of human rights; the promotion of gender equality and the empowerment of women and girls; and the lasting protection of the planet and its natural resources.

The 17 Sustainable Development Goals are:

- Goal 1: End poverty in all its forms everywhere;
- Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture;
- Goal 3: Ensure healthy lives and promote well-being for all at all ages;
- Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all;
- Goal 5: Achieve gender equality and empower all women and girls;
- Goal 6: Ensure availability and sustainable management of water and sanitation for all;
- Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all;
- Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all;
- Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation;
- Goal 10: Reduce inequality within and among countries;
- Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable;
- Goal 12: Ensure sustainable consumption and production patterns;
- Goal 13: Take urgent action to combat climate change and its impacts;
- Goal 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development;
- Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss;
- Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels; and
- Goal 17: Strengthen the means of implementation and revitalize the global partnership for sustainable development.

The 2030 Agenda advocates "sustainable development in all of its three dimensions, for all countries (developing and developed), based on the fundamental recognition and protection of human rights, dignity and equity". Further, SDGs endeavour to create a suitable environment for "sustainable, inclusive and sustained economic growth, shared prosperity and decent work for all, taking into account different levels of national development and capacities" (http://www.fao.org/3/a-i7808e.pdf). These SDGs are ambitious and universal and at the same time, they direct towards a path for nations to achieve fair, equitable, inclusive and environment-friendly development. In other words, we can say that human and environmental rights underpin the foundation of the SDGs that demand robust and integrated actions nationally and also charted out the role of different actors in the process. The SDGs being interdependent require actions at all levels to attain the development outcomes.

Check Your Progress 1

Note: a) Use the space given below for your answers.
b) Check your answers with those given at the end of the unit.

1. Give an overview of the 2030 Agenda for Sustainable Development.

……
……
……
……
……

2. What are Sustainable Development Goals?

……
……
……
……
……

16.6 SDG 13: TAKE URGENT ACTION TO COMBAT CLIMATE CHANGE AND ITS IMPACTS

According to the Sustainable Development Goals Report, 2019, the most urgent area for action is climate change. There is an urgent need to contain the greenhouse gases emissions so that the global average temperature doesn't overshoot 2.0°C. The impacts of climate change are catastrophic and irreversible; increasing frequency and magnitude of disasters; ocean acidification; land degradation and coastal erosion; and loss of biodiversity. Climate change affects the poor and disadvantaged groups. They have the potential to impact agricultural production leading to food shortages, famines and hunger. Further, climate change is projected to displace up to 140 million people by 2050. According to the World Meteorological Organization, 2018 was the fourth warmest year on record, with the past four years (2015, 2016, 2017, 2018) being the four warmest years on record. The world continues to experience rising sea levels, extreme weather

conditions and increasing concentrations of greenhouse gases. Climate change is a cross-cutting and immediate threat to the achievement of the SDGs, and the survival and well-being of island nations and coastal communities. This calls for urgent and accelerated action by countries as they implement the 2030 Agenda for Sustainable Development and their commitments to the Paris Agreement on Climate Change.

Box 16.2: Status and Trends: Climate Change

Climate change is happening right now, and its effects are visible. The global mean temperature for 2018 is estimated to be 0.99 ± 0.13 °C above the preindustrial baseline, arctic temperatures exceptionally high relative to a long-term average, and many countries experienced their warmest year on record. The impacts are being felt all over the world and addressing these requires a robust two-pronged approach: reduction in the greenhouse gas emissions, and adaptation planning. As of February 2019, 185 parties had ratified the Paris Agreement. Parties to the Paris Agreement are expected to prepare, communicate and maintain successive nationally determined contributions (NDCs). As of 27 February 2019, 182 Parties (181 countries plus the European Commission) had communicated their first NDCs to the United Nations Framework Convention on Climate Change Secretariat (UNFCCC).

Climate action requires efforts on mitigation, adaptation and means of implementation – climate finance, technology and capacity building. Just as problems are interrelated, the solutions to poverty, inequality, climate change and other global challenges are also interlinked. Valuable opportunities exist to accelerate progress by examining inter-linkages across goals. For example, tackling climate change requires a shift to clean energy, reversing the trend in forest loss, and changing our production and consumption patterns. Promoting sustainable agriculture can help reduce both hunger and poverty since close to 80 per cent of those who are extremely poor live in rural areas. Increasing access to safe drinking water, sanitation and hygiene can save millions of lives per year and improve school attendance.

