Block 4

URBAN AREAS, COASTAL AREAS AND LIVELIHOOD

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## PROGRAMME DESIGN AND EXPERT COMMITTEE

<table>
<thead>
<tr>
<th>Dr. Himanshu Pathak</th>
<th>Dr. B. Rupini</th>
<th>Dr. Sushmitha Baskar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Director, ICAR–National Rice Research Institute</td>
<td>Environmental Studies</td>
<td>School of Interdisciplinary and Trans-disciplinary Studies</td>
</tr>
<tr>
<td>Cuttack, Odisha.</td>
<td>School of Interdisciplinary and Trans-disciplinary Studies IGNOU, New Delhi.</td>
<td>IGNOU, New Delhi.</td>
</tr>
<tr>
<td>Prof. Pawan Kumar Joshi</td>
<td>Prof. Nandini Sinha</td>
<td>Dr. V. Venkat Ramanan</td>
</tr>
<tr>
<td>School of Environmental Sciences</td>
<td>Kapur, School of Interdisciplinary and Trans-disciplinary Studies, IGNOU, New Delhi.</td>
<td>Environmental Studies, School of Interdisciplinary and Trans-disciplinary Studies IGNOU, New Delhi.</td>
</tr>
<tr>
<td>Jawaharlal Nehru University</td>
<td>Dr. Shubhangi Vaidya</td>
<td>Dr. Deeksha Dave</td>
</tr>
<tr>
<td>New Delhi.</td>
<td>School of Interdisciplinary and Trans-disciplinary Studies IGNOU, New Delhi.</td>
<td>Environmental Studies, School of Interdisciplinary and Trans-disciplinary Studies IGNOU, New Delhi.</td>
</tr>
<tr>
<td>Prof. S.K. Yadav</td>
<td>Dr. Shachi Shah</td>
<td>Dr. Y.S.C. Khuman</td>
</tr>
<tr>
<td>School of Agriculture</td>
<td>Environmental Studies, School of Interdisciplinary and Trans-disciplinary Studies IGNOU, New Delhi.</td>
<td>School of Interdisciplinary and Trans-disciplinary Studies IGNOU, New Delhi.</td>
</tr>
<tr>
<td>IGNOU, New Delhi.</td>
<td>Dr. Sadananda Sahoo</td>
<td></td>
</tr>
<tr>
<td>Prof. Jaswant Sokhi</td>
<td>School of Interdisciplinary and Trans-disciplinary Studies IGNOU, New Delhi.</td>
<td></td>
</tr>
<tr>
<td>School of Sciences, IGNOU</td>
<td></td>
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</tr>
<tr>
<td>New Delhi.</td>
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<td></td>
</tr>
<tr>
<td>Prof. Basanti Pradhan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Staff Training and Research Institute of Distance Education</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IGNOU, New Delhi.</td>
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<td></td>
</tr>
<tr>
<td>Dr. M. Prashanth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>School of Sciences</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IGNOU, New Delhi.</td>
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## PROGRAMME COORDINATORS

**Dr. V. Venkat Ramanan**  
School of Interdisciplinary and Trans-disciplinary Studies  
IGNOU, New Delhi.

## BLOCK PREPARATION TEAM

### Course Contributors

<table>
<thead>
<tr>
<th>Prof. Yogesh T. Jasrai (Unit 13)</th>
<th>Department of Botany, Gujarat University, Ahmedabad</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr. Laxminarayana (Unit 14)</td>
<td>Ex. Principal Scientist, and Head, Fisheries Environment Management, Central Marine Fisheries Research Institute, Cochin</td>
</tr>
<tr>
<td>Prof. Subhakanta Mohapatra (Unit 15)</td>
<td>School of Sciences, IGNOU</td>
</tr>
</tbody>
</table>

### Content Editors

<table>
<thead>
<tr>
<th>Dr. V. Venkat Ramanan</th>
<th>Environmental Studies, School of Interdisciplinary and Trans-disciplinary Studies IGNOU, New Delhi.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr. Shachi Shah</td>
<td>Environmental Studies, School of Interdisciplinary and Trans-disciplinary Studies IGNOU, New Delhi.</td>
</tr>
</tbody>
</table>

## COURSE COORDINATOR

Dr. V. Venkat Ramanan  
Environmental Studies, School of Interdisciplinary and Trans-disciplinary Studies  
IGNOU, New Delhi.

## FORMAT EDITORS

<table>
<thead>
<tr>
<th>Dr. V. Venkat Ramanan</th>
<th>Environmental Studies, School of Interdisciplinary and Trans-disciplinary Studies IGNOU, New Delhi.</th>
</tr>
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## PRINT PRODUCTION

<table>
<thead>
<tr>
<th>Mr. Y. N. Sharma</th>
<th>Mr. Sudhir</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asst. Registrar (P), IGNOU, New Delhi</td>
<td>Section Officer (P) IGNOU, New Delhi</td>
</tr>
</tbody>
</table>

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The effects of urbanization and climate change are converging in dangerous ways. This block “Urban Areas, Coastal Areas and Livelihood” discusses the magnitude and impacts of climate change on urban and coastal areas and adaptation options. Extreme weather events can generate new health hazards and cause disruption to public health and livelihood. Keeping this in view, this block deals with the effects of climate change on urbanization, coastal community, livelihood and human health.

Unit 13 “Urban Areas” deals with the causes of urbanization, the impacts of climate change on urbanization, and also the impacts of the extreme weather events and extreme temperature conditions on the spread of diseases in the urban areas.

Unit 14 “Coastal Ecosystem and Low lying Areas” discusses the coastal ecosystem from the perspective of coastal economy and livelihood security. Further, the unit deals with the coastal vulnerability and vulnerability of coral reefs, low-lying coastal zones and small islands to climate change.

Unit 15 “Livelihood” deals with the impacts of climate change on various climate sensitive sectors related to livelihoods like agriculture, water, forestry, biodiversity and fisheries. An effort has also been made to analyse the impacts of climate change on human life i.e. food security, income, employment and migration.

Unit 16 “Human Health” deals with the climate change impacts on human health, and the climate change induced health care problems.

**Objectives**

After studying this block, you should be able to:

- Explain the impacts of climate change on urbanization;
- Explain the impacts of the extreme events and extreme temperature conditions on the spread of diseases in the urban areas.
- Discuss the coastal vulnerability to climate change;
- Discuss the vulnerability of coral reefs, low-lying coastal zones and small islands to climate change.
- Explain the interrelationship between climate change and livelihood particularly in developing countries;
- Analyse the impacts of climate change on human life i.e. food security, income, employment and migration; and
- Explain the impact of climate change on human health.

We hope that after studying this block, you will acquire an understanding of the impacts of climate change on urbanization, coastal community, livelihood and health.

Wishing you success in this endeavour!
UNIT 13 URBAN AREAS

Structure

13.1 Introduction
13.2 Objectives
13.3 Urbanization
13.4 Impacts of Climate Change on Urbanization
   13.4.1 Impact of Floods in Urban Areas
13.5 Environmental Degradation
   13.5.1 Greenhouse Gases Emissions
13.6 Impact of Extreme Weather Events in the Spread of Diseases in the Urban Areas
13.7 Let Us Sum Up
13.8 Keywords
13.9 Suggested Further Reading/References
13.10 Answers to Check Your Progress

13.1 INTRODUCTION

The humans in the beginning of their evolution were wanderers and did not settle at a place. They were all the time wandering for food and shelter. It was only after the beginning of agricultural practices that they settled at a place closer to the river and started growing the food grains. This is the reason why almost all the civilization like Harappa, Mesopotamia and the Nile valley civilization flourished near the banks of the rivers like Indus, Tigris and Euphrates, and Nile respectively. The population has from then started expanding. Because of the availability of better prospects for employment and facilities, rural people move towards cities. Various human activities like clearance of the forest for expanding agriculture lands, house construction, industrial area or special economic zone development have all resulted in the urbanization process. This unit explains about impact of climate change on urbanisation.

13.2 OBJECTIVES

After studying this unit, you should be able to:

- discuss the causes of urbanization;
- explain the impacts of climate change on urbanization; and
- explain the impacts of the extreme events and extreme temperature conditions on the spread of diseases in the urban areas.
Urban Areas, Coastal Areas And Livelihood

13.3 URBANIZATION

Urbanization can be simply defined as the shift from a rural to an urban society. It also involves an increase in the number of people in urban areas during a particular year. Urbanization is the outcome of the social, economic and political developments that lead to urban concentration and growth of large cities, changes in land use and transformation from rural to metropolitan pattern of organization and governance. Urbanization is increasing in both the developed and developing countries. Available statistics shows that more than half of the world’s population live in urban areas, crowded into 3 percent of the Earth’s land area. In Asia and Africa where urbanization is still considerably lower (40 percent), both are expected to be 54 percent urban by 2025.

There are many reasons for increase in urbanization; some factors can be natural population increase (high births than deaths) and migration. The natural increase is further increased by improved medical care, better sanitation and improved food supplies, which reduce death rates and cause populations to grow. In many developing countries, the rural poverty drives the people from the rural areas into the city in search of employment, food, shelter, education and other facilities. Although urbanization is the driving force for modernization, economic growth and development, there is increasing concern about the effects of expanding cities, principally on human health, livelihood and environment and also the changing climate.

13.4 IMPACTS OF CLIMATE CHANGE ON URBANIZATION

Urbanization involves a change in the land use patterns. Climate change is resulting in catastrophic conditions like increase in the number and intensity of extreme weather events like floods, droughts, heat waves, cyclones, hurricanes, etc. Due to these extreme events, cities are also vulnerable to any damage to the larger systems on which they depend - for instance for water supply and treatment, transport and electricity and thus everything that depends on electricity, including lighting, pumping and communications. All these extreme events also result into health hazards for the humans and animals. The droughts lead to famine conditions hence posing a threat to the human food security. The floods result in many water borne diseases like cholera, diarrhoea as human health impacts. The heat waves also kill a large number of people in the developing countries. The cyclones and hurricanes devastate the infrastructure and means of communications. All the extreme events thus kill a huge population of the humans and animals and also destroy the vegetation.

13.4.1 Cities as Heat Islands

As cities add roads, buildings, industry, and people, heat islands are created in urban areas. An urban heat island is the name given to describe the characteristic warmth of both the atmosphere and surfaces in urban sprawls as compared to their non-urbanized or less urbanized surroundings. The heat island is an example of unintentional climate modification when urbanization changes the characteristics of the Earth’s surface and atmosphere. An urban heat island is a metropolitan area that is significantly warmer than its surrounding
rural areas. Unlike, global warming which causes a worldwide rise in temperature, heat islands occur at the local level. According to the US Environment Protection Agency (EPA), many cities and suburbs have air temperatures up to 5-8°C warmer than their neighbouring areas. Heat islands result due to the replacement of the natural land cover in the cities with pavement, buildings and other infrastructure. This change contribute to higher urban temperatures as removal of trees, soil and vegetation takes away the natural cooling effects that shading and water evaporation from soil and leaves ordinarily provide. Also the tall buildings and narrow streets heat the air trapped between them and reduce airflow. And waste heat from vehicles, factories and air conditioners adds warmth to the surroundings, further enhancing the heat island effect.

A number of factors contribute to the occurrence and intensity of heat islands. These include: weather, geographic location, time of day and season, city form and city functions. Urban heat islands also can impact local weather, altering local wind patterns, spurring the development of clouds and fog, increasing the number of lightning strikes, and influencing the rates of precipitation. There are three types of heat islands such as Canopy Layer Heat Island (CLHI); Boundary Layer Heat Island (BLHI) and Surface Heat Island (SHI). The CLHI and BLHI refer to a warming of the urban atmosphere while the SHI refers to the relative warmth of urban surfaces. Scientists measure air temperatures for CLHI or BLHI directly using thermometers, whereas the SHI is measured by remote sensing.

The heat island effect can be reduced through the use of white and light-coloured construction materials (including white roofing materials) in buildings, which will reflect the sun’s heat skyward rather than absorb it (as dark surfaces tend to absorb). A biologically related solution is to use vegetation to reduce urban heat. Vegetation provides important shading effects as well as cooling through evaporation. Some examples include: planting trees around individual buildings to shade the urban surfaces. This reduces temperature, especially roofs and south, east, and west facing walls. The reduction in surface temperature also leads to substantial reductions in energy use for air conditioning. Preserving or creating pockets of green space and vegetation including creation of green roofs or rooftop gardens will certainly help to cool areas naturally.

13.4.2 Impact of Floods in Urban Areas

A flood is an excessive amount of water on land that’s normally dry and is a situation where inundation is caused by high flow, or overflow of water in an established water-course such as a river, stream, or drainage ditch or water-pond at or near the point where the rainfall has taken place. A flood can strike anywhere without warning, it occurs when a large volume of rain falls within a short time.

