UNIT 7 HUMAN FOOTPRINTS ON GLOBAL WARMING

Structure

7.1 INTRODUCTION

The human population is one of the major driving factors of ecological footprints. The disproportionate increase in population resulted in far many times difficulty in managing resource depletion and global warming. The human settlement and their activities interact with the environment in very complex means. The industrialization, deforestation, urbanization, desertification and stratospheric ozone depletion which are major issues faced globally in this 21st century, are resulted from the pressure exerted by the human population to meet their demands.

7.2 OBJECTIVES

After studying this unit, you should be able to:

- explain the contributions of industrialization, deforestation, urbanization, and desertification to global warming.

7.3 HUMAN POPULATION GROWTH

The earth's carrying capacity plays a major role in population growth. As per different estimates based on standard of living, resource production and consumption, technological interventions and waste generation, support of the earth ranged from 4 billion to 16 billion. The present day global population is about 7.6 billion which is expected to cross 11.18 in 2100. The addition of one billion inhabitants occurred within last 12 years. The distribution of the world population in Asia, Africa, Europe, Latin America and the Caribbean and Northern America and Oceania was sixty per cent (4.5 billion), 17 per cent (1.3 billion), 10 per cent (742 million), 9 per cent (646 million), and the remaining 6 per cent (361 million) and (41 million) respectively. The contribution of China (1.4 billion) and India (1.3 billion) was 19 and 18 per cent of the global total (United Nations, 2017). The rate of population growth of a country depends on income, geography, and culture. The increase in population since 1980 in low-income countries was 112 percent in contrast to middle-income and high income countries with 52 percent and 23 percent.

The human and earth's climate are related by two important factors in the past few decades (IPCC):

- Anthropogenic activities including but not limited to burning of fossil fuels, land-use change, agriculture and industries are responsible for emissions of greenhouse gases and eventually change in climate; and
- Human communities are more vulnerable to hazards such as extreme high temperature events, storms, floods and droughts resulting from increasing population density in sensitive areas, such as river basins and coastal plain.

7.4 INDUSTRIALIZATION

The process of social and economic change of an agrarian society to an industrial society is known as industrialization. This is related to development of a country and helped in employment generation. But industrialization had a major role in the global warming. The industrial sector releases 21% of 2010 global greenhouse gas emissions. The emissions were from the energy consumption; fossil fuel burning; chemical, metallurgical, and mineral transformation processes; and waste management activities. The fossil fuel combustion and the global manufacture of cement are responsible for more than 75% of human-caused CO_2 emissions (IPCC, 2014).

7.5 DEFORESTATION

The forest ecosystem has productive, protective and regulative functions. The forests have special role in maintaining the carbon cycle. The estimates for the terrestrial sink of carbon dioxide for the decade 1993-2003 was 3,300 $MtCO_2$/year (IPCC 2007; Denman et al., 2007).

The deliberate conversion of forests to non-forested land use like arable land, urban use, logged area or wasteland results in deforestation. According to FAO, deforestation is the conversion of forest to another land use or

the long-term reduction of tree canopy cover below the 10% threshold.

The deforestation process contributes directly to greenhouse effect by non-availability of that forest area to sequester carbon dioxide from atmosphere. According to the Millennium Ecosystem Assessment scenarios, forest area in developing regions will decrease by about 200 to 490 million ha between 2000 and 2050. The removal of forest cover reduces water retention capacity of soil and increases soil erosion. The impact was more in lowland areas with high intensity of floods.

7.5.1 Causes of Deforestation

These are the forces that motivate the agents to clear the forests.

- Direct agents are referred to as sources of deforestation, first level or proximate causes (Caviglia, 1999) and their identification is comparatively easy.
- Indirect causes are the main drivers of deforestation and they are
  - expansion of farming land: contribute to 60 per cent of total tropical deforestation;
  - shifting agriculture;
  - urbanization/industrialization and infra-structure (construction of roads, railways, bridges, and airports);
  - forestry and other plantations mainly timber plantations;
  - logging and fuel wood;
  - overgrazing;
  - forest fires induced by human; and
  - mining.