Sustainable Development Goal 13 (SDG 13 Climate Action) commits to take "urgent action to combat climate change and its impacts", emphasizing the globally agreed need to mitigate anthropogenic greenhouse gas emissions and adapt to the damages caused by climate change while acknowledging that the "United Nations Framework Convention on Climate Change is the primary international, intergovernmental forum for negotiating the global response to climate change." The UNFCCC acknowledges that "the global nature of climate change calls for the widest possible cooperation by all countries and their participation in an effective and appropriate international response, following their common but differentiated responsibilities and respective capabilities and their social and economic conditions."

To achieve the Sustainable Development Goals and implement the Paris Agreement, developed and developing countries alike will need to transform their energy systems, ecosystem management, agriculture and land use, urban management, material use, gender outcomes, health, education, governance and other areas. Goal 13 in particular focuses on the "urgent action" required

to "combat climate change and its impacts", thus incorporating both climate change mitigation and climate change adaptation. Its scope includes three targets: 13.1- strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries; 13.2- integrate climate change measures into national policies, strategies, and planning; and 13.3- improve education, awareness-raising and human institutional capacity on climate change mitigation, adaptation, impact reduction, and early warning.

Box 16.3: Global Warming of 1.5°C Special Report

According to the "Global Warming of 1.5°C Special Report" from the Intergovernmental Panel on Climate Change (IPCC), the world has already warmed by 1°C, increasing the episodes and intensity of extreme weather events. The report states that limiting global warming to 1.5°C is still possible but would require "rapid and far-reaching" transitions in how we manage land, energy, industry, buildings, transport and cities. Specifically, global net human-caused emissions of carbon dioxide would need to fall by about 45 per cent from 2010 levels by 2030, reaching "net zero" around 2050.

Achieving all other SDGs will be much more challenging without urgent climate action, including those related to poverty, hunger, access to water, terrestrial and marine ecosystems, health, gender equality and the empowerment of women and girls, among others. Conversely, many of the goals and targets can also be achieved in ways that would enable adaptive responses to climate change. The energy transitions envisaged in SDG 7 would contribute significantly to lowering greenhouse gas (GHG) emissions relative to business-as-usual pathways.

From the perspective of protection of the climate system and GHG emission reduction, UNFCCC and SDG 13 endeavour to strengthen and augment resilience and adaptive capacity. The developing countries and low-income countries in their pursuit of sustainable development, require climate change interventions, which demand both "financial and technological inputs".

BOX 16.4: Goal 13: Take urgent action to combat climate change and its impacts

The United Nations Framework Convention on Climate Change is acknowledged as the primary international, intergovernmental forum for negotiating the global response to climate change.

13.1: Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries.

13.2: Integrate climate change measures into national policies, strategies, and planning.

13.3: Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction, and early warning.

13.a: Implement the commitment undertaken by developed country Parties to the UNFCCC to a goal of mobilizing jointly USD100 billion annually by 2020 from all sources to address the needs of developing countries in the context of meaningful mitigation actions and transparency on

implementation and fully operationalize the Green Climate Fund through its capitalization as soon as possible.

13.b: Promote mechanisms for raising capacities for effective climate change-related planning and management, in LDCs, including focusing on women, youth, and local and marginalized communities.

Source: http://www.cisdl.org/wp-content/uploads/2018/03/SDG_13_Climate_-_Issue_Brief__-_06.09.2016_-Final_-_UNEP.pdf