The changes in land use associated with urban development affect flooding in many ways. In urban areas, where much of the land surface is covered by roads and buildings, have less capacity to store rainfall. Construction of roads and buildings often involves removing vegetation, soil, and depressions from the land surface. The permeable soil is replaced by impermeable surfaces such as roads, roofs, parking lots, and sidewalks that store little water, reduce infiltration of water into the ground, and accelerate runoff to ditches and streams. Urbanization generally increases the size and frequency of floods and may expose communities to increasing flood hazards.
Frequent flooding in the urban streams increases channel and bank erosion. In many urban areas, stream-bank erosion represents an ongoing threat to roads, bridges, and other structures that is difficult to control even by hardening stream banks. There are many approaches for reducing flood hazards in basins under development. Areas identified as flood-prone can be used for parks and playgrounds that can tolerate occasional flooding. Buildings and bridges can be elevated, protected with floodwalls or designed to withstand temporary inundation. Drainage systems must be expanded with increased capacity for detaining and conveying high stream flows. Techniques that promote infiltration and storage of water in the soil column, such as infiltration trenches, permeable pavements, soil amendments, and reducing impermeable surfaces must be incorporated into new and existing residential and commercial developments to reduce runoff from these areas. The runoff water can be reduced by incorporating vegetation and native tree plantation. It is also necessary to develop a flood information and notification system (FINS) to address the need for prompt notification of flood conditions in urban areas where streams rise and fall rapidly. Similarly, stream flow-gauging stations provide a continuous record of stream flow that can be used in the design of new urban infrastructure including roads, bridges, culverts, channels, and detention structures. Storm water managers can use stream flow information in combination with rainfall records to evaluate innovative solutions for reducing runoff from urban areas.

13.5 ENVIRONMENTAL DEGRADATION

The environment comprises of four interlocking systems: the atmosphere, the lithosphere, the hydrosphere and the biosphere. Environmental degradation can be of two types:

- Degradation of the productive capacity of the life support systems (like land, water and forest) on which the humans rely and
- Pollution which destroys the natural resources and makes them unfit for various usage.

It has been established by science that global climate change increases the intensity and frequency of climate related disasters like cyclones, floods, forest fires, and droughts and causes environmental degradation. This reduces the resilience of the ecosystems and the humans against the impacts of the climate change and extreme environmental disasters. It also degrades the environment and converts the carbon sequestering ecosystems (carbon sinks) to carbon sources. Thus it further enhances the climate change phenomenon.

As a result of the expanding urban sprawl, the water bodies in the cities like lakes, rivers, groundwater, etc. are all under pressure of the increasing human demands. They are also getting overexploited due to the human activities such as industrial and domestic utilities. The encroachment around the water bodies has resulted in the shrinking of the lakes and rivers. Even people have started settling on the river beds as well as on the dried lakes. The water bodies in urban areas also get polluted through sources such as industrial effluents, sewage disposals and domestic wastes.

The extent of environmental degradation is increasing; India and China are cited as prime examples. River systems contain four times more pollution than the
global average. The total forest cover is 65 percent below world standards and is falling fast. The environmental degradation in the region is now becoming pervasive, accelerating and are largely unmanageable. The natural resources that underpin long-term economic development are at risk. Within the next 15-20 years, at least about 50 percent of Asians are expected to be migrating into huge urban sprawls with some of the most important industrial facilities. Large tracts of fertile farmland have been lost to salinization and water logging because of poor irrigation and drainage practices in Indian sub-continent. Another large chunk of the land has been converted into deserts in semi-arid areas of South Asia. The prime cause of land deterioration being deforestation is occurring at the rate of 1 percent a year, destroying hundreds of species with it. Asia accounts for 40 percent of the world’s species of plants and animals; but in the present state, Asian countries have lost 70-90 percent of their original wildlife habitats to agriculture, infrastructure, deforestation and land degradation. Biodiversity loss reduces the resilience in ecosystems and it results in loss of the livelihoods of the poor who depend on these ecological resources.

Climate change as a result of anthropogenic activities increases the risks of climate related disasters. The IPCC Report has projected that the resilience of the ecosystems is going to exceed by 2100 because of a combination of changing climate, associated disturbances (like droughts, floods, forest fires, ocean acidifications, increase in the pest and vector populations) and other climate change drivers (like land use change, pollution and over exploitation of resources). The ecosystems which are the most vulnerable to the climate change are the boreal forest, tundra, mountains, Mediterranean type ecosystems, mangroves and salt marshes, coral reefs and the glaciers and sea ice.

Check Your Progress 1

Note: 1) Use the space given below for your answers.
         2) Check your answers with those given at the end of this unit.

1. Define urbanization. What are the causes of urbanization?
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2. What is the Heat island Effect? How is it caused? How can it be prevented?
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3. Describe in short the impacts of flooding in urban areas.
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13.5.1 Greenhouse Gases Emissions

Atmosphere is a complex system of gases and suspended particles. However, the composition of the atmosphere keeps on changing and so also its structure
is variable in time and space. The atmosphere is mainly composed of gases like $N_2$ (78.8%), $O_2$ (20.95%), argon (0.93%), and other trace gases like $CO_2$ (387ppm), $CH_4$ (2ppm), $N_2O$ (0.3ppm), water vapour (variable in ppm), etc. Long lived gases that are increasing at a substantial rate because of human activities are of particular current interest since they eventually lead to stratospheric ozone depletion, global warming and disturbances in the atmospheric chemistry that will be harmful to the ecosystem. Air pollution occurs due to the stationary sources, but the greatest source of air pollution is the mobile source, which are mostly automobiles. Various types of natural processes like volcanic eruptions, lead to the changes in the global atmospheric composition along with the man-made activities like industrialization, urbanization and modernization of agricultural activities.

Vehicular air pollution contributes to the air pollution by emissions such as carbon monoxide, unburnt hydrocarbons, nitrogen oxides, sulphur oxides, lead compounds, smoke, particulates and odour. The vehicular pollution has increased fast throughout the world owing to an increase in the transportation. Industrial air pollution contributes to air pollution by the release of particulates, smoke, fluoride, ammonia, hydrocarbon, odour and gases like $SO_2$, $NO_x$, $CO$, $CO_2$, etc.

Important greenhouse gases are carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), water vapour ($H_2O$) and ozone ($O_3$). Further, human activities in recent decades have also added HFCs (Hydrofluorocarbons). Carbon dioxide (72%), nitrous oxide (9%), and methane (18%) are the three main greenhouse gases that trap infrared radiation and contribute to climate change. The important greenhouse gases have long lifetimes in the atmosphere with large fractions of emissions remaining there for decades to centuries and in some cases like carbon dioxide for around 100 years. Cutting emissions of such long lived gases therefore leads to only slow reductions in their warming effects.

As regards the $CO_2$ emissions from automobiles, the rapidly increasing number of motor vehicles in India and other developing countries due to urbanization is contributing to high level of urban air pollution including socio economic, environmental and health impacts. Every decade has seen the number of motor vehicles doubling in many Asian countries but the increase in the European counties is only 2-5% per annum. The number of the two wheelers dominates the roads of Asian countries. The rapid growth of automobiles is of prime concern as it causes air pollution and also regional and global impacts relating to energy security and climate change. Transportation consumes about half of the world’s oil. It has been reported that the energy consumption and carbon dioxide emissions due to transport has increased tremendously, maximum of which was contributed by the developing countries. The main pollutants released as a result of automobile pollution are hydrocarbons, nitrogen oxides, sulphur dioxide, carbon monoxide and carbon dioxide. Since $CO_2$ is one of the leading greenhouse gases and vehicular pollution contribute about 12% of total global $CO_2$ emissions. The $CO_2$ emissions from the vehicles need to be taken care of by either using efficient fuel or making the fuel efficient or by making fuel efficient cars so as to reduce $CO_2$ emissions. Today cars with the emission capacity of 89-500 g $CO_2$ per kilometer are available in the market.

In order to reduce air pollution being caused by the release of the pollutants from the factories, certain measures can be implemented. The measures include
the replacement of the burning of fossil fuels by renewable sources like solar energy, tidal energy and geothermal energy for energy generation or by using efficient fuels like biofuels from palms, jatropha, etc. Another method to control air pollution can be by a number of mechanical devices that can in a way be helpful in reducing the amount of air pollutants at the time of their emission like gravity settling chambers, cyclone collectors, dynamic precipitators, spray towers, venturi scrubbers, electrostatic precipitators, etc.

Air pollution and climate change are thus correlated and an increase in the practices contributing to air pollution enhances the level of greenhouse gases in the atmosphere resulting in global warming. Hence reducing the level of air pollution at the grass root levels of industrial and vehicular emissions will surely bring down the levels of greenhouse gases in the atmosphere and thus make earth a better place to live.

13.6 IMPACT OF EXTREME WEATHER EVENTS IN THE SPREAD OF DISEASES IN THE URBAN AREAS

Global climate change would disturb the Earth’s physical systems (for example weather patterns) and ecosystems (for example disease vector habitats). These disturbances, in turn, would pose direct and indirect risks to human health. Researchers have found that there is a close link between local climate and the occurrence or severity of some diseases and other threats to human health. Higher temperatures, in combination with favourable rainfall patterns, could prolong disease transmission seasons in some locations where certain diseases already exist. It is estimated that climate variability and climate change cause 150,000 deaths and 5 million illnesses per annum.

Extreme Temperatures

In a warmer world, heat waves are expected to become more frequent and severe, with cold waves becoming less frequent. Increased frequency and severity of heat waves may lead to an increase in illness and death, particularly among the young, the elderly, the poor, the frail and the ill, especially in large urban areas. Heat-related illness and death are largely preventable through behavioural adaptations such as use of air conditioners and increased intake of fluids. In the United States, use of air conditioning is expected to become nearly universal by the year 2050. Other adaptive measures include development of community-wide heat emergency plans, improved heat warning systems, and better heat-related illness management plans.

Extreme Events

It has been postulated that there will be increases in the frequency and severity of extreme events, which may result in an increase in deaths, injuries, toxic contamination or ingestion, infectious diseases, and stress-related disorders, as well as other adverse health effects associated with social disruption, environmentally forced migration, and settlement in poorer urban areas. Frequencies of heavy precipitation events have been increasing. Extreme weather events such as urban floods, storms, droughts can have disastrous effects on health. Floods are responsible for increased spread of diseases causing organisms, increased insect
breeding, and spread of water-borne diseases such as typhoid, hepatitis, cholera, etc. Climate change is responsible for spread of diseases through emergence of disease friendly conditions in new regions, and extension of geographic range of disease-causing organisms. Mosquitoes are extremely sensitive to changes in temperature. Changing climate influences mosquitoes population, as the increasing temperature increase the reproduction rate, extends the breeding season, increase the number of blood meals, etc. Eventually, mosquito-borne disease causing organisms such as dengue fever, malaria are responsive to changes in temperature. It is reported that insect-borne diseases are observed in the higher elevations due to warming temperatures. It is also reported that drought intervened by heavy downpour causes the population of insects and rodents to increase. Climate change is also expected to contribute to some air quality problems too. Respiratory disorders may be exacerbated by warming-induced increases in the frequency of smog (ground level ozone) events and particulate air pollution.

Check Your Progress 2

Note: 1) Use the space given below for your answer.
2) Check your answers with those given at the end of this unit.

1. Establish a correlation between extreme weather events and the spread of diseases in urban areas in the scenario of climate change.

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13.7 LET US SUM UP

Climate variability and climate change impact the urban ecosystem through their influence on urban life support system. Urbanization leads to urban heat island effect which makes life difficult for humans. The extreme temperature conditions are reported to cause deaths of thousands of people due to heat waves especially in the poor and developing countries. There are also the cold waves as in Russia and China where in the humans, animals and plants all succumb to the changing temperature. The extreme events of the weather like cyclones, hurricanes, droughts and floods are all resulting in the death of thousands of humans, plants and animals not only due to their extreme behaviour but also due to the miserable conditions they bring along with them like water-borne vector-borne, rodent-borne diseases including viral, bacterial and other infectious diseases. There needs to be the strict implementation of the environmental standards so as to prevent further degradation of the environment due to the anthropogenic activities.

13.8 KEYWORDS

Urbanization  : It is the expansion of the urban areas (cities) due to economic growth and migration from the rural areas.

Heat Island Effect  : Various anthropogenic activities lead to the increase in the temperature of the urban
areas which is more than the surrounding non-urbanized areas. This results in the heat island effect.

**Floods** : A flood is an excessive amount of water on land which is normally dry and occurs due to overflow of water in an established watercourse such as a river, stream or pond of water at or near the point where the rainfall has occurred.

**Environmental Degradation** : Depletion or degradation of the potentially natural resources like forests and biodiversity.

**Extreme Weather** : The increase in the uncertainties as well as the intensities of the occurrence of certain weather conditions like cyclones, floods, etc. due to climate change.

### 13.9 SUGGESTED FURTHER READING/REFERENCES


13.10 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress 1

1. Your answer must include the following points
   - Expansion of the human population
   - Causes: Population explosion, industrial setups, migration, economic growth and development.