These agents are linked to deforestation, degradation and fragmentation of forests. This phenomenon not only represents loss of forest by converting to non-forest activities but also include the degradation of forest quality. The forest degradation refers to reduction in values of forest including the reduction in biomass by unsustainable harvest or land-use practices, logging, fire and other anthropogenic disturbances, and fuelwood collection (Asner et al., 2005). Forest is the habitat of terrestrial biodiversity (80%), support livelihoods (1.6 billion people), act as carbon sink and helps in climate change mitigation.

7.5.2 Direct and Indirect Impacts of Deforestation

7.5.2.1 Climate Change

The deforestation causes change in the local and global climate. The dry climate occurred due to deforestation in parts of India, peninsular Malaysia, parts of the Philippines, Ivory Coast and the Panama Canal area and perhaps also in southwestern China, northwestern Costa Rica and northern Tanzania.

The forest loss and forest degradation increase carbon dioxide level in the atmosphere. The deforestation and degradation affect the annual absorption of 2.4 billion tonnes of CO_2 released by fossil fuel burning. The emission from deforestation was roughly two billion tonnes of carbon to the atmosphere per year (Houghton, 2005).

The radiation budget is getting affected by increase in the albedo of the land surface (Gupta et al., 2005). It also affects the flow of wind, wind velocity, water vapour exchange. The rainfall pattern and intensity is affected. The deforestation increases drought and desertification, crop failures, melting of the polar ice caps, coastal flooding and displacement of major vegetation regimes.

7.5.2.2 Biodiversity and Habitat Loss

The deforestation is directly related to habitat destruction and fragmentation. Tropical forests are rich in biodiversity that act as habitat for two thirds of all known species and contain 65 per cent of the endangered species. The habitat loss also increases the human-wildlife conflicts.

7.5.2.3 Loss of Soil and Water Resources

The removal of forest reduces the evapotranspiration and directly affects the water cycle. This influences the water recharge in rivers, and other aquatic habitats. The ultimate result is the scarcity of water for drinking and irrigation. It increases the soil erosion as the forest roots no longer hold the soil and water infiltration. This result in runoff and siltation in water bodies, wetlands and man-made dams. The heavy siltation increases river beds and cause flooding. The deforestation also creates environmental refugees in some parts of the world.

7.6 URBANIZATION

The urbanization is a global phenomenon involves transformation of human settlements. It covers the movement of people from rural to urban areas as well as the transformation of rural areas into urban areas. The current percent of total world population that live in urban areas is 55 percent. The UN report projects increase in urban population up to 60 percent and will reach 5 billion by 2030 (UN, 2006). The urban activities are major source of greenhouse gas emissions and rapid growing urban population is more vulnerable to impacts of climate change. As per Census of India (2011) the growth in urban population during 2001–2011 was 31.8 percent against national population growth of 17.6 percent. India has more than 35 cities (Ministry of Home Affairs, India 2011) and estimated housing for 14 percent of global urban population by 2025 (McKinsey & Company 2010). Delhi (22.7 million), Mumbai (19.7 million) and Kolkata (14.4 million) ranks second, seventh and tenth position as most populous urban agglomeration in the globe (UN-DESA 2012). Emergence of urban clusters and their expansion consumes significant proportions of agricultural land and substantially impacts biological diversity.

The urbanization has affected the microclimate and cause

- Urban Heat Island (UHI) effect;

- increase in flood hazards;
- deterioration in air quality;
- impacts on the local climate; and
- change in precipitation.