16.7 INDIA'S PROGRESS AND PREPAREDNESS TOWARD SDG 13

In the previous section, you have got an idea of SDG - 13. In this section, we will discuss, India's preparedness and progress toward SDG 13. We know that India has signed and ratified the Paris Agreement, making it obligatory for it to reach its commitments. India is also a signatory among 192 nations to the 2030 Global Agenda for Sustainable Development. The Government of India has entrusted NITI Aayog, with coordinating the SDG Agenda in India and has asked the states to prepare action plans and has also embarked upon an exercise to develop national indicators for the 17 Goals, besides undertaking consultations on specific goals. NITI Aayog is expected to come up with the long-term vision (2015-30) and medium-term plan (2015-22), in response to which it recently developed a short-term action agenda. NITI Aayog has carried out a draft mapping of goals and targets against existing schemes and these goals have been assigned to respective ministries. There is also active at the state level, with states asked to put forward their plans for implementing the SDGs to NITI Aayog, looking at the SDGs as a guiding framework for their long-term development strategy. This includes a proposal to introduce an SDG charter for each government ministry. The MoEFCC has been assigned the responsibility of three goals (Goal 12, 13 and 15) directly where they need to coordinate with different ministries on individual targets. Further, they have partial responsibility for another seven goals for which they will engage with other ministries. NITI Aayog is also given the responsibility to develop an energy policy in light of India's commitment to the Paris Agreement. The MoEFCC has designed the Nationally Determined Contributions with consultations from state governments, ministries and civil societies.

16.7.1 NATIONAL ACTION PLAN ON CLIMATE CHANGE (NAPCC)

In this section, we will discuss the National Action Plan on Climate Change (NAPCC) and other initiatives by the Government of India. The NAPCC consists of eight National Missions namely:

- Jawaharlal Nehru National Solar Mission;
- National Mission for Enhanced Energy Efficiency;
- National Mission on Sustainable Habitat;

- National Water Mission;
- National Mission for Sustainable Agriculture;
- National Mission for Sustaining the Himalayan Ecosystem;
- National Mission for a Green India; and
- National Mission on Strategic Knowledge for Climate Change.

Under these initiatives, the Government has been able to make significant progress toward achieving SDG and SDG 13. Apart from these initiatives, the Indian government set up the National Clean Energy Fund (NCEF) in 2010 to finance and promote clean energy initiatives along with the allocation of resources for clean energy research. Under Jawaharlal Nehru National Solar Mission (JNNSM), the installation of solar photovoltaic (SPV) lights and small capacity lights were done. The scope of the NCEF also includes projects under the Ministry of New and Renewable Energy (MNRE), which are being implemented under the flagship programmes of "Grid-Interactive and Distributive Renewable Power" and "Research, Design, Development in Renewable Energy". Several of the NAPCC missions (Energy Efficiency, Water and Greening India, for example) offered opportunities for urban-scale engagement, including one (the Mission on Sustainable Habitat) that focussed explicitly on cities.

Following the development of the NAPCC, in 2009, the Government of India asked state governments to follow this process in their respective states, focussing specifically on developing policies and plans that align with the eight NAPCC missions and the development priorities of each state. As of October 2016, 32 states and union territories in India have State Action Plans on Climate Change that have been endorsed by the National Steering Committee on Climate Change (MoEFCC, 2016). The state plans seem to focus largely on good sustainable development strategies, on adaptation rather than mitigation, integrating their climate change action plans with the overall development goals of the state.

Although India has done well on many sustainable development goals and climate goals, much is yet desired to achieve sustainable development in the real sense. First and foremost is the need for a clear road map to implement the SDGs with identified roles for the state governments, and a monitoring mechanism to measure progress. Public education and awareness are second to none in terms of invoking people in the achievement of the SDGs. The SDGs are more complex than to be achieved by the policies and government programmes alone. The countries need to harness the energy, understanding and participation of all stakeholders including the NGOs to make sustainable development a reality.

Under the SDGs' framework, actions under Goal 13 are largely based on the outcomes of the climate change negotiations in the United Nations Framework Convention on Climate Change (UNFCCC). The 2030 Agenda and the Paris Agreement give us the tools to address the challenges posed by climate change,

poverty and inequality. We must use them judiciously. And, as UN Secretary-General António Guterres said "we need more action, more ambition and more political will. This will take unprecedented levels of collaborative, multilateral action. It will take increased efforts not by nations alone, but by all segments of society".

16.7.2 Intended Nationally Determined Contri Bution

The Prime Minister of India, speaking at the SDGs Summit in the UN, in September 2015 said, "Today, much of India's development agenda is mirrored in the Sustainable Development Goals. Since independence, we have pursued the dream of eliminating poverty in India. We have chosen the path of removing poverty by empowering the poor." India's institutional framework on climate change is focused on achieving its pre-2020 commitments and the Nationally Determined Contributions (NDCs) rather than achieving SDGs in general or SDG 13 in particular.