2. Your answer must include the following points
   - Heating of the urban areas more than the surrounding areas
   - Types of heat island effects: CLHI, BLHI, SHI
   - Causes: Increasing pollution, emissions from vehicles and industries, material of building construction,
   - Prevention: Tree plantations, roof gardens, use of white construction material.

3. Your answer must include the following points
   - Destruction of infrastructure, roads, bridges;
   - Economic losses;
   - Cut-off of various means of communication (transport, electricity, etc.); and
   - Spread of diseases.

Check Your Progress 2

1. Global climate change would pose direct and indirect risks to human health. There is a close link between local climate and the occurrence or severity of some diseases and other threats to human health. Extreme weather events such as urban floods, storms, droughts can have disastrous effects on health. Floods are responsible for increased spread of diseases causing organisms, increased insect breeding, and spread of water-borne diseases such as typhoid, hepatitis, cholera, etc. Climate change is responsible for spread of diseases through emergence of disease friendly conditions in new regions, and extension of geographic range of disease-causing organisms. Mosquitoes are extremely sensitive to changes in temperature. Changing climate influences mosquitoes population, as the increasing temperature increase the reproduction rate, extends the breeding season, increase the number of blood meals, etc. Eventually, mosquito-borne disease causing organisms such as dengue fever, malaria are responsive to changes in temperature.
14.1 INTRODUCTION

All the elements within an ecosystem are interrelated, these system can be quite complex. Changing even one element, say climate, can change the entire ecosystem – for good or bad. We rely on coastal and marine ecosystem for food, recreation, transportation and more. If we are not careful, our use of these resources can upset the balance of entire ecosystem. In this unit, the various components such as coastal ecology and economy, livelihood and business perspectives, coastal vulnerability with respect to disasters, the need for the conservation of coral reefs, threats to low lying coastal zones and land inundation due to climate change, threats to small islands and challenges to coastal ecosystems due to human intervention are discussed. Knowledge on the above topics will enable you to get an insight into the various impacts of climate change on coastal ecosystem.

14.2 OBJECTIVES

After studying this unit, you should be able to:

- explain coastal ecosystem from the perspective of coastal economy and livelihood security;
- discuss the coastal vulnerability; and
- discuss the vulnerability of coral reefs, low-lying coastal zones and small islands to climate change.
14.3 COASTAL ECOSYSTEMS AND COASTAL ECOLOGY

Coastal ecosystems are areas where land and water join to create an environment with a distinct structure, diversity and flow of energy. They include salt marshes, mangroves, wetlands, estuaries and bays, which are home to many different types of plants and animals. However, coastal ecosystems are also very sensitive to changes in the environment, and there is a great concern that some areas are now struggling to maintain their diversity due to human activity, introduction of exotic species and other factors such as climate change.

Coastal Ecology

The coastal zone has been defined based on administrative, physical, environmental units or simply based on fixed distances from the shore. The coastal habitats include wetlands, estuaries, coral reefs, mangroves, salt marshes and sea grasses. Wetlands are the ecotones or transitional zones between permanently aquatic and dry terrestrial ecosystem. A wide variety of wetlands like marshes, swamps, open water bodies, mangroves and tidal flats and salt marshes, etc. exists in India. In our country, the distribution of wetlands is widespread from the cold arid zone of Ladakh to wet Manipur, from warm and arid zone of Rajasthan to tropical monsoon central India and humid southern Peninsula.

As fresh water flows down a river basin toward the sea, it eventually meets salt water. Commonly, it does so in a semi-enclosed area that we call an estuary. Hence, estuaries may be defined as places where seawater is measurably diluted with fresh water. Estuaries may take the form of well-demarcated valleys, semi-enclosed bays, or shallow lagoons often associated with sandbars at their seaward edge.

The special nature of estuaries is related to two main physical processes. First, fresh water is lighter than salt water and often gives rise to a two-layered system. In the lighter upper layer, the water moves seaward. As it does so it carries with it some of the salt water from the lower layer. Thus, in the lower layer, salt water must move in from the shelf to take its place. This two-way estuarine circulation tends to stimulate primary production. It also provides an opportunity for plankton and fish to take advantage of the special circulation patterns.

The second special feature is that rivers commonly bring a load of suspended sediment to the estuary. Particles carried by fresh water undergo a change in surface charge as they meet the salt water. This causes them to aggregate, or flocculate, in the estuary, in a zone known as the turbidity maximum. Further down the estuary, the particles formed by flocculation begin to settle out, forming a rich sediment. The two-way circulation mentioned earlier may also bring sediment from the sea, which augments that deposited from river water. This sediment is fertile ground for the growth of salt-tolerant flowering plants such as salt-marsh grasses, sea grasses, and mangroves, which give estuaries a special biological character.

Salt marshes are found between high and low tide in temperate climates, in places where silt and mud can accumulate. There are two types of habitat those along the edges of estuaries, in places where the river silt is deposited, and those close to the mouth of the estuary, on the shattered side of sand.
or single banks. The contribution of marshes to the coastal food web is substantial. Clams, oysters and fish such as menhaden are among the commercially valuable consumers of salt marsh detritus.

Mangroves are woody trees or shrubs that flourish at the sea/land interface in tropical estuaries and inlets. They can be subdivided into two categories: true mangroves, which only occur here, and mangrove associates, which can also be found elsewhere, e.g. rainforest. An individual tree is termed a mangrove, while the whole forest habitat is a mangal (or simply ‘mangrove forest’).

Mangrove forests as a whole provide a range of valuable functions that influence surrounding coastal systems, and impact on human activities such as fisheries. Two of the most important are their potential role in nutrient input and energy flux between mangrove and marine systems, and the provision of a nursery for fish species that recruit to local fisheries and coral reefs.

Sea grasses are the only truly marine angiosperms, generally growing in soft sediments in shallow coastal waters. Below the ground, there is a network. The sea grasses can form extensive meadows covering large areas of creating one of the most important and extensive sub-tidal marine habitats in the world. Unlike mangroves and salt marshes, sea grasses are found in all the world’s coastal seas except Antarctica and cover approximately 0.1 to 0.2% of the global ocean. The global cover of sea grasses has been reduced dramatically (15%) as they are sensitive to changes in light levels, nutrients and mechanical disturbance. Coral reefs are some of the most diverse and productive communities in the marine environment. They are created from tiny coral polyps but are easily visible from space. With the exception of deep water corals, most corals grow at temperatures of 18-36°C and most are found 30° North or South of the Equator.

Reefs provide millions of people, often in the world’s poorest countries, with a vital source of food, income and other environmental services. Coral reefs are threatened by human impacts, including fishing, pollution, sedimentation and climate change. Coral bleaching is a generalized response of corals to stress. The most severe bleaching events have been attributed to high temperatures.

Check Your Progress 1

Note: 1) Use the space given below for your answers.
       2) Check your answers with those given at the end of this unit.

1. What is the meaning of coastal ecosystems?
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2. What are mangroves?

14.3.1 Coastal Economy

Surrounded by the Indian Ocean, Arabian Sea and Bay of Bengal, India has a coastline of 8129 km that spans 13 maritime mainland states and Union Territories (UTs). The Exclusive Economic Zone (EEZ), a coastal zone within which a nation has exclusive rights to its fisheries of India is 2.02 million square Km. India is a home to variety of coastal and marine ecosystems that are storehouses for biodiversity. From an economic perspective, these coastal and marine ecosystems are of great importance in that they provide a wide range of ecosystem goods and services. The key coastal livelihood activities are fishing and agriculture, including fish processing, mariculture practices, aquaculture and honey collection. For those living along the coastal belt, the fisheries sector provides employment to more than 6 million people. Sustainable use of these valuable resources to support local livelihoods and community participation in their management will also need to be promoted.

14.3.2 Livelihood Perspectives

As a matter of fact, most of the coastal communities living in the developing countries are vulnerable. They are dependent on the natural resources mainly fish resources which are presently over utilized. Further, the coastal ecosystem per se is fragile and vulnerable to environmental degradation, human activities and climate change. These challenges in fact exacerbate the vulnerability of the coastal communities. It is difficult for them to figure out a sustainable option to get rid of poverty and achieve sustainable livelihood. Further, natural disasters immensely affect the livelihood of coastal communities. For instance, the December 2004 tsunami affected the livelihoods of up to 2.5 million people living in the coastal environments of India, Indonesia, Sri Lanka and Thailand. Further, it is a necessity on the part of the government and also United Nations to take proactive measures to augment and rebuild the livelihoods of coastal communities in addition to rebuilding the physical infrastructure. In fact, augmenting the livelihood options is good for achieving sustainability and also the community would become resilient to changing climate.

14.4 COASTAL VULNERABILITY

On the Earth surface, coastal ecosystem is considered as one of the vulnerable disaster-prone regions. In addition to the geographical attributes of coastal environments, the vulnerability is accentuated due to the narrow livelihood options with the coastal communities. Hazards such as environmental hazards, extreme climate events can cause disasters in the fragile coastal regions. Disasters cause loss of human life, damage to physical infrastructure, loss of employment opportunities, disturbance to transport, and communication system, and migration. Disasters also disturb the national government through its impact on financial resources and
developmental agenda.

14.4.1 Coral Reef Ecosystem

Most of the coral reefs are built from the stony corals. The stony corals are hard corals. The individual animals are called as polyps and they live in groups. The polyps secrete calcium carbonate to form hard exoskeleton, which in fact protects and supports the soft-bodied poly. Coral reefs prefer warm waters, shallow, and clear waters for growth and development. Though the coral reef ecosystem occupy just less than 1% of the ocean surface, they provide habitat to more than 25% of all marine organisms. For their richness in biodiversity and productivity, they are called as “rainforest of the sea”.

Coral reefs deliver ecosystem services to tourism, fisheries and shoreline protection. Coral reefs are one of most important links in the chain of pristine habitats that form the bedrock of human existence. Reefs are centres of high biological productivity, sites of CO\(_2\) sink, ecosystem of very high biodiversity, shore line protectors, source of huge deposit of CaCO\(_3\), centres of scientific research and they provide us with many natural raw materials for pharmacological products and live-saving drugs. They are also excellent tourist spots. However, in India, very little effort has been made to utilize them in a judicious manner, except for exploiting the limestone and resources they harbor.

It is reported that coral reef ecosystem must be conserved as the services provided by these ecosystem are invaluable. It is estimated that the value of coral reefs is between US $100,000 to US $600,000 per square kilometer a year. However, the cost of protecting these fragile ecosystem is only US$775 per square kilometer per annum. Coral reefs protect the beach erosion, provide habitat to fisheries and also provide livelihood security to coastal communities.

One of the steps that should be taken immediately is the creation of marine reserves off limits to fishing. About six percent of the world’s land is in parks. But at sea, less than one-half of one percent is in any kind of protected area. At the same time, we will have to develop alternative livelihoods for fishermen and regulate the trade in live reef fish and other threatened marine animals (corals, clams, turtles etc.).

There is urgent need to protect the coral reefs. Coral reefs, attract tourists from all over the world, who go out in grass bottomed grasses to view wonders of the coral and the tropical fish. These tourists provide employment for the area and spend money in all the local hotels and businesses and are of great economic importance to the area.

Check Your Progress 2

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

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

1. What are the livelihood options?

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2. Write the importance of coral reefs.

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14.4.2 Low-lying Coastal Zones

Coastal zones are particularly vulnerable to climate variability and change. Key concerns include sea level rise, land loss, changes in maritime storms and flooding, and implications for water resources. Higher temperatures are expected to further increase the sea level by expanding ocean water, melting mountain glaciers and small ice caps, and causing portions of Greenland and the Antarctic ice sheets to melt. The International Panel on Climate Change (IPCC) estimates that the global average sea level will rise between 28 and 98 cm by the year 2100 based on the emissions scenario.

The range reflects uncertainty about global temperature projections and how rapidly ice sheets will melt or slide into the ocean in response to the warmer temperatures. Furthermore, some processes affecting sea level have long (centuries and longer) time-scales, so that current sea level change is also related to past climate change, and some relevant processes are not determined solely by climate. Climate models, satellite data and hydrographic observations demonstrate that sea level is not rising uniformly around the world.

Rising sea levels inundate wetlands and other low-lying lands, erode beaches, intensify flooding, and increase the salinity of rivers, bays, and groundwater tables. Some of these effects may be further compounded by other effects of a changing climate. Additionally, measures that people take to protect private property from rising sea level may have adverse effects on the environment and on public uses of beaches and waterways.

Low-lying coastal wetland ecosystems, such as salt marshes and mangroves are particularly vulnerable to rising sea level because they are generally within a few feet of sea level. Wetlands provide habitat for many species, play a key role in nutrient uptake, serve as the basis for many communities’ economic livelihoods, provide recreational opportunities, and protect local areas from flooding. As the sea level rises, the outer boundary of these wetlands will erode, and new wetlands will form inland as previously dry areas are flooded by the higher water levels. The amount of newly created wetlands, however, could be much smaller than the lost area of wetlands – especially in developed areas protected with bulkheads, dikes, and other structures that keep new wetlands from forming inland. By 2080, sea level rise could convert as much as 33 percent of the world’s coastal wetlands to open water.

