



Block

4

EMERGING ISSUES IN DEVELOPMENT

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BLOCK 4 EMERGING ISSUES IN DEVELOPMENT

Block 4 on ‘**Emerging Issues in Development**’ consists of three units. This block gives an overview of emerging issues in development, mainly comprising of energy and development nexus, natural resources management and environment and issue of sustainable development as relevant to the Development Studies.

Unit 1 on ‘**Energy and Development Nexus**’ discusses the basic concepts of energy, including types and distribution of energy. This unit also covers the issues relating to sustainable energy. It also describes various issues and challenges of energy and development nexus.

Unit 2 on ‘**Natural Resource Management and Environment**’ discusses the issues revolving around the natural resource management and environment. It describes the various types of natural resources, issues revolving the biodiversity including threats to biodiversity and various conservation initiatives and issues relating to management of natural resources.

Unit 3 on ‘**Sustainable Development**’ deals with the concepts of sustainable development, including various components, and indicators of sustainable development. It also describes various measures to promote the sustainable development.

Unit 4 on ‘**Climate Change**’ discusses the meaning, sources and impact of climate change. Besides, this unit also comprises climate change mitigation and adaption and protocol on Climate Change.

UNIT 1 ENERGY AND DEVELOPMENT NEXUS

Structure

- 1.1 Introduction
- 1.2 Energy: Meaning and Types
- 1.3 Energy and Development: The Nexus
- 1.4 Sustainable Energy and Its Aspects
- 1.5 Energy Related Issues and Challenges
- 1.6 Let Us Sum Up
- 1.7 Reference and Suggested Readings
- 1.8 Check Your Progress – Possible Answers

1.1 INTRODUCTION

Energy is a fundamental prerequisite for development. It is deeply connected with the economic, social, environmental dimensions of human development. Energy is required for not only sustainable livelihood, but also for having a respectable quality of life. Quality of energy influences environmental development. Access to sustainable sources of energy produces considerable impact on the social development of the nation particularly education and health care. Sustainable access to modern sources of energy is fundamental to fulfilling basic social needs, achieving higher economic growth and fuelling human development. UNIDO's UN Energy considers that the development of a sustainable, long-term solution to meeting the world's energy is a defining issue of our time.

After studying this unit, you should be able to:

- discuss about energy and its classification;
- differentiate between conventional and non conventional sources of energy;
- describe the exploitation and management of natural resources; and
- have an extensive knowledge of thermal and hydropower, advantages and challenges in the sector

1.2 ENERGY: MEANING AND TYPES

1.2.1 Meaning, Characteristics and Importance

Energy is at the centre stage of the critical economic, social, environment and human development issues and challenges facing the world today. The most common definition of 'Energy' is the ability to do work. Energy is an enabling element and is the capacity of a physical system to perform work. Energy is found in different forms such as heat, kinetic or mechanical energy, light, potential energy, electrical, or other forms. Therefore, energy is a potential power, without which nothing can survive on Earth. The sustainable source of energy should have the following characteristics.

- It should be less costly and affordable and available in large amount.

- It should be less pollutant
- It should be easily accessible.
- It should be easy to store and transport.
- It should be safe to use and non hazardous

Energy is the heart of all type of development and is one of the important elements for quality of life. Clean, sustainable, efficient, affordable and reliable energy services are critical and indispensable for the local and global prosperity. It is customarily seen that the “energy poor” suffer from poverty, illiteracy and ill-health. The people in general and women in particular are disproportionately affected by energy deficiency and quality. The UNDP and WHO in 2009 estimated that over three billion people lack access to modern fuels for cooking and heating. The energy system is a dominant contributor to environment and climate change. Emission from the combustion of fossil fuels is one of the important contributors of the unpredictable effect on climate change. It is remarked that global carbon dioxide emissions (CO₂) will increase by some 50 percent by 2030 unless major policy reforms and technologies are introduced to transform the way energy is produced and consumed. Therefore, energy system design by providing stronger incentives for reduced GHG emissions will be critical to the risk of reducing irreversible, catastrophic climate change.