7.6.1 Urban Heat Island (UHI) Effect

The Urban Heat Island (UHI) effect has formed by the increase in temperature in urban areas than near surroundings by anthropogenic waste heat emissions. The temperature of urban areas has increased due to direct heat generation from human activities, removal of vegetation, construction of buildings, roads, pavement and other human transformations of the natural environment. So, the surface heat was accelerated by increase in latent heat flux by lack of evapotranspiration from trees and more radiation absorption by urban canopy (Seto and Kaufmann, 2009).

7.6.2 Urban Flooding

The urbanization causes change in land use and microclimate, which affects hydrology and hydro-climatology of the area. This variability directly influence flood hazards in cities. The frequency and magnitude of floods increased due to climate change driven extreme precipitation (IPCC 2002, 2007) and poor infiltration in cities. The urbanization also affects the rainfall pattern due to alteration in hydrometeorology. The cities in the coastal regions or near river deltas are more prone to floods with its urban characteristics as well as from changes in sea level, tides and large-scale runoff to rivers.

Factors causing urban flood hazards are

- Meteorological factors (cyclonic storms, small-scale storms, temperature, and snowmelt)
- Hydrological factors (soil moisture level, groundwater level, natural surface infiltration rate, impervious cover, cross-sectional shape and roughness of channels, presence or absence of over bank flow, channel network, synchronization of runoffs from various parts of watershed and high tide impeding drainage); and
- Human factors aggravating natural flood hazards (land-use changes, surface sealing, increase in run-off, sedimentation, flood plain obstructing flows, inefficiency or non-maintenance of infrastructure, increase flood peak, climate change and urban microclimate).

The urban floods are classified based on causal factors into four categories:

- Local Floods
- Riverine Floods
- Coastal Floods
- Flash Floods

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. How deforestation is linked with urbanization and industrialization?

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2. How you can mitigate the urban heat island effects?

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7.7 PARTICULATES

The particulates or particulate matter (PM) refers to a suspended solid particles and liquid molecules in air. It includes inorganic dust, organic soot, smoke and liquid droplet that differ in size, composition and origin. These are either primary or secondary particles with natural and anthropogenic sources. The natural sources are wildfires, sea spray, and re-suspension of organic matter and human made sources are vehicular emissions, and wood-smoke emissions from combustion of fossil fuels and biomass. The industries like brickworks, refineries, cement works, iron and steel making, quarrying, and fossil fuel power plants are sources of particulate matter.

There are two types of PM:

- PM10: The particulate matter with less than or equal to 10 micrometers aerodynamic diameter.
- PM2.5: The particulate matter with aerodynamic diameter smaller or equal to 2.5 micrometers. These are fine particles which are inhalable form. It is also known as 'fine PM'.

Particulate matter also include aerosols emitted from the marine environment, mineral dust, biological aerosols and volcanic ash. The biogenic emissions, open burning of biomass, or fossil fuel act as sources for secondary organic aerosol (SOA) precursor gases. The primary biological aerosol particles (PBAPs) comprise viruses (0.05–0.15 μm), bacteria (0.1–4 μm), fungal spores (0.5– 15 μm) and pollen (10–30 μm) (Despres et al., 2012). The dry deposition act as sink for the particulates. The particulate matter can move long distance causing local, regional and global impacts. The particulates are directly related with health, visibility and radiative forcing.

7.8 DESERTIFICATION

United Nations Convention to Combat Desertification (UNCCD) defined desertification as land degradation in the arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and

human activities. Eswaran et al. (2019) with the help of spatial databases on global soils and climates developed derivative maps of global zones vulnerability to desertification. The thickly populated areas are more vulnerable to desertification and possess a very high risk for further land degradation. The Mediterranean countries of North Africa, West African countries, large areas of Central and Southern Asia, South America, the northeast corner of Brazil are prone to desertification. The consequences of desertification are reduction in land cover, quantity and quality of water, crop production, carbon dioxide emissions, increase in wind erosion and formation of gullies. It is reported that population in drylands are going to be affected badly. As per UNCCD (2015), the global loss of productive land due to desertification is 12 million hectares per annum. The desertification affects the climatic condition in dryland areas and these regions are more prone to drought.