14.4.3 Small Islands

Small island nations are inherently vulnerable to natural disasters including storms, droughts, tsunamis and cyclones due to their proximity to sea level. Improvements in trade, transportation, communications, human resources, stabilization of income and higher export earnings will increase food security in these islands. These low-lying coastal nations face common barriers to sustainable development,
Coastal Ecosystem and Low Lying Areas

including limited resources, poor economic development, vulnerability to sea level rise and natural disasters. While small island nations emit less than one percent of global greenhouse gas emissions, their geographic and economic characteristic put them at risk to experience the effects of climate change with more immediacy and severity than anywhere else in the world.

Climate change is expected to result in a variety of environmental, social and economic effects on island states, including threats to natural habitat, loss of habitable and agricultural land, coastal erosion, increased intensity and frequency of tropical storms, decreased food and water security, and adverse impacts on human health. Given these serious threats arising from climate change, many small island states have joined in collaborative organizations and formulated national action plans that address and respond to climate change. These plans and approaches combine elements of climate adaptation and greenhouse gas mitigation to achieve a greater degree of resilience in the face of a changing climate and higher energy prices.

Small island states contain a highly unique range of biological diversity with over 4,000 species of endemic plants and animals, including some of the largest and most diverse coral reefs. Niche habitats and small populations often result in species with unique traits and adaptations to environmental and climatic conditions.

A range of common characteristic leave many island states economically vulnerable and include small human populations, dependence on only one or a few sectors of the economy, and vulnerability to internal and global economic developments. Future changes in weather patterns and sea level predicted by climate change models will further affect virtually all areas of their economies and societies.

The governments of most small island states regards climate change as an immediate threat to their national welfare, and many have openly criticized industrial nations for failing to mitigate their greenhouse gas emissions. The United Nations first recognized the susceptibility of small island nations at the 44th session of General Assembly in 1989, adopting a resolution that outlined the negative impacts of climate change on small island states.

The severity and specific effects of climate change will differ from island to island, but for many small developing island states, the sea level rise currently projected by the Intergovernmental Panel on Climate Change (IPCC) will result in major land loss, and by extension, social changes that potentially include total relocation. Islands are already at high risk due to their low-lying geography and vulnerability to natural disasters. Their ability to adapt to climate change will be further complicated by existing anthropogenic pressures, such as population growth.

Island states most susceptible to sea level rise include the low-lying atoll states of the Maldives, Tuvalu, Kiribati, the Marshall Islands, and Tokelau. Island states such as Papua New Guinea and the low-lying outer island of other states are also expected to be affected. On islands that project at greater distance from sea level, low-lying parts of the coast may be lost, low-lying inland areas may become swamplier, and fertile areas may be submerged. An overall trend of increased rates of shoreline erosion is also
projected to take place as vulnerable coastlines such as sand-barrier and lagoon coasts erode.

Because of their small size and the endemic nature of many species, the biological diversity of small island developing states is extremely fragile. Deforestation and forest degradation have affected the dynamic interactions of ocean, coral reefs, land formations and vegetation.

Inhabitants of small island states may be most dramatically impacted by climate change through decreased agricultural yield and the reduced availability of fresh water. For example, 80% of the population of Pacific communities rely on agriculture for subsistence and economic livelihood.

Most small island states already struggle to maintain a sufficient supply of fresh water to meet domestic, commercial and agricultural needs. The main source of fresh water is usually rain water, and in many island countries, the wet season sees four times more rain than the dry season, often meaning frequent flash floods in the wet season and serious water shortages during the dry season.

Fisheries frequently contribute up to ten percent of the Gross Domestic Product (GDP) in many small island states and therefore the socio-economic implications of impacts from climate change on fisheries could be significant. Changes in sea surface temperatures will affect fish migration pattern and depth of fish stocks. This will have consequences on the size and seasonality of fish harvests. Coral bleaching and other damage to coastal ecosystems will further hamper fishing activities by damaging fish habitat.

Some island states are already experiencing land loss that puts human life in jeopardy. On the Carteret Islands, social pressures caused by rising sea levels have led to a formal plan to relocate the Island’s 2,500 inhabitants to Bougainville, another island on Papua New Guinea. The typical sea level around the Carteret Islands (1.5 meters) has risen steadily over recent years, covering formerly inhabited areas and salinizing freshwater supplies and subsistence crops. The government of Papua New Guinea has organized a voluntary evacuation plan for the Islands that began in 2008 and will continue through 2020. The world’s first community of climate change refugees, the Carteret Islands may be considered a microcosm of the societal effects of climate change.

14.5 CHALLENGES TO COASTAL ECOSYSTEM

Initially, it was thought that oceans, being a reservoir of CO$_2$, are capable of absorbing the excess CO$_2$ released by human-activity. But the studies showed that ocean is absorbing only about half of the anthropogenically released CO$_2$. Thus, one of the major concerns of the earth-system scientist of present day is the effect of global warming triggered by the ever increasing level of atmospheric CO$_2$ due to anthropogenic activities. Human-induced global warming has different manifestations such as increased number and intensity of tropical cyclones, changing rainfall pattern and drought, increase in vector borne deceases, etc. Recent studies shows that the warming is not confined to the ocean surface alone but also started penetrating into deep oceans and the response of different ocean and the adjacent land mass to global warming and climate change is different. For example, an increase of 0.5°C in the sea surface temperature (SST) per 100 years in the Indian Ocean was reported, while it was 0.4°C per 100 years for both the Arabian Sea and the Bay of Bengal.
Recent study showed that the Arabian Sea is responding to human-induced climate change and its effect is also felt in the adjacent Indian landmass.

Poorly planned and concentrated development of coastal aquaculture is known to bring about the following impacts on the ecology and environment of an area; (1) reduction of productive and eco-essential mangroves in the coastal areas due to their conversion to fish ponds; (2) self-pollution of ponds due to excessive sediment deposition, poor quality water supply, accumulation of wastes due to excess feeding and other metabolites, unregulated use of fertilizers, chemicals and drugs; (3) improper designing and lay out of ponds in the area with inadequate facilities for water supply and drainage; (4) salinization of arable lands and underground freshwater resources; (5) eutrophication and use of the coastal environment beyond its carrying capacity; (6) effect of effluent discharges from the ponds as well as from other pollution generating agro-industries in the area and (7) the conflict in the use of coastal area by different production systems and the consequent ecological imbalances.

The mangrove ecosystem plays a significant role in the food web of the complex group of marine organisms as well as valuable estuarine and near shore fisheries and in the maintenance of biodiversity of the area. It also serves as a sanctuary, nursery and breeding grounds for a number of terrestrial and aquatic fauna. The large scale conversion of mangroves to ponds would not only destroy the unique ecosystem but also adversely affect the natural biodiversity of the coastal zone and mangrove dependent fisheries. However, the realization of the fact that mangroves often contain underneath acid sulphate soils and pose difficulties in the construction of ponds with proper tidal water exchange has arrested their conversion to fish farms in recent years in several regions.

The semi-intensive and intensive farming involves higher stocking densities and consequently requires higher rate of feeding of the stocked population with compounded diets and better water quality management. As shrimps are known to be rather not efficient converters of feed, excessive feeding would naturally get wasted and accumulated in the sediment of the pond bottom. This together with the other metabolites results in the self-pollution of the pond ecosystem. This situation, along with the supply of water of poor quality and often development of undesirable blooms leads to the depletion of dissolved oxygen of the pond water and results in the large scale mortality of the stocked population or leads to frequent disease outbreaks.

Self-pollution of salt water ponds also occurs due to improper use of fertilizers, haphazard application of bio-active compounds used in the control of diseases and number of hormones and growth promoters used to alter the sex and to enhance the growth and production of the cultured organisms. In certain areas in India as well as other south east countries, conflicts are already reported caused by affected villagers due to salinization of fresh water resource mainly caused by seepage of saline water used in the aqua farms. Salinization of arable lands and underground freshwater aquifers is also reported in the shrimp culture ponds constructed in higher grounds and supplied with pumped salt water. Adequate care has to be taken to avoid such ecological implications during the design and construction of farms.

The release of soluble inorganic nutrients (nitrogen and phosphorus) from intensive fish and shrimp farming has the potential to cause nutrient enrichment and eutrophication of a water body. It has also been pointed
out that organic compounds together with components such as vitamins could influence the growth or toxicity of particular species of phytoplankton.

The adverse effects of the discharge of effluents rich in nutrients and organic material from shrimp ponds include increased sedimentation and siltation, hypoxia, hyper nitrification and alterations of productivity and community structures of benthic organisms.

Most of the shrimp farms do not have proper water treatment systems and drain water directly to rivers or the sea. Waste water from shrimp farms is high in nitrogen, phosphorus, carbon compounds, organic matter, shrimp excretory products, plankton and some chemical and antibiotic medicine. The effluent waters from the shrimp ponds include the water released during rearing in the ponds as well as the water discharged during harvesting.

The picture may not be complete without mentioning the social consideration and conflicts arising out of the rapid development in aquacultural sectors. The investment for aqua farms has, by and large come from entrepreneurs and not from farmers or fishermen. Hence, there is an apprehension that in the long run, the fishermen are at a receiving end, although some initial benefits like employment opportunities are provided. The development of coastal aquaculture has also led to conflicts in land use and in certain regions on rice production. It is also competing with the capture fisheries in the estuarine and brackish water areas. These issues require careful consideration and pragmatic approach for the balanced growth and utilization of the resources in the coastal zone.

**Check Your Progress 3**

**Note:**
1) Use the space given below for your answers.
2) Check your answers with those given at the end of this unit.

1. What are the threats to low-lying coastal zones due to climate change?

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2. Discuss the various challenges to coastal ecosystem due to human induced global warming.

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**14.6 LET US SUM UP**

- The different types of coastal ecosystems are described briefly.
- The ecology and economy of the coastal ecosystems such as wetlands, estuaries, coral reefs, mangroves, salt marshes and seagrass are briefly discussed.
The coastal vulnerability to disasters are discussed with the strategies to cope with these disasters.

We have discussed the vulnerability of coral reefs, low-lying coastal zones and small islands to climate change.

Finally, the challenges to coastal ecosystem due to human interventions and the consequent threats to livelihoods of the coastal population are discussed with examples.

14.7 **KEYWORDS**

**Salt Marshes**: Marshy area found between high and low tide in coastal area of temperate climate, where silt and mud can accumulate.

**Sea Grasses**: Marine angiosperms, growing in shallow soft sediments in coastal waters.

14.8 **SUGGESTED FURTHER READING/REFERENCES**


Worldfish. (2006). The threat to fisheries and aquaculture from climate change policy brief. The world fish center, Penang, Malaysia (available at: www.worldfishcenter.org)


**Web Links**

https://www.globalchange.gov/climate-change/glossary

14.9 **ANSWERS TO CHECK YOUR PROGRESS**

Check Your Progress 1

1. Coastal ecosystems are areas where land and water join to create an environment with a distinct structure, diversity and flow of energy.

2. Mangroves are woody trees or shrubs that flourish at the sea/land interface in tropical estuaries and inlets.
Check Your Progress 2

1. The people in coastal areas undertake a range of activities. Fishing is the main occupation of the coastal communities and new strategies are being adopted to meet the changing conditions.

2. Coral reefs deliver ecosystem services to tourism, fisheries and shoreline protection. Reefs are the centres of high biological productivity, sites of CO₂ sink, ecosystem of very high biodiversity, sources of huge deposits of calcium carbonate and provide raw materials for preparing drugs.

Check Your Progress 3

1. Coastal zones are vulnerable to climate variability and change. The impacts are rise in sea levels, land loss; and flooding.