1.2.2 Types of Energy

Broadly, there are two different types of energy such as conventional energy and non conventional energy.

i) Conventional Energy

The various sources of conventional energy are fossil fuels, thermal energy and hydroelectric energy. Fossil fuels are the most commonly used fuels those are wood, crop residue and cow dung cake; coal, petroleum and natural gas. These fossil fuels are non renewable sources of energy. If we do not use them judiciously they will exhaust and might create energy crisis in future. Therefore, conservation of these conventional sources of energy is essential. Some of the features of conventional sources of energy are:

- These are the most traditional sources of energy and are being use for long time.
- These are very expensive and exhaustible.
- They cause pollution and emit smoke and ash.
- They are very expensive and the prices of these energies are increasing day by day.
- Their maintenance such as transport and storing are very costly.
- These are non-renewable sources of energy

Let us discuss them one by one:

a) Wood/Crop Residue and Cow dung Cake

Wood is one of the major sources of conventional energy. It is widely used for cooking and heating and other household energy purpose. It is a primary fuel which can be used directly to produce heat. In rural areas, people in general and the impoverished household in particular use not only wood but also crop residue and cow dung cake for cooking purpose. The crop

residue and cow dung cake are being used in the country side because they are easily available and less costly. However, their use and burning in heating water and cooking cause a lot of damage. The women found to be suffering from eye and heart ailments such as asthma and tuberculosis. It is observed that in the tribal areas cutting of woods for heating and cooking purpose lead to deforestation. Besides, rural women lose a lot of man-hours in collecting fire woods which they could use for other useful purpose.

b) Coal

Coal is one of the traditional forms of energy used in industry and railway. Coal is formed in layers called seams and takes millions of years to be formed. It is not available in all part of the country. The coal in India is largely available in the Eastern part of India such as Odisha, Bihar, Jharkhand, and Chhattisgarh. It consists largely of carbon, hydrogen, oxygen, and small amounts of sulphur and nitrogen. The oxides of carbon, nitrogen and sulphur are acidic oxides, and are released when coal and petroleum are burned. This leads to acid rain which affects our water and soil resources. Coal varies in quality according to the amount of pressure and heat to which it is subjected to during its formation.

c) Petroleum

Petroleum is formed on hydrocarbon. It is broadly defined as a class of liquid hydrocarbon mixtures. It includes crude oil, lease condensate, unfinished oils, refined products obtained from the processing of crude oil, and natural gas plant liquids. It is popularly used in the vehicles both household and commercial. It is also a non-renewable source of energy as over the period of time it may exhaust. The price of petroleum is also increasing day by day and it becomes a major political issue in the developing countries. It causes more pollution.

d) Natural Gas

Natural gas occurs deep beneath the earth's surface. Natural gas consists mainly of methane, a compound with one carbon atom and four hydrogen

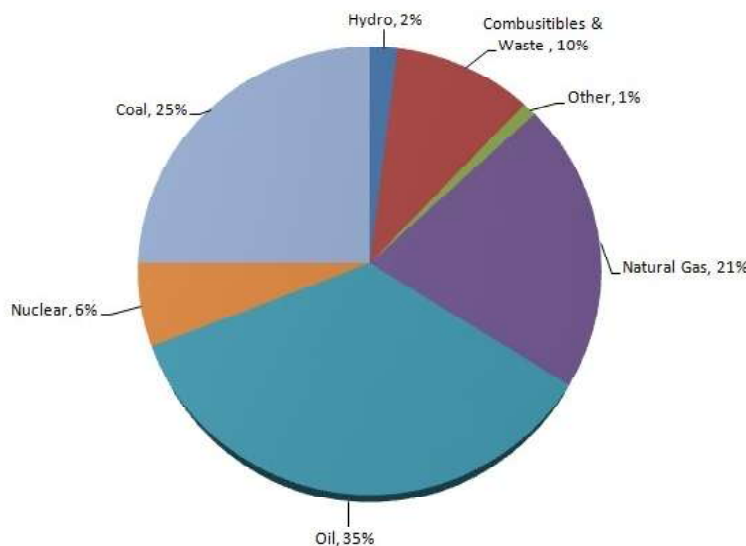


Figure 1 : Share of World Primary Energy Supply in 2005

Source: IEA, http://www.iea.org/textbase/nppdf/free/2007/key_status_2007, p.6

atoms. Natural gas also contains small amounts of hydrocarbon gas liquids and non-hydrocarbon gases. The natural gas is used as a fuel to make materials and chemicals. However, for the past few years, natural gas is used in the household for cooking purpose largely in the urban areas of India. One fourth of all energy used in the USA is natural gas. However, leak of natural gas is extremely dangerous. One of the advantages of natural gas is that it causes less pollution as compared to coal and petroleum.

ii) **Non-conventional sources energy**

Non conventional sources of energy include wind, tides, solar geo-thermal heat, and biomass including farm and animal waste, as well as human excreta. All of these sources are renewable or inexhaustible. They are inexpensive in nature. Some of the characteristics of non-conventional sources of energy are:

- i) These are recent as compared to the conventional sources of energy.
- ii) These are largely renewable sources of energy.
- iii) These energies are pollution free.
- iv) These energies are less costly as compared to the non-renewable sources of energy.
- v) These are non-exhaustible.