India's effort in integrating climate change measures into national policies has been focused on achieving pre-2020 commitment and its Nationally Determined Contribution (NDC) as also reflected by the national indicators. India agreed in Copenhagen (2009) to reduce its energy intensity by 20-25% by 2020 over the 2005 level. Through its INDC (2015), it voluntarily committed to reducing its energy intensity by 30-35% by 2030 (over the 2005 level), achieving 40% cumulative electric power installed capacity for the fossil fuel-based energy resources by 2030 (conditional and transfer of technology and international finance), and create an additional carbon sink of 2.5–3 billion tonnes of CO_2 through additional forest cover. The National Plan on Climate Change (NAPCC, 2008) and State Action Plan/s on Climate Change are constrained by financial support, appropriate institutional structure, meaningful monitoring and a clear road map.

Box 16.5: India's Commitments

India agreed to reduce its emission intensity by 20-25% by 2020 over the 2005 level. In the Paris Agreement, India's NDC committed to achieving three targets:

- 33% - 35% reduction in the energy intensity of its GDP by 2030 over 2005 (20-25% by 2020 over 2005 in the Copenhagen Accord);
- 40% cumulative electric power installed capacity for the fossil fuel-based energy resources by 2030 (conditional and transfer of technology and international finance);
- Additional carbon sinks of 2.5–3 billion tonnes of CO_2 through additional forest cover.

Check Your Progress 2

Note: a) Use the space given below for your answers.

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

1. Give an overview of SDG-13.

……

……
……
……
……..

2. Discuss India's preparedness for SDG-13.

……
……
……
……
……..

16.8 LET US SUM UP

It is clear that climate change threatens decades of development progress and jeopardizes inclusive and sustainable growth. The SDGs framework provides the best path for addressing this climate emergency in ways that help everyone, in particular women, children, youth, older persons, persons with disabilities and those living in small island developing states. We have discussed in this unit the genesis of sustainable development and sustainable development goals; recognized the urgency for climate action through SDG 13, and reviewed the progress and preparedness of India toward SDG 13.

16.9 KEY WORDS

MDGs: The Millennium Development Goals (MDGs), endorsed by governments at the United Nations in September 2000, aim to improve human well-being by reducing poverty, hunger, child and maternal mortality, ensuring education for all, controlling and managing diseases, tackling gender disparity, ensuring sustainable development and pursuing global partnerships.

Paris Agreement (PA): At COP21 in 2015, after many years of negotiations, countries signed the momentous Paris Agreement, setting out the global expectations for dramatically reducing carbon emissions. The Paris Agreement entered into force in November 2016 and lays out the overarching global goals and framework for international climate action in the post-2020 period. Under the PA, countries have pledged to keep global temperature increases below 2 degrees from pre-industrial times.

Green Climate Fund: Established by the UNFCCC, as an operating entity of the financial mechanism to assist developing countries in mitigation of and adaptation to practices to climate change.

16.10 SUGGESTED FURTHER READING/ REFERENCES

- http://unfccc.int/files/meetings/durban_nov_2011/decisions/application/pdf/cop17_durbanplatform.pdf.
- http://www.cisdl.org/wp-content/uploads/2018/03/SDG_13_Climate_-_Issue_Brief__-_06.09.2016_-Final_-_UNEP.pdf
- http://www.fao.org/3/a-i7808e.pdf

- http://www4.unfccc.int/ndcregistry/Published Documents/India%20First/INDIA%20INDC%20TO%20UNFCCC. pdf
- Prime Minister's Council on Climate Change (2010). National Action Plan on Climate Change. New Delhi: Government of India.
- SDG 13 on Taking Action on Climate Change and its Impacts: Contributions of International Law, Policy and Governance, Issue Brief, 2016
- UN (2015). Transforming Our World: The 2030 Agenda for Sustainable Development.
- United Nations Development Group (2016). Mainstreaming the 2030 Agenda for Sustainable Development: Reference Guide for UN Country Teams. UNDG, New York.
- United Nations (2016). Global Sustainable Development Report: 2016 Edition. New York: United Nations Department of Economic and Social Affairs, Division for Sustainable Development.
- WCED. (1987). Our Common Future. Ed. Gro Harlem Brundtland. World Commission on Environment and Development. www.un-documents.net/our-common-future.pdf