2. The various challenges to coastal ecosystems due to human-induced global warming are increase in number and intensity of tropical cyclones, changing pattern of rainfall and drought, increase in the vector borne diseases, etc.
UNIT 15 LIVELIHOOD

Structure

15.1 Introduction

15.2 Objectives

15.3 Interrelationship between Climate Change and Livelihood

15.4 Adverse Impact of Climate Change on Primary Sectors Related to Livelihood

  15.4.1 Impact of Climate Change on Agriculture
  15.4.2 Impact of Climate Change on Forests and Biodiversity
  15.4.3 Impact of Climate Change on Fisheries

15.5 Climate Change, Forced Migration and Changing Livelihood Pattern

15.6 Let Us Sum Up

15.7 Keywords

15.8 Suggested Further Readings/References

15.9 Answers to Check Your Progress

15.1 INTRODUCTION

Various studies including the studies reported by IPCC has clearly demonstrated that climate change has differential impacts on places and people now and forever (McCarthy et al., 2001; Mendelsohn et al., 2006; and Parry et al., 2007). Importantly, the Fourth Assessment Report (AR4) of the IPCC has asserted that that “Warming of the climate system is unequivocal, as is now evident of observations of increases in global average air and ocean temperatures, widespread melting of sea and ice and rising global average sea level” (Solomon et al., 2007). In particular, the developing nations are disproportionately highly vulnerable in comparison to the developed nations (Mendelsohn et al., 2006; and Stern, 2006). It is due to three reasons: (i) geographical region, (ii) high dependency on natural resources and agriculture, and (iii) availability of fewer resources for adaptation (Stern, 2006). For instance, during the period 2000-04 on an average annual basis, one in 19 people living in developing world was affected by climate related disasters (HDR, 2007). It has further been observed that flooding affected the lives of 68 million people in East Asia and 40 million people in South Asia. In addition, monsoon floods and storms in South Asia during the 2007 season displaced more than 14 million people in India and 7 million people in Bangladesh, and more than 1000 people lost their lives across South Asia (HDR, 2007: 76). These climatic disasters make the livelihood of the people more susceptible, especially in South Asia as they are already vulnerable to the conventional problems, e.g. poverty and food security, etc. It is argued that South Asia is particularly vulnerable to predicted climate change impacts because of its high population density, low adaptive capacity, several unique and valuable ecosystem (coral reef, large deltaic region with rich biodiversity), and vast low-altitude agricultural activities (Roy, 2007). In some areas, people are forced
to migrate and change their livelihood due to extreme events like flooding, drought, famine, etc. in their respective places for a quite longer time. In this unit, an attempt is being made to analyse the impacts of climate change on various climate sensitive sectors related to livelihoods like agriculture, water, forestry, biodiversity and fisheries. An effort has also been made to analyse the impacts of climate change on human life i.e. food security, income, employment and migration.

15.2 OBJECTIVES

After studying this unit, you should be able to:

- explain the interrelationship between climate change and livelihood particularly in developing countries;

- describe the impact of climate change on primary sectors of economy like agriculture, forestry, biodiversity and fisheries in developing countries with a special reference to India; and

- analyse the impacts of climate change on human life i.e. food security, income, employment and migration.

15.3 INTERRELATIONSHIP BETWEEN CLIMATE CHANGE AND LIVELIHOOD

One of the most widely accepted definition of livelihoods is: “A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable, when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base” (Carney 1998: 4). It is the means of production available to a given individual, household or group that can be used in their livelihood activities. There are five forms of livelihood assets namely:

i) **Natural capital**: The natural resource stock from which resource flows useful to livelihoods are derived. The actual resources available to an individual household reflects the characteristics of the local resource base and the extent to which the household is able to gain access to these resources, which in turn reflects issues of ownership and entitlements as well as the availability of technologies that make it possible to use the resource potentials.

ii) **Social capital**: The set of social relationships upon which people draw in pursuit of their livelihood. This includes the range of contact networks, membership of groups and organizations, relationships of trust and access to wider institutions of society that are important in the actual operation of livelihood activities and that can be determining in terms of access to markets, credit, government services and many other factors of production.

iii) **Human capital**: The skills, knowledge and good health important to the ability to pursue livelihood activities. For individual households, this includes
both the quantity (number of productive individuals) and the quality (what these individuals know and how hard they are able to work) of human resources. It includes knowledge and skills learned from formal education and through experience and non-formal learning.

iv) Physical capital: The basic infrastructure for transport, buildings, water management, energy, and communications and productive capital (tools, machines, etc.) which enables people to pursue the livelihoods. It includes both those that people own and those that they have access to (roads, irrigation systems, telephone networks, etc.) whether provided by government or the private sector (either free or paid for).

v) Financial capital: The financial resources which are available to people (whether savings, supplies of credit, regular remittances and pensions, social security payments or insurance) and which provide them with different livelihood options. This includes finances (including credit) for investments in new productive assets, for inputs into production and for responding to the effects of different vulnerabilities, including recovering and reconstructing livelihoods after disasters.

Taken together, these livelihood assets determine much about how livelihoods work, and in particular are the basis for understanding how people will respond to climate-induced vulnerabilities. This in turn means they are (or at least should be) the basis for the development of adaptation strategies. All of these assets are important, but for the poorest and most vulnerable of the world (especially the rural poor), natural resources are of particular significance. This poverty-environment link has been recognized for some time: “predominantly the poor of the world depend directly on natural resources, through cultivation, herding, collecting or hunting for their livelihoods. Therefore, for sustainable livelihoods, there is a need for sustenance= natural resources” (Rennie and Singh, 1996: 16). This recognition is now reflected in international summit that “poor people tend to be most dependent upon the environment and the direct use of natural resources, and therefore most severely affected when the environment is degraded or their access to natural resources is otherwise limited or denied”.

With environmental resources playing such a crucial role for a large proportion of the world’s population, threats to ecosystem functioning and integrity undermine livelihood security. All the evidences suggest that environmental vulnerabilities are going to significantly increase in the future, in part due to climate change but also because of other forms of resource and livelihoods pressures, unless effective and substantial measures are taken to ameliorate them through adaptation and other strategies.

The range of vulnerabilities that poor people face in different parts of the world encompasses all aspects of life, with most not directly related to climate change (though many are affected in some way by it). Here we relate the likely changes to vulnerabilities identified in the report to the dynamics of the livelihoods of poor people in different major types of agro-ecological zones of the developing world. In doing so, it strongly agree that: people are highly variable in their endowments and it will be high in developed world, particularly least developed nations; it led to more vulnerable to the climate change, and more extreme among the poor people.
For example, sea level rise will displace millions of the poor, with the areas least likely to be protected those where people are poorest. Small island states and low coastal areas and deltas such as southern Bangladesh, Eastern Coast of India is most at risk. In many cases, those displaced will have few opportunities to re-establish their lives except in urban areas, where livelihood opportunities are limited without the skills, capital and contacts needed to cope with urban life. Even where people are not physically displaced, rising seas will reduce the natural capital in ecosystems such as coastal fisheries, mangroves and wetlands that are essential to the current livelihood patterns of many poor communities, while the dangers of salinization of water supplies will affect these and other coastal communities.

In addition, changes in temperature and rainfall patterns (both to averages and to the variability of rainfall) are widely predicted, with many semi-arid parts of the developing world likely becoming even hotter and drier with even less predictable rainfall. These changes will both directly affect crop yields and will produce changes to ecosystem distributions and species ranges. This will dramatically affect the livelihoods of many poor people, particularly through declining food security and problems with the viability of many livelihood activities, including livestock raising, fishing and the use of forest products as well as agricultural production. Further, the secondary impacts will likely include increases in urban food prices and greater problems with services such as water supply and sanitation (exacerbating pressures that rapid urbanization will bring) that affect the urban poor.

The changing climate patterns, and especially the increased frequency and/or severity of extreme events, will increase vulnerability to natural disasters, both slower-onset ones such as droughts and rapid-onset disasters such as floods and cyclones. These will affect many areas, but semi-arid areas (droughts) and coastal and deltaic regions (floods and storms) are particularly vulnerable. Dangers of erosion, landslides and flash floods will also increase, particularly in many hilly and mountainous areas. Changing climate patterns and more extreme events will have impacts on new livelihood activities such as from tourism, that will limit diversification of opportunities which, combined with damage to infrastructure and other types of physical capital, will affect the wider range of vulnerabilities (such as limited access to markets) the poor face. The poor social and political capital, along with extremely limited access to financial capital, mean that these communities are least likely to be protected by investments in infrastructure or disaster mitigation and relief systems. Predicted adverse health risks will affect the poor in particular throughout the developing world. These risks are in particular those associated with water-borne (such as dysentery or cholera) vector-borne (such as malaria) diseases as well as heat stress morbidity and mortality. These health impacts pose a double jeopardy for poor people’s livelihoods: the contribution of key productive members of the household is lost and the cost of health care is expensive and time consuming. Such risks will be widespread, but the dearth of medical care systems in many more remote, poorer areas of Africa and Asia in particular mean that the poor in these areas are the most vulnerable to these risks.

The deterioration of the availability or quality of water supplies in many areas (again due to wider resource stresses that climate change will exacerbate) will significantly increase many of these health risks, while poorer nutritional states caused by declining food security will make many poor people more vulnerable.
Livelihood

to the effects of diseases when they do strike. The increased danger of damage to crops, livestock and gathered plants and animals from pests will be similar in distribution and impact to those of increased health risks, but will be exacerbated by the risks of physical damage caused by floods, droughts and storms. Although the development of more pest-resistant or drought-tolerant crop strains may limit these risks, many poor rural communities are far less able to gain access to such new varieties (which in any case make them more dependent upon external inputs that can be unreliable in their availability), placing them at an even greater disadvantage in agricultural markets.

This has been highlighted by Human Development Report 2007/08 and World Development Report 2010. According to Human Development Report 2007/08 titled ‘Fighting Climate Change: Human Solidarity in a Divided World’ stated that “Climate change is the defining human development issue of our generation. All development is ultimately about expanding human potential and enlarging human freedom. It is about people developing the capabilities that empower them to make choices and to lead lives that they value. Climate change threatens to erode human freedoms and limit choice. It calls into question the Enlightenment principle that human progress will make the future look better than the past.” (p.1)

Climate change has potential to erode the international efforts in the areas of health, nutrition, poverty, education, etc. In particular, climate change can undercut the developments in the areas of “Agricultural production and food security”; “Water stress and water insecurity”; “Rising sea levels and exposure to climate disasters”; “Ecosystems and biodiversity”; and “Human health”.

In the context of India, using climate scenarios predicted from RCM and SWAT model (Gosain and Rao 2003; Gosain, Rao, and Basuray 2006), BIOME 4 (Ravindranath, Joshi, Sukumar, et al. 2006), simulations for mean sea level (Unnikrishnan, Kumar, Fernandes, et al. 2006), malaria transmission window analysis (Bhattacharya, Sharma, Dhiman, et al. 2006), and simulations based on dynamic crop models (GoI, 2004) show the following findings (see Roy, 2007).

- Hydrological cycle is likely to be altered. Drought and flood intensity will increase. Overall runoff will decline.
- Crop yield will decrease with temperature.
- The overall effect will be crop productivity decline induced by decline in crop duration.
- Under the A2 and B2 scenarios, there will be shifts towards wetter forest types. Due to CO₂ increase and warming, NPP will grow to double under the A2 and 70% under the B2 scenario for the forestry sector.
- Frequencies and intensities of tropical cyclones in the Bay of Bengal will increase, particularly in the post-monsoon period and there will be increased flooding in low-lying coastal areas. Sea-level rise of less than 1 mm/year has been predicted for Mumbai, Visakhapatnam, and Kochi (much evidence); but there is probability of a decrease in sea level around Chennai.
- Malaria-prone states will continue to be so (Odisha, West Bengal, and southern parts of Assam bordering West Bengal). This may later shift from the central Indian region to the south-western coastal states of
Maharashtra, Karnataka, and Kerala. New regions (states like Himachal Pradesh, Arunachal Pradesh, Nagaland, Manipur, and Mizoram) may become malaria-prone and the transmission duration window may widen in northern and western states and shorten in the southern states.

In the following sections we will analyse in details three primary sectors i.e. agriculture, forestry and fishery, which are strongly related to livelihoods of nearly 7 billion people of the world and adversely affecting billions of people in the developing world including India.

15.4 ADVERSE IMPACT OF CLIMATE CHANGE ON PRIMARY SECTORS RELATED TO LIVELIHOOD

15.4.1 Impact of Climate Change on Agriculture

Growing population in India challenges the sustainability of agricultural system. The growing demand for food grain production, and nutritive food products demand transformation of agricultural system. Further, the undernourished and malnourished population in India is emerging as a critical issue. At the same time, agriculture is being affected negatively by a series of biotic and abiotic stresses including climate change. To a great extent, Indian agriculture is rainfed and it is dependent on the groundwater as well. Other characteristic of agriculture in India is the resource poor farmers’ who are highly vulnerable to climate change. Under such circumstances, increasing agricultural production is indeed a huge task.

Agriculture and allied activities constitute an important component of India’s economy. However, given that 62% of the cropped area is still dependent on rainfall, Indian agriculture continues to be fundamentally dependent on the weather. The impacts of climate change on agriculture are critical in India. As some 75% of the population live in rural areas, agricultural performance is closely related to poverty levels. The focus is on the two main cereal crops – rice and wheat – in terms of the effects of climate change on crop yields, overall food production, and welfare.

Acute water shortage conditions, combined with thermal stress, could adversely affect wheat and, more severely, rice productivity in India even under the positive effects of elevated CO$_2$ in the future. The simulations of four different sites (Kalra, Aggarwal, Chander, et al. 2003; GoI 2004) under various climate change scenarios for each crop reveal the following:

- The yields of both crops – rice and wheat – would decrease with a rise in temperature levels and increase with a rise in precipitation.
- Higher CO$_2$ concentrations in the atmosphere would have beneficial effects for both crops by increasing the rate of photosynthesis, radiation use efficiency, and water use efficiency.
- Increased CO$_2$ levels would be more favourable for wheat than for rice.