7.9 STRATOSPHERIC OZONE DEPLETION

This phenomenon refers to steady lowering of stratospheric ozone concentration with its peak at spring time. The ozone layer is present in the stratosphere of the atmosphere. This is considered as good ozone as it prevents the UV-B radiation to the earth surface. The thinning of ozone layer occurs in the temperate zone latitude. This is a continuous process with high effect at spring times. The ozone hole was discovered over Antarctica in 1985. The ozone hole is more prominent in Antarctica than Arctic due to favorable conditions for polar stratospheric cloud formation.

The substances that have the potential to deplete the ozone layer is known as ozone depleting substances (ODS). The major ODS include chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), halons, methyl bromide, carbon tetrachloride, hydrobromofluorocarbons, chlorobromomethane, and methyl chloroform. The sources are refrigerants; air conditioners; foam blowing agents; fire suppressors; components in electrical equipment; industrial solvents; and solvents in dry cleaning, aerosol spray propellants and fumigants. Few ozone depleting substances are also greenhouse gases.

The chemical reactions causing ozone depletion are primarily based on atomic Cl and ClO, the product of its reaction with ozone. The ozone depletion mechanism depends on the catalytic chain reactions involving the chemical species HO, HO_2, NO, NO_2, Cl and ClO. The Montreal Protocol in 1987 banned the consumption of CFCs that deplete ozone layer.

The Ozone depletion increases the exposure to UVB (290–320 nm wavelength) radiation. The UVB radiation reaching earth surface causes non-melanoma skin cancer, malignant melanoma development and cataracts in human. The physiological and developmental functions are affected in plants and also disturb plant competitive balance, herbivory, plant diseases, and biogeochemical cycles. The phytoplankton productivity and survival rate is reduced. The UVB radiation causes damage to early developmental stages, reproductive capacity and impair larval development in marine animals. The ozone depletion has no direct role in increase in greenhouse gas emissions but it is related with ODS substances with more radiative forcing.

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. Why the air quality deterioration in major Indian cities is more during winters?

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7.10 LET US SUM UP

Population growth, industrialization and urban expansion increase anthropogenic emissions of greenhouse gases to the atmosphere and increases global temperature. The industrialization and urbanization are major agents of deforestation. The urban design reduced potential for evaporative cooling and causes urban heat islands with a unique microclimate. The particulate matter emissions from vehicles and industries are high in urban areas. The desertification results from the warming up of the earth due to human pressure. The stratospheric ozone depletion due to human emitted ozone depleting substances cause UVB radiation exposure to human, animals and plants. In effect, the climate change and variability that we observe in the present times are mainly due to human activities including but limited to deforestation, industrialization and urbanization.

7.11 KEYWORDS

Carrying Capacity : It is the maximum number of individuals of a population that a particular environment can support for an indefinite period assuming no changes in environment.

Deforestation : Deforestation is human-induced conversion of forest to non-forest land uses; It is typically associated with large immediate reductions in forest carbon stock, through land clearing.

Shifting Agriculture : It is also called slash and burn agriculture is the clearing of forested land for raising or growing the crops until the soil is exhausted of nutrients and/or the site is overtaken by weeds and then moving on to clear more forest.

Land Degradation : It is defined as a "reduction or loss, in arid, semi-arid, and dry sub-humid areas, of the biological or economic productivity and complexity of rain-fed cropland, irrigated cropland, or range, pasture, forest, and woodlands resulting from land uses or from a process or combination of processes, including processes arising from human activities and habitation patterns, such as: (i) soil erosion

caused by wind and/or water; (ii) deterioration of the physical, chemical, and biological or economic properties of soil; and (iii) long-term loss of natural vegetation.

Inversion : It occur during the winter months when normal atmospheric conditions (cool air above, warm air below) become inverted.