Let us discuss the various types of non-conventional or renewable sources of energy one by one:

a) **Wind Energy**

Wind energy is an indirect form of solar energy. It describes the process by which wind is used to generate electricity. Wind turbines convert the kinetic energy in the wind into mechanical power. A generator can convert mechanical power into electricity. It can be used for pumping water, a prime need in irrigating farms in the countryside. Areas with constant and high speed winds are suitable for the purpose. Besides windmills, there are also wind farms. During last decades the use of wind energy has been increased. In 2006, the installed generating capacity in the world increased by 25%, a growth rate which has more or less been sustained during the last decade. As the supply of wind is unlimited then it is less costly. It is also non-polluting. Wind energy is far more eco-friendly than the burning of fossil fuels for electricity. However, one of the disadvantages of wind energy is that its installation cost is higher.

b) **Tidal Energy**

Tidal energy is one of the oldest forms of energy generation. The gravitational pull of the moon and sun along with the rotation of the earth cause the tides. These tides are helpful in generating electricity. It is a renewable form of energy that converts the natural rise and fall of the tides into electricity. This energy sources is unlimited and inexhaustible. The Gulfs of Kutch and Cambay are ideally suited to develop electricity from the energy produced by high tides those enter into narrow creeks.

c) **Solar Energy**

One of the most powerful and abundant source of energy is the solar

energy. It is a renewable source of energy. The energy derive from the sun is a universal source and has huge potential. However, this energy source constitute only one percent of total world energy. The European Investment Bank has invested \$400m in solar power in India. Besides, government and the corporate sectors are also investing in solar energy projects. The rooftop and office top installations are becoming popular day by day. The uses of solar latrines, bulbs, etc. are also becoming popular day by day in many developing countries being promoted by the government, private and international agencies. It is less costly, however, the installations cost is high. Besides, other demerits of the solar energy system that it uses a lot of space and also causes pollution. The successful applications of the solar energy, so far, have been for cooking, heating water, water desalination, space heating, and crop drying. It is going to be the energy of the future when fossil fuels, namely coal and oil, are totally exhausted.

d) Thermal Energy

Thermal energy is produced by heat. This energy is generated by the movements of tiny particles within an object. Illustrious example of thermal energy is kinetic energy. The advantage of the thermal energy is that the generation cost of thermal energy is low. It has no environmental impact as its does not create any emission. It is a good source of renewable angry. Energy so produced can be used for running cold storage plants.

e) Other Sources of Non-Conventional Energy

Some of the other non-conventional sources of energy used are:

i) Energy from Urban and Industrial Waste

Now a day many countries are utilizing the urban and industrial waste to produce energy. Urban solid waste treatment plants are being established in many Municipalities of India and energy is being generated. The waste-to-energy plants have two important benefits: (i) it is an environmentally safe waste management and disposal and use of waste for energy purpose; (ii) secondly it generate clean electricity city for the city. The growing use of waste-to-energy as a method waste disposal and treatment for energy purpose has greatly reduced environmental pollution caused by the municipal wastes .In rural areas also in Kerala pilot plant for demonstration purposes has already been set up.

Table 1: Sources of Energy in Selected Nations, 2016

Countries	Access to Electricity	Renewable Energy Consumption	Carbon dioxide Emission
Afghanistan	89.5	16.7	0.3
Bangladesh	62.4	37.5	0.5
China	100.0	17.1	7.5
Finland	100.0	41.2	8.7
India	79.2	36.5	1.7
Japan	100.0	5.5	9.5
Pakistan	97.5	47.2	0.9

Sri Lanka	92.2	57.6	0.9
Uganda	20.4	89.2	0.1
United Kingdom	100.0	7.3	6.5
United States	100.0	8.9	16.5

Source: *World Development Indicators, 2016; also see <http://wdi.worldbank.org/table/WV.5>(accessed on 10/4/2018)*

ii) Energy produced from Farm, Animal, and Human Wastes

By using farm and animal wastes as well as human excreta, *gobar gas* plants are being set up in villages to make them self sufficient in their power requirements. The energy generated from these plants is used for cooking, lighting homes and streets, and meeting the irrigation needs of villages. The government of India provides subsidies and also offer training and technological help for setting up of these plants at individual, community, and village levels.