Overall, the simulation suggests that temperature rise is going to have the following effects.
Livelihood

- Larger negative impacts are expected to neutralize positive impacts, if any, of CO₂ fertilization.
- Net yield losses in rice under irrigation could be some 13%–22%, compared with losses of 16%–34% for wheat.
- Quality of products such as cotton, fruits, vegetables, tea, coffee, aromatic and medicinal plants, and the nutritional quality of cereals and pulses may be moderately affected.
- Decline in grain protein content in cereals could partly be related to increasing CO₂ concentrations. Wheat yields in central India are likely to suffer by up to 2% in the pessimistic scenario, but there is also a possibility that these might improve by 6% if the global change is optimistic.
- Changes in soil water induced by global climate change may affect all soil processes and, ultimately, crop growth.
- An increase in temperature would also lead to increased evapotranspiration, which may result in the lowering of the groundwater table at some places.
- Increased temperature, coupled with reduced rainfall, may lead to upward water movement, leading to accumulation of salts in upper soil layers.
- A rise in sea level associated with increased temperatures may lead to salt-water ingress in the coastal lands, making them unsuitable for conventional agriculture.
- An increase of 1°C in soil temperature may lead to higher mineralization.

15.4.2 Impact of Climate Change on Forests and Biodiversity

Climate is probably the most important determinant of vegetation patterns globally and has significant influence on the distribution, structure and ecology of forests. Several climate–vegetation studies have shown that certain climatic regimes are associated with particular plant communities or functional types. It is therefore logical to assume that changes in climate would alter the configuration of forest ecosystems. Recent modelling studies indicate that forest ecosystems could be seriously impacted by future climate change. Even with global warming of 1–2°C, much less than the most recent projections of warming during this century, most ecosystems and landscapes will be impacted through changes in species composition, productivity and biodiversity. These have implications for the livelihoods of people who depend on forest resources for their livelihoods.

India is a mega-biodiversity country where forests account for about 20% (64 million ha) of the geographical area. With nearly 200,000 villages classified as forest villages, there is obviously large dependence of communities on forest resources. Thus, it is important to assess the likely impacts of projected climate change on forests and develop and implement adaptation strategies for both biodiversity conservation and the livelihoods of forest dependent people. Preliminary qualitative assessments of potential climate change impacts on forests in India were based on earlier GCM (General
Urban Areas, Coastal Areas And Livelihood

Circulation Model) outputs of climate change that have undergone considerable refinement. Following this, there were two regional studies, the first pertaining to potential climate change impacts on forests in the northern state of Himachal Pradesh, and the second in the Western Ghats. These studies indicated moderate to large-scale shifts in vegetation types, with implications for forest dieback and biodiversity. The studies conducted in India so far have had several limitations, e.g. coarse resolution of the input data and model outputs due to the use of GCM scale grids, the use of earlier versions of the BIOME model that had limited capability in categorizing plant functional types, and the absence of any national level model-based assessment of climate impacts. A recent study using the BIOME3 model and climate change scenarios of HadCM2 projected large-scale shifts in areas under different vegetation types and an increase in NPP.

Climate is an important determinant of the geographical distribution, composition, and productivity of forests. Therefore, changes in climate could alter the configuration and productivity of forest ecosystems. NTFPs (non-timber forest products) provide about 40% of total official forest revenues and 55% of forest-based employment. In India, about 200 million people depend on forests directly or indirectly for their livelihoods. Indian forests support more than 5150 plant species, 16 214 insects, 44 mammals, 42 birds, 164 reptiles, 121 amphibians, and 435 fish species. Forests meet nearly 40% of India's energy and 30% of fodder needs. In India, out of 15000 plant species, 3000 species yield NTFPs such as fruits, nuts, edible flowers, medicinal plants, rattan and bamboo, honey, and gum.

The aggregate quantity of potentially extractable NTFPs is projected to lead to the following.

- Increase in expanding evergreen and moist deciduous forest types.
- Decline in the dry deciduous, dry thorn, and montane forest areas.

As a result, there will be an increase in income from potentially extractable NTFPs with the income per hectare likely to increase by about 22%. However, there is uncertainty regarding the transient response of vegetation to climate change and this could lead to forest dieback and loss of vegetation. Conversely, fuel wood and timber production may increase due to increased productivity as a result of increased CO₂ fertilization and nitrogen deposition. Under moderate climate projections, the total area under tree cover in all biomes except the tundra and xerophytic woods in Himachal Pradesh is projected to increase by 11%. The tundra forests show a uniform downward trend with sharp reduction in area by early 2020. By 2080, more than 70% of the area under tundra forests is projected to decline under the moderate scenario.

GCM (Global Climate Model) projections (for example, the Hadley Centre Model, HADCM2) for India indicate an increase in precipitation by up to 30% for the north-eastern region, in addition to a relatively moderate increase in temperature of about 2°C by the period 2041–60. This could increase the incidence of flooding in the Brahmaputra basin and thus favour the maintenance of moist grasslands in the region. For the rest of the country (southern, central, and north-western) a steep increase in temperature by 3°C in the southern (except along the coast) to over 4°C in the north-western, and a decrease in precipitation of over 30% in the north-western regions would
cause major changes in the composition of present-day vegetation in these regions, with an overall shift to a more arid type. Increased atmospheric CO$_2$ levels and temperatures, resulting in lowered incidence of frost, would favour exotic weeds such as wattle, which could invade the montane grasslands of the Western Ghats. The cool, temperate grasslands of the Himalayas could also be impacted by rising temperatures, which would promote the upward migration of woody plants from lower elevations.

The recent study (Ravindranath et al. 2006) concludes that 77% and 68% of the forested grids in India are likely to experience shift in forest types for climate change under A2 and B2 scenarios, respectively. In addition there have been two regional studies, the first focusing on potential climate change impacts on forests in the northern state of Himachal Pradesh (Deshingkar 1997) and the second in the Western Ghats (Ravindranath et al. 1997). These studies indicated moderate to large-scale shifts in vegetation types with implications for forest dieback and biodiversity. Impacts of climate change on forests have severe implications for the people who depend on forest resources for their livelihoods. India is a mega-biodiversity country where forests account for more than one fifth of the geographical area. With nearly 173,000 villages classified as forest villages, there is a large dependence of communities on forest resources in India (Kishwan et al. 2009). India has a large afforestation programme of over 1.32 Mha per annum (Ravindranath et al. 2008), and more area is likely to be afforested under programmes such as ‘Green India mission’ and ‘Compensatory Afforestation Fund Management and Planning Authority’ (CAMPA). Thus it is necessary to assess the likely impacts of projected climate change on existing forests and afforested areas, and develop and implement adaptation strategies to enhance the resilience of forests to climate change.

It is very timely that Government of India under NAPCC (National Action Plan on Climate Change), has brought a proposal to afforest more than 6 mha of degraded forested lands (Government of India 2008). Most of the studies have recommended that care should be taken to plant mixed species and planting should also be executed in such a way as to link the existing fragmented forests. Efforts should also be made to convert open forests to dense forests. Chaturvedi et al. (2011) have suggested that Western Ghats, though a biodiversity hotspot, has fragmented forests in its northern parts. This makes these forests additionally vulnerable to climate change as well as to increased risk of fire and pest attack. Similarly, forests in parts of western as well as central India are fragmented and are having low biodiversity. At the same time these are the regions which are likely to witness a high increase in temperature and either decline or marginal increase in rainfall. They notice that most of the mountainous forests (sub-alpine and alpine forest, the Himalayan dry temperate forest and the Himalayan moist temperate forests) are susceptible to the adverse effects of climate change. This is because climate change is predicted to be larger for regions that have higher elevations. There is a need to explore win-win adaptation practices in such regions such as anticipatory plantations, sanitary harvest, and pest and fire management.

Forests are likely to benefit to a large extent (in terms of NPP) in the northern parts of Western Ghats and the eastern parts of India, while they are relatively adversely affected in western and central India. This means that afforestation, reforestation and forest management in northern Western Ghats and eastern India may experience carbon sequestration benefits. Hence, in these regions, a species-
mix that maximizes carbon sequestration should be planted. On the other hand, in the forests of western and central India, hardy species which are resilient to increased temperature and drought risk should be planted and care should be taken to further increase forest resilience. This may be achieved by planting mixed species, linking up forest fragmentations, devising effective pest and fire management strategies and carrying out anticipatory plantation activities.

15.4.3 Impact of Climate Change on Fisheries

Even without climate change, between 25 and 30 percent of marine fish stocks are overexploited, depleted, or recovering from depletion—and are thus yielding less than their maximum potential. About 50 percent of stocks are fully exploited and producing catches at or close to their maximum sustainable limits, with no room for further expansion (WDR, 2010, p. 157).

Climate change driven “rising ocean temperature”, and “ocean acidification” are reported to affect the aquatic ecosystem including the distribution and productivity of fish species. Eventually, climate change affects the sustainability of fisheries and livelihood of fishing community. Also, climate change affects the carbon sequestration potential of marine ecosystem. Ocean acidification affects the marine organisms such as oysters, corals, and shrimps. Impacts on fish distribution, and productivity have cascading effect on marine food web.

Countries and communities dependent on fishing would be vulnerable to climate change as it affects the fish production and productivity. The countries such as Maldives, and Tuvalu, which are low-lying are highly vulnerable to climate change, and also the vulnerability and impact may lead to climate refugees. In countries like Bangladesh, the fishing community experience the problem of climate change which is manifested both in terms of rise in sea level and flooding due to cyclones and other extreme events. It is reported that the fishing communities in Mekong River system produce more than 1 million tons of Basa fish per annum. Due to climate change and sea water intrusion, the Basa fish production would be drastically affected. Further, decline in fish production due to climate change and other drivers, may greatly influence the nutritional security and livelihood as it is reported that “fish provides essential nutrition for 3 billion people and at least 50% of animal protein and minerals to 400 million people from the poorest countries. And over 500 million people in developing countries depend, directly or indirectly, on fisheries and aquaculture for their livelihoods”.

As far as India is concerned, mainland India has about 6100 km long coastline and total Indian coastline would be of about 7517 km if we add to this the coastline of Andaman and Nicobar Island in the Bay of Bengal and Lakshadweep Islands in Arabian Sea. Conservative estimate suggests that about 3.5 millions of people derive their livelihood from marine capture fisheries in the over 4000 fishing villages situated along the Indian coastline, though other estimates put the number of people dependent on marine fisheries as much higher. Hundreds of thousands are also supported indirectly, through the marketing and trade of marine produce. The sector is dominated by small-scale and artisanal fish workers, making a livelihood from fishing and small-scale trading activities. Climate change is also affecting fresh water aquaculture. This is due to sea level rise and intrusion of saline water in the fresh water. Apart from this, fishing communities living along the coast are more vulnerable to extreme weather events like cyclones and tsunamis in terms loss of life and livelihoods.
Check Your Progress 1

**Note:**
1) Use the space given below for your answers.
2) Check your answers with those given at the end of this unit.

1. Define Livelihood. Discuss briefly, how climate change is affecting livelihood of poor people?

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2. Describe any four effects of increase in temperature on agriculture of India.

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15.5 CLIMATE CHANGE, FORCED MIGRATION AND CHANGING LIVELIHOOD PATTERN

Climate change has potential to cause migration which includes migration within the country and migration from outside the country. The migration within the India may occur due to climate change induced effects like drought, low agricultural productivity, desertification, etc. Migration may occur from other countries where the effects of climate change are more marked. However, studies are not providing categorical evidence in this regard. Increased occurrence of drought induces migration. It is reported that about 3 lakh labourers migrate every year from drought prone Bolangir district, Western Odisha (Deshingkar 2003). It is reported that the rivers like Mahi, Tapi, and Sabarmati are vulnerable to water shortage (NATCOM 2004). Studies report that the semi-arid regions of Indian Peninsula and Western region of India are vulnerable to climate change impacts and the drought occurrence in these regions would induce migration to urban centres (Revi 2007). Further, migration from coastal regions may occur due to climate change induced impact on livelihood. The effects of climate change in the coastal region include salt water intrusion, and occurrence of cyclones. Reports show that the sea level since the 1950s has risen at the rate of 2.5 mm per year along the Indian coast. It is projected that sea level would rise by 46-59cm by the end of 21st century. It is projected that 1m of sea level rise has potential to displace about 7 million people in India (NATCOM 2004). Further, it is observed that submergence of a small island called Lohachara Island has forced people to migrate to Sagar Island in the Sundarbans. The major metropolitan cities in coastal region like Mumbai, Kolkata due to increased occurrence of storms may witness migration (Dasgupta et al 2009).

Migration from neighbouring countries may be induced by climate change. For instance, the vulnerability of Bangladesh to climate change is one of the prime reason for out-migration. Myers (2002) argues that “climate refugees from Bangladesh alone might outnumber all current refugees worldwide. He projected that 26 million refugees will come from Bangladesh”. Studies show that the
climate change may cause large scale migration from Bangladesh leading to tremendous pressure on resource, livelihood, etc.