7.12 SUGGESTED FURTHER READING/ REFERENCES

Aikawa, M., Hiraki, T., and Eiho, J. (2008). Change of atmospheric condition in an urbanized area of Japan from the viewpoint of rainfall intensity, Environ. Monitor. Assess., 148, 449–453, doi:10.1007/s10661-008-0174-0, 2008

Ansar S, Dhanya CR, Thomas G, et al. (2012). A study of urban/rural cooling rates in Thiruvananthapuram. Journal of Indian Geophysical Union. 16:29–36

Barbier, E. B.; Burgess, J. C. and Folke, C. (1994). Paradise lost? The ecological economics of biodiversity. Earthscan

Caviglia, J. (1999). Sustainable Agriculture in Brazil. Economic Development and Deforestation. Edward Elgar.

Charney, J. G. (1975). Dynamics of deserts and drought in the Sahel. Quarterly Journal of Royal Meteorological Society 101: 193-202.

Chomitz, K. M.; Buys, P.; Luca, G. D.; Thomas, T. S. and Wertz-Kanounnikoff, S. (2007). At loggerheads? Agricultural expansion, poverty reduction and environment in the tropical forests. World Bank Policy Research Report. World Bank, Washington DC.

Denman, K.L., et al. (2007). Couplings Between Changes in the Climate System and Biogeochemistry, Chapter 7 in: Climate Change 2007: The Physical Science Basis, The IPCC Fourth Assessment Report, Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge.

Deosthali V. (2000). Impact of rapid urban growth on heat and moisture islands in Pune city, India. Atmospheric Environment. 34:2745–2754. doi: 10.1016/ S1352-2310(99)00370-2

Després, V.R., et al. (2012). Primary biological aerosol particles in the atmosphere: a review Tellus B, 64 (1): 15598, 10.3402/tellusb.v64i0.15598

Devdas, M.D., and Lilly Rose A. (2009). Urban factors and the intensity of heat island in the city of Chennai. In *The seventh international conference on urban climate.* Yokohama, Japan.

Devi, S.S. 2006. Urban heat islands and environmental impact. In *86th American meteorological society annual meeting*. Atlanta, Georgia.

Government of India. (2015). *Census of India 2011.* http:// www.censusindia.gov.in/2011Census/pes/Pesreport.pdf

Gupta, A.; Thapliyal, P. K.; Pal, P. K. and Joshi, P. C. (2005). Impact of deforestation on Indian monsoon- A GCM sensitivity study. Journal of Indian Geophysical Union 9: 97- 104.

Houghton, R. A. (2005). Tropical deforestation as a source of greenhouse gas emissions. In: Tropical deforestation and Climate change, eds. Moutinho, P. and Schwartzman, S. Pp 13-20. Amazon Institute for Environmental Research, Belem Brazil.

http://www.ipcc.ch/report/ar5/wg1/

http://www.ipcc.ch/report/ar5/wg2/

http://www.ipcc.ch/report/ar5/wg3/

http://www.ipcc.ch/report/ar5/syr/

https://www.ipcc.ch/sr15/

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

Myers, N. and Mittermeier, R. A. (2000). Biodiversity hotspots for conservation priorities. Nature 403: 853-854.

http://www.unccd.int/ Lists/OfficialDocuments/cop12/20add1eng.pdf

WMO/GWP. (2008). Associate Program on Flood Management: Urban Flood Risk Management – A tool for Integrated Flood Management.

7.13 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress 1

1. Urbanization and industrialization at the cost of deforestation lead to ecological imbalances. Further, urbanization, industrialization, and deforestation are responsible greatly to increase in atmospheric concentration of greenhouse gases emissions leading to climate change and variability.

2. The UHI effect can be reduced by managing the urban architecture and augmenting urban greening.

Check Your Progress 2

1. The air quality is influenced by both climatic and human factors. The diffusion of gases and depends on geographical and meteorological conditions like winter inversion.