16.11 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress 1

1. The 2030 Agenda for Sustainable Development has provided a blueprint for shared prosperity in a sustainable world. The 2030 Agenda focuses on the "elimination of hunger and reduction of poverty and inequality (opportunity, resource access, gender, and youth) in all their forms". The 2030 Agenda and its seventeen Sustainable Development Goals (SDGs) build on the Millennium Development Goals (MDGs), are much broader in scope and ambition, encompassing the eradication of poverty and hunger and improved health and nutrition; reduction of inequality; the building of peaceful, just and inclusive societies; the protection of human rights; the promotion of gender equality and the empowerment of women and girls; and the lasting protection of the planet and its natural resources. The 2030 Agenda advocates "sustainable development in all of its three dimensions, for all countries (developing and developed), based on the fundamental recognition and protection of human rights, dignity and equity". Further, SDGs endeavour to create a suitable environment for "sustainable, inclusive and sustained economic growth, shared prosperity and decent work for all, taking into account different levels of national development and capacities".

2. The Sustainable Development Goals are a "universal set of goals and targets agreed by 194 UN member states to guide their development policies and initiatives over the next 15 years". The 17 Goals of the 2030 Agenda for Sustainable Development came into force on 1 January 2016.

Check Your Progress 2

1. Sustainable Development Goal 13 (SDG 13 Climate Action) commits to take "urgent action to combat climate change and its impacts", emphasizing the globally agreed need to mitigate anthropogenic greenhouse gas

emissions and adapt to the damages caused by climate change while acknowledging that the "United Nations Framework Convention on Climate Change is the primary international, intergovernmental forum for negotiating the global response to climate change." The UNFCCC acknowledges that "the global nature of climate change calls for the widest possible cooperation by all countries and their participation in an effective and appropriate international response, following their common but differentiated responsibilities and respective capabilities and their social and economic conditions."

Goal 13 in particular focuses on the "urgent action" required to "combat climate change and its impacts", thus incorporating both climate change mitigation and climate change adaptation. Its scope includes three targets: 13.1- strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries; 13.2- integrate climate change measures into national policies, strategies, and planning; and 13.3- improve education, awareness-raising and human institutional capacity on climate change mitigation, adaptation, impact reduction, and early warning.

2. India has signed and ratified the Paris Agreement, making it obligatory for it to reach its commitments. India is also a signatory among 192 nations to the 2030 Global Agenda for Sustainable Development. The Government of India has entrusted NITI Aayog, with coordinating the SDG Agenda in India and has asked the states to prepare action plans and has also embarked upon an exercise to develop national indicators for the 17 Goals, besides undertaking consultations on specific goals. The MoEFCC has been assigned the responsibility of three goals (Goal 12, 13 and 15) directly where they need to coordinate with different ministries on individual targets. Further, they have partial responsibility for another seven goals for which they will engage with other ministries. NITI Aayog is also given the responsibility to develop an energy policy in light of India's commitment to the Paris Agreement. The MoEFCC has designed the Nationally Determined Contributions with consultations from state governments, ministries and civil societies. India has launched the National Action Plan on Climate Change (NAPCC) which consists of eight National Missions.

India's institutional framework on climate change is focused on achieving its pre-2020 commitments and the Nationally Determined Contributions (NDCs) rather than achieving SDGs in general or SDG 13 in particular. India's effort in integrating climate change measures into national policies has been focused on achieving pre-2020 commitment and its Nationally Determined Contribution (NDC) as also reflected by the national indicators. India agreed in Copenhagen (2009) to reduce its energy intensity by 20-25% by 2020 over the 2005 level. Through its INDC (2015), it voluntarily committed to reducing its energy intensity by 30-35% by 2030 (over the 2005 level), achieving 40% cumulative electric power installed capacity for the fossil fuel-based energy resources by 2030 (conditional and transfer of technology and international finance), and create an additional carbon sink of 2.5–3 billion tonnes of CO_2 through additional forest cover.

ignou
THE PEOPLE'S
UNIVERSITY

ignou
THE PEOPLE'S
UNIVERSITY