Check Your Progress 2

Note: 1) Use the space given below for your answers.
       2) Check your answers with those given at the end of this unit.

1. How climate change leads to forced migration in India? Explain any two situations with examples.

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2. Why is it being predicted that climate change would lead to a large number of migration from Bangladesh to India?

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15.6 LET US SUM UP

- Developing nations are disproportionately highly vulnerable in comparison to the developed nations. It is due to three reasons: (i) geographical region, (ii) high dependency on natural resources such as agriculture, and (iii) availability of less resource for adaptation.

- A livelihood comprises the capabilities, assets and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base. There are five forms of livelihood assets namely as natural, socio-political, human, physical and financial capital.

- Due to climate change, rising ocean temperatures and ocean acidification are radically altering aquatic ecosystems. This is modifying fish distribution and the productivity of marine and freshwater species. This has impacts not only on the sustainability of fisheries and aquaculture, but also on the livelihoods of the communities that depend on fisheries.

- Even with global warming of 1–2°C, much less than the most recent projections of warming during this century, most ecosystems and landscapes will be impacted through changes in species composition, productivity and biodiversity. These have implications for the livelihoods of people who depend on forest resources for their livelihoods.

- Climate change might result in two types of displacement and migration in India. First, increased migration is likely within India due to the effects of climate change such as drought, desertification, sea level rise, water scarcity and low food productivity, and melting glaciers. Second, climate
change might lead to increased flow of migrants from neighbouring countries due to the accelerated effects of climate change.

### 15.7 KEYWORDS

**Financial Capital**: The financial resources which are available to people (whether savings, supplies of credit, regular remittances and pensions, social security payments or insurance) and which provide them with different livelihood options.

**Human Capital**: The skills, knowledge, and good health important to the ability to pursue livelihood activities.

**Livelihood**: A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living.

**Natural Capital**: The natural resource stock from which resource flows useful to livelihoods are derived.

**Physical Capital**: The basic infrastructure for transport, buildings, water management, energy, and communications and productive capital (tools, machines, etc.) which enables people to pursue the livelihoods.

**Social-political Capital**: The set of social relationships upon which people draw in pursuit of their livelihood.

**Sustainable Livelihood**: A livelihood is sustainable, when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base.

### 15.8 SUGGESTED FURTHER READING/REFERENCES


Kalra N, Aggarwal P K, Chander S, Pathak H, Choudhury R, Chaudhury A, Sehgal M, Rai H


**Web links**

https://lup.lub.lu.se/luur/download?func=downloadFile&amp;recordOId=1670257&amp;fileOId=1670258

https://www.undp.org/content/dam/india/docs/undp_climate_change.pdf
15.9 **ANSWERS TO CHECK YOUR PROGRESS**

**Check Your Progress 1**

1. A livelihood comprises the capabilities, assets and activities required for a means of living. Poor people tend to be most dependent upon the environment and the direct use of natural resources, and therefore most severely affected when the environment is degraded or their access to natural resources is otherwise limited or denied.

2. Temperature rise is going to have the following effects: (i) Larger negative impacts are expected to neutralize positive impacts, if any, of CO\textsubscript{2} fertilization; (ii) Net yield losses in rice under irrigation could be 13%–22%, compared with losses of 16%–34% for wheat; (iii) Quality of products such as cotton, fruits, vegetables, tea, coffee, aromatic and medicinal plants, and the nutritional quality of cereals and pulses may be moderately affected; (iv) Decline in grain protein content in cereals could partly be related to increasing CO\textsubscript{2} concentrations; (v) Changes in soil water induced by global climate change may affect all soil processes and, ultimately, crop growth; (v) An increase in temperature would also lead to increased evapo-transpiration, which may result in the lowering of the groundwater table at some places; and (vi) Increased temperature, coupled with reduced rainfall, may lead to upward water movement, leading to accumulation of salts in upper soil layers. (Any four).

**Check Your Progress 2**

1. Migration is likely to increase within India due to the effects of climate change. This is due to increase in intensity of extreme weather events like drought, flood, and cyclone. This will lead to desertification, sea level rise, flooding in the coastal and low lying urban areas, water scarcity and low food productivity, etc. which would force poor, marginal and vulnerable sections of population to migrate.

2. Various studies find that Bangladesh is currently faced with severe crisis of land and water, caused by population growth, environmental change and recurring natural disasters. This might increase the flow of migration from Bangladesh to India at a faster rate.
UNIT 16  HUMAN HEALTH

Structure
16.1 Introduction
16.2 Objectives
16.3 Climate Change Impacts on Natural Ecosystems
   16.3.1 Changes in Air and Water Quality
   16.3.2 Allergens/Air Pollutants
   16.3.3 Spread of Disease Causing Organisms
16.4 High Infant and Maternal Mortality Rates and Climate Change
16.5 Climate Change Induced Health Care Problems
16.6 Top Ten Actions for National and Local Policy Makers
16.7 Let Us Sum Up
16.8 Keywords
16.9 Suggested Further Reading/References
16.10 Answers to Check Your Progress

16.1 INTRODUCTION

Climate change is also expected to bring more natural disasters such as drought and flooding. Such changes will inevitably affect health, particularly in the developing world, leading to more deaths from heat stress, diarrhoeal diseases and malnutrition. The incidence of mosquito-borne diseases, in particular, is likely to change. In some tropical regions, both cyclones and floods create breeding grounds for the mosquitoes that carry malaria and dengue. Poor populations in coastal areas are particularly vulnerable to sea level rise and the associated threat of mosquito-borne disease.

Climate change can no longer be considered simply an environmental or developmental issue. More importantly, it puts at risk the protection and improvement of human health and well-being. A greater appreciation of the human health dimensions of climate change is necessary for both the development of effective policy and the mobilization of public engagement.

Strengthening of public health services needs to be a central component of adaptation to climate change. The international health community already has a wealth of experience in protecting people from climate-sensitive hazards, and proven, cost-effective health interventions are already available to counter the most urgent of these. Broadening the coverage of available interventions would greatly improve health. Coupled with forward planning, it would also reduce vulnerability to climate changes as they unfold in the future. To create the political will needed to address climate change and mosquito-borne disease, countries need information to identify potential sufferers and evaluate current state of preparedness. They should be assessing existing health system infrastructure, identifying the latest intervention tools available and providing the resources required to combat
the health consequences of climate change. Governments must establish local communities’ capacity to cope so as to determine what additional inputs are needed. With the right research, tools and political will, regions like South and South-East Asia can prepare for any rise in mosquito-borne disease caused by climate change. But it will require concerted efforts to develop the research capacity needed for assessing the threat of climate change.

16.2 OBJECTIVES

After studying this unit, you should be able to:

- explain the impact of climate change on human health; and
- elucidate the climate change induced health care problems.

16.3 CLIMATE CHANGE IMPACTS ON NATURAL ECOSYSTEMS

Rising temperatures, shifting rainfall patterns and increasing humidity affect the transmission of diseases by vectors and through water and food. Vector-borne diseases currently kill approximately 1.1 million people a year. Climate change will affect, in profoundly adverse ways, some of the most fundamental pre-requisites for good health: clean air and water, sufficient food, adequate shelter and freedom from disease. The global climate is now changing faster than at any point in human civilization, and many of the effects on health will be acutely felt. The most severe risks are to developing countries, with negative implications for the achievement of the health-related goals and for health equity. Many of the major killer diseases transmitted by water and contaminated food, and by insect vectors are highly sensitive to climatic conditions and weather extremes. Climate change threatens to slow, halt or reverse current progress against many of these infections.

Likely health impacts that are currently not quantifiable include those due to:

- Changes in air pollution and aero-allergen levels.
- Altered transmission of other infectious diseases.
- Effects on food production via climatic influences on plant pests and diseases.
- Drought and famine.
- Population displacement due to natural disasters, crop failure, water shortages.
- Destruction of health infrastructure.
- Conflict over natural resources.
- Direct impacts of heat and cold (morbidity).

Surveys have shown that many populations, including those in Australia, China and Italy, place climate change high on lists of threats to their security and well-being.
16.3.1 Changes in Air and Water Quality

Extremely high temperature can cause immense negative impact on human health. The frequency of extreme heat events is rapidly increasing in the last two decades and it is reported that such events would be rather a norm in the second half of 21st century. Further, increasing surface air temperature and climate change would increase the levels of air pollutants such as tropospheric ozone levels. It is also reported that urban air pollution causes about more than 1.2 million deaths per annum due to respiratory and cardio-vascular diseases. The spread of water-borne diseases have been increased due to the factors such as “climate shifts”, “water-cooled air conditioning plants”; industrial agricultural practices; climate disaster, etc. Further, demographic changes, increasing vulnerable population combined with changes in human behaviour are also the driving factors causing human health burden.

16.3.2 Allergens/Air Pollutants

The phenomenon called “pollution” is and inescapable consequence of the presence of human being and his activities. Today, air pollution has become more subtle and recognize no geographical or political boundaries. Air pollution is one of the present-day health problems throughout the world. More than 100 substances which pollute air have been identified. The important ones are carbon monoxide, carbon dioxide, hydrogen sulphide, sulphur dioxide, sulphur trioxide, nitrogen oxides, fluorine compounds, organic compounds (e.g. hydrocarbons, aldehydes, ketones, organic acids), metallic contaminants (e.g. arsenic, zinc, iron resulting from smelting operation), radio-active compounds, photochemical oxidants (e.g. Ozone), and others include asbestos, beryllium, mercury, benzene, fluorides, vinyl chloride, lead and mercury, benzene, fluorides, vinyl chloride, lead and radiation. Indoor air pollutions contributes to acute respiratory infections in young children, chronic lung disease and cancer in adults, and adverse pregnancy outcomes (such as stillbirths) for women exposed during pregnancy. Acute respiratory infections, principally pneumonia, are the chief killers of young children, causing 10 per cent of the total burden of disease in developing countries. Air pollution can affect by two ways:

The health effects of air pollution include both immediate and delayed effects. The immediate effects are born by the respiratory system. The resulting state is acute bronchitis. If the air pollutions is intense, it may result even in immediate death by suffocation. Air pollution damages the human respiratory and cardio-respiratory system in various ways. As regards the socio-economic aspects, air pollution causes negative impacts on physical infrastructure, plant and animal life, etc.

The WHO has recommended the following procedures for the prevention and control of air pollution: (a) containment that is prevention of escape of toxic substances into the ambient air. By a variety of engineering methods such as enclosure, ventilation and air cleaning. (b) Replacement that is replacing a technological process causing air pollution by a new process that does not cause pollution. (c) Dilution: Dilution is valid so long as it is within the self-cleaning capacity of the environment. (d) Legislation: Air pollution is controlled in many countries by suitable environmental legislation. (e) International Action: To deal with air pollution on a world-wide
scale, the WHO has established an international network of laboratories for the monitoring and study of air pollution.

16.3.3 Spread of Disease Causing Organisms

The interactions between the pathogen or disease causing organisms and the host in a changing environment are indeed complex. Due to the changing environment, both the host and pathogen try to adapt itself and in the ensuing cycle of interactions, even the pathogen try to evolve itself. Further, climate variability and climate change greatly extend the geographical range of mosquitoes, increase the breeding season, increase the number of blood meal and eventually increase the spread and occurrence of mosquito borne diseases. Also, the climate change induced disasters such as floods increase the occurrence of vector-borne diseases.

Check Your Progress 1

Note: 1) Use the space given below for your answers.
       2) Check your answers with those given at the end of this unit.

1. What are the likely health impact of climate change?

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2. How climate change induce spread of disease causing organisms?

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16.4 HIGH INFANT AND MATERNAL MORTALITY RATES AND CLIMATE CHANGE

Climate sensitive diseases already place an enormous burden on child health. Perinatal conditions principally include low birth weight, prematurity, birth asphyxia (breathing difficulty) and birth trauma (injury). This definition is relatively narrow as it excludes stillbirths, malformations and other conditions affecting liveborn infants that may be affected by environmental factors. Higher rates of low-birth-weight infants were observed for mothers exposed to the environmental risks of air pollution, tobacco smoke or various chemicals. Children, particularly in poor countries, have made the least contribution to the greenhouse gases that are causing climate change, yet they are among the most vulnerable to the resulting health risks and will be exposed longer to the health consequences of a degraded natural environment.

The most important climate-sensitive diseases are those that affect poor children: 90% of the burden of malaria and diarrhoea, and almost all of the burden of diseases associated with under- nutrition, are borne by children.
aged 5 years or less, mostly in developing countries. These major diseases of children are highly sensitive to variations in temperature and precipitation. The problems of under nutrition and associated diseases are most common among populations that are either directly dependent on rain-fed subsistence agriculture or who have low incomes and therefore high sensitivity to increases in food prices when harvests are diminished by floods and drought.

It is a fact that increased population growth causes immense pressure on quality of water, and access to water resources. Access to quality water is essential to health security. In fact, water-borne diseases are a cause of concern globally. Incidentally, the pathogens responsible for water-borne diseases like cholera, typhoid, etc. are influenced by the changing environmental conditions including climate change, sanitation, etc.

Malnutrition is also an important factor driving the population to be vulnerable to climate change. Land degradation and soil pollution, as well as climate change, can also contribute to malnutrition to a certain extent. It was estimated that climate change accounted for 2% of the health burden of malnutrition. Overall, 50% of the health burden of malnutrition was estimated to be attributable to the environment and in particular to poor water, sanitation and hygiene. Malnutrition causes vulnerability and increases the risk of adverse health outcomes, particularly in children.

Malnutrition probably plays a role in more than half of all child deaths; 50% of malnutrition’s disease burden is attributable to the environment. Malnourished children tend to have more frequent episodes of severe diarrhoea and are more susceptible to infectious diseases such as respiratory infections and meningitis. Malnourished children have a poorer prognosis for almost all infectious diseases. Hence, malnutrition is one of the most important risk factors for children globally.

**Check Your Progress 2**

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

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

1. What are the climate change induced diseases affecting children?

2. What is malnutrition? What are the climatic factors responsible for conditions of malnutrition?
Infections caused by pathogens that are transmitted by insect vectors are strongly affected by climatic conditions such as temperature, rainfall and humidity. These diseases include some of the most important current killers: malaria, dengue and other infections carried by insect vectors, and diarrhoea, transmitted mainly through contaminated water.

Protection from climate change is part of a basic, preventive approach to public health, not a separate or competing demand. The public health community has a wealth of experience in protecting people from climate sensitive hazards. Many of the most important actions are public health interventions of proven effectiveness, from controlling vector-borne disease, to providing clean water and sanitation, and reducing reliance on energy sources that pollute the environment and harm health. Widening the coverage of these measures will save lives now, and is a critical contribution to the global effort to adapt to climate change.

Improving the environmental and social determinates of health are critical to protecting pollution from climate change. Addressing known environmental risk factors could greatly improve health, while supporting sustainable development. Improving environmental conditions could prevent up to a quarter of the global burden of disease, rising to a third in the poorest countries. For example, scaling up water and sanitation services and household disinfection would immediately reduce diarrhoea and, at the same time, lessen the health impacts of decreasing and more variable water supplies. The benefits of such interventions are already several times greater than the costs, and the threat of climate change makes these preventive health measures an even wiser investment.

**Increasing Tropical Diseases**

Vectors, pathogens and hosts each survive and reproduce within a range of optimal climatic conditions: temperature and precipitation are the most important, while sea level elevation, wind, and daylight duration are also important. At increased temperatures, the rate of digestion of blood meal increases which in turn accelerates the ovarian development, egg laying, reduction in duration of the gonotrophic cycle and more frequency of feeding on hosts, thus, increasing the probability of transmission. Thus, climatic conditions play important role in the distribution, degree of endemicity and epidemicity of diseases in an area. Some areas, which have the most favourable conditions of temperature and rainfall, experience transmission of disease throughout the year, while in areas experiencing colder months, transmission is seasonal and does not take place throughout the year.

**Early Warning of Malaria**

As an adaptation measure to reduce the negative impacts of climate change, development of tools for early warning of malaria/diseases is warranted. Studies between climate variability and malaria with emphasis on different sites in India show that rainfall is an important indicator for early warning of malaria in Rajasthan and Gujarat. Work on relationship between El Nino Southern Oscillation (ENSO), vegetation index and malaria is being undertaken.
to find out the indicators for early warning of malaria. The case studies undertaken in selected districts of Gujarat, Rajasthan and Karnataka reveal that rainfall, ENSO and satellite derived Normalized Difference in Vegetation Index (NDVI) may be used for early warning of malaria in some epidemic prone states. Efforts are being made to develop such a system in India by using meteorological and satellite derived parameters.

**Water-borne Diseases**

Globally, about 1.5 million deaths per year from diarrhoeal diseases are attributable to environmental factors, essentially water, sanitation and hygiene. A large proportion of diarrhoeal diseases are caused by faecal-oral pathogens. In the case of infectious diarrhoea, transmission routes are affected by interactions between physical infrastructure and human behaviour. If sanitation or related hygiene is poor, e.g. when hand washing facilities are inadequate, or when faeces are disposed of improperly, human excreta may contaminate hands, which can then contaminate food or other humans (person-to-person transmission).

**Floods and Droughts induced Health Issues**

Globally, climate change is likely to widen the area affected by drought, with particularly severe impacts in areas that are already water-stressed. These trends will impact on lives and on health. Floods cause drowning and physical injuries; heighten the risk of diseases transmitted through water, insect vectors and rodents; damage homes; and disrupt the supply of essential medical and health services. The number of floods reported globally is rising rapidly – much more rapidly than disasters unrelated to weather conditions. Droughts increase the risk of food shortages and malnutrition. They also increase the risk of diseases spread by contaminated food and water. Diarrhoea remains one of the biggest killer of children. Viruses and bacteria transmitted through water and contaminated food can cause severe diarrhoea in children, often locking them into a vicious cycle of undernourishment, susceptibility to other infectious diseases, and eventually death. Higher temperatures and too much or too little water can all facilitate transmission of this disease. Both flooding and unusually low levels of water can also lead to water contamination and bring higher rates of illness and death from cholera and other forms of diarrhoea. Warming and greater variability in precipitation threaten to increase the burden of this disease.

16.6 **TOP TEN ACTIONS FOR NATIONAL AND LOCAL POLICY MAKERS**

- **Advocate for strong and equitable climate change agreements:** Current and projected stresses on the Earth’s life support systems (food, shelter, water and energy) require a fair, scientifically sound and globally binding commitment to reduce net greenhouse gas emissions and stabilize the global climate.

- **Promote the need for health-oriented agreements:** Protecting health and wellbeing is one of the three main objectives of the original climate convention, (alongside development and environment), and should be a priority within any new agreement; the strengthening of health systems
should be identified as a priority area for adaptation to climate change; and mitigation measures that bring health and other socio-economic benefits should be prioritized.

- **Establish multi-sectoral processes to oversee climate change and health policy development:** Utilize health impact assessments to evaluate social and economic costs of threats and prioritize action and investment areas.

- **Protect the most vulnerable:** Globally, people at the greatest risk of adverse health effects associated with climate change include the very young, the elderly, and the medically infirm and socio-economically disadvantaged groups should be protected.

- **Strengthen health system adaptive capacity:** Public education, disease surveillance, disaster preparedness, vector control, food hygiene and inspection, nutritional supplementation, vaccines, primary and mental health care, and training are to be strengthened to adapt to climate change.

- **Take into account health co-benefits when considering different greenhouse gas mitigation options:** Reducing greenhouse gas emissions is also good for health. In countries where cars are the predominant means of transport, shifting to more walking and cycling and discouraging private car use in urban centres lowers carbon emissions, increases physical activity (which reduces obesity, heart disease and cancer), and results in less pollution and noise.

- **Increase funding for inter-disciplinary research on climate change mitigation technologies and strategies across a range of sectors:** Build capacity by supporting the career development and training of young researchers in relevant disciplines.

- **Measure public awareness and attitudes:** Develop communication and social marketing plans to address perceptual and behavioural obstacles.

- **Measure and address the ‘carbon footprint’ of public institutions:** Encourage public institutions to lead by example. As highly visible, high-energy-use centres, public institutions can serve as models by reducing their own carbon emissions, improving health and saving money.

- **Incentivize your workforce and all stakeholders:** This would to reduce their personal carbon footprint including through increased use of active transport.

**Check Your Progress 3**

**Note:**
1) Use the space given below for your answers.
2) Check your answers with those given at the end of this unit.

1. What are the vector-borne diseases that are influenced by climate change?

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2. What are the effects of heat stress? Name a health condition caused by heat?

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3. How do you attribute diarrhoeal disease as a product of environmental conditions?

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16.7 LET US SUM UP

Climate variability and climate change impact the human health through increases in near surface temperature, varying precipitation patterns and other indicators of climate change such as droughts and floods. Climate change is reported to increase the spread and occurrence of tropical diseases and many vector-borne and water-borne diseases. The skills, capacities and shared values of the public health community can make an important contribution to a fair and effective response to climate change. Climate change can no longer be considered simply as an environmental or a developmental issue. It will affect the health and well-being of all populations, with impacts escalating into the foreseeable future. A greater understanding of the health implications of climate change and related development choices can lead to improved policies and more active public engagement.

16.8 KEYWORDS

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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<tbody>
<tr>
<td>Morbidity</td>
<td>It is an incidence of ill health. It is measured in various ways, often by</td>
</tr>
<tr>
<td></td>
<td>the probability that a randomly selected individual in a population at some</td>
</tr>
<tr>
<td></td>
<td>date and location would become seriously ill in some period of time.</td>
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<tr>
<td>Vector-borne Disease</td>
<td>A disease that is transmitted to humans or other animals by an insect or</td>
</tr>
<tr>
<td></td>
<td>other arthropod.</td>
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<tr>
<td>Allergens</td>
<td>An abnormally high sensitivity to certain substances such as pollens, foods</td>
</tr>
<tr>
<td></td>
<td>or microorganisms.</td>
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<tr>
<td>Pathogens</td>
<td>Agents that causes infection or disease, especially a microorganism, such</td>
</tr>
<tr>
<td></td>
<td>as a bacterium or protozoan, or a virus.</td>
</tr>
<tr>
<td>Malnutrition</td>
<td>It is the eventual result of an imbalanced diet. Consuming too much or too</td>
</tr>
<tr>
<td></td>
<td>little of any one of the nutrients can cause malnutrition.</td>
</tr>
</tbody>
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16.9 SUGGESTED FURTHER READING/REFERENCES


Web Links

https://www.globalchange.gov/climate-change/glossary

16.10 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress 1

1. Extremely high temperature can cause immense negative impacts on human health. The frequency of extreme heat events is rapidly increasing in the last two decades and it is reported that such events would be rather a norm in the second half of 21st century. Further, increasing surface air temperature and climate change would increase the levels of air pollutants such as tropospheric ozone levels. The spread of water-borne diseases have been increased due to the factors such as “climate shifts”, “water-cooled air conditioning plants”; industrial agricultural practices; climate disaster, etc. Further, demographic changes, increasing vulnerable population combined with changes in human behaviour are also the driving factors causing human health burden.

2. The interactions between the pathogen or disease causing organisms and the host in a changing environment are indeed complex. Due to the changing environment, both the host and pathogen try to adapt itself and in the ensuing cycle of interactions, even the pathogen try to evolve itself. Further, climate variability and climate change greatly extend the geographical range of mosquitoes, increase the breeding season, increase the number of blood meal and eventually increase the spread and occurrence of mosquito borne
diseases. Also, the climate change induced disasters such as floods increase the occurrence of vector-borne diseases.

Check Your Progress 2

1. The most important climate-sensitive diseases are those of poor children: 90% of the burden of malaria and diarrhoea, and almost all of the burden of diseases associated with under nutrition, are borne by children aged 5 years or less, mostly in developing countries. These major diseases of children are highly sensitive to variations in temperature and precipitation. The problems of under-nutrition and associated diseases are most common among populations that are either directly dependent on rainfed subsistence agriculture or who have low incomes and therefore high sensitivity to increases in food prices, when harvests are diminished by floods and drought. The distribution of malaria in time and location is influenced to a large extent by temperature, humidity and rainfall.

2. Malnutrition has been used to refer both to over-nutrition and under-nutrition. Individual nutritional status depends on the food that an individual eats, his or her general health, and the physical environment. In all three aspects, poor water and sanitation play an important role in malnutrition and several infectious diseases associated with malnutrition, including diarrhoea and other diseases caused by intestinal parasites, are related to poor water, sanitation, hygiene and food safety.

Check Your Progress 3

1. Infections caused by pathogens that are transmitted by insect vectors are strongly affected by climatic conditions such as temperature, rainfall and humidity. These diseases include some of the most important current killers: malaria, dengue and other infections carried by insect vectors, and diarrhoea, transmitted mainly through contaminated water.

2. As many as 14 disorders resulting from exposure to heat have been recognized and documented. Heat Stroke: This is attributed to failure of the heat regulating mechanism. It is characterized by high body temperature which may rise to 110 °F (43.3 °C) and produce disturbances including delirium, convulsions and partial or complete loss of consciousness.

3. Infections occurs by contact with contaminated drinking water, recreational water, or food. This may result from human actions such as improper disposal of sewage wastes, or due to weather events. Rainfall can influence the transport and dissemination of infectious agents, while temperature affects their growth and survival. Globally, about 1.5 million deaths per year from diarrhoeal diseases are attributable to environmental factors, essentially water, sanitation and hygiene. A large proportion of diarrhoeal diseases is caused by faecal-oral pathogens.