Using Bio-gas: A case study of Naravi Village

Naravi village is situated approx. 65 km from M.I.T campus. It is a small village with 20 families each owning 3-4 buffaloes/cows. It is located in the hinterland and falls in one of the remotest parts of Karnataka. The grid supply is present but is highly unreliable with power cuts of up to 6 – 8 hrs during peak summer season. The capital required is more in setting up transmission & distribution for this far flung village. Also Transmission & distribution losses increase due to the increased distance from the Power station. On the other hand, lighting in these rural areas can be effectively achieved by decentralized electricity generation using locally generated biogas. This also makes the system self-reliant. The raw material is abundantly available. The fuel is clean and locally available and the entire system can be developed using indigenous technology. The place of the case study is ideally located for the power generation using the Biogas energy. It is an ideal model which can be adopted by the Panchayat at the village level, so that the entire energy demand of the village including power, lighting and cooking can be overcome by using the cow dung and other human waste product.

Two Biogas plants of 15 cubicmeter capacity each of the type floating dome was setup at the cost of Rs. 30,000 for the entire project. The biogas generated is used to run a diesel engine of capacity 5 H.P using a mixture of diesel and biogas (2:8).[5] The power generated is directly used for lighting purpose. This leads to direct saving of diesel. The Alternator (AC generator) is used in this case is of capacity 4.5 KVA powered by a 5 H.P diesel engine. Since the output of this unit is used for lighting purpose, it runs for 6 hrs/day generating about 21.6 Kwh of electricity per day. The saving in diesel is 16 liters per day. The Biogas generated in this plant is also used to run the kiln/dryer, which in turn is used to bake areca nut, a local plantation.

Source: *<http://www.iitk.ac.in/npsc/Papers/NPSC2002/181.pdf>(accessed on 6/4/2018)*

Energy and development are inter-linked. Availability of cheap and reliable energy boosts economic growth rate and development. It is remarked that the increasing availability of cheaper and higher quality forms of energy inputs has played a key role in driving economic growth in industrialized and emerging economies (Ayres and Warr, 2009). Some of the link between energy and economic growth and discussed below:

- i) Energy is one of the primary requirements for the economic growth. Economic growth requires rise in productivity which can be brought about in the modernization of the agriculture, industry and service sector. The functioning of the tractors and lift irrigation in agriculture requires low cost and affordable energy. Similarly the foundation of industrial development depends on energy. Functioning of shopping malls and all service sector activities such as educational institutions, banking institutions, hospital, etc. also depends on energy. Thus energy and development are interlinked. A World Bank study indicates that countries with underperforming energy systems may lose up to 1-2 percent of growth potential annually as a result of electric power outages, over-investments in backup electricity generators, energy subsidies and losses, and inefficient use of scarce energy resources.
- ii) Energy is required for quality of life and also for the eradication of poverty. It is said that a well-performing energy system that improves efficient access to modern forms of energy would strengthen the opportunities for the poorest few billion people on the planet to escape the worst impacts of poverty. The underdevelopment of rural areas in the developing countries are lack of electricity and other energy for hitting, cooking and lighting. It hampers the education of the children and also affects the cold chain for the immunization of children and women. Without energy and electricity you cannot make your city and village smart and cannot integrate impoverished households those who do not have electricity into the mainstream. Availability of cheap energy will promote small and tiny industries in the rural areas and would be helpful in poverty reduction.
- iii) Energy is required for the social development. The key variables of social development are education and health. Many children in the rural areas of the developing countries are deprived of education because of lack of electricity in their houses. Moreover, functioning of health care centres and hospitals requires electricity. The social networking such as functioning of computers and mobile telephones also requires the connectivity which is derived from energy. Therefore, energy is essential to social development.
- iv) Energy is linked to faster modernization. The possession of modern gadgets such as refrigerators, air conditioners, television, etc. requires energy and those gadgets which educate people on social change. All the developed countries of Europe, America and Asia, those who have achieved modernization since long back had done elaborate arrangement of ensuring energy to facilitate modernization.
- v) Energy is required for the economic and social empowerment of women. In rural areas particular women spend a lot of time in the collection of fire

wood and cow dungs to be used for the cooking purpose. The burning of cow dung cake, paddy husk and fire wood also causing a lot of damage to women health. The availability of cooking gas and electricity will ease out the burden on women and enable them to spend their time in doing some self employment business and even spend in tutoring their children.

- vi) Availability of energy will enhance private sector investment in industry and service sector. Further it will also attract foreign direct investment to the developing countries. It is observed that the state and district which have secured supply of electricity and other form of energy have attracted more FDI as compared to other state having poor availability of energy.
- vii) Energy is an essential need of sustainable development. Safe and clean energy which is non-pollutant is a pre-requisite of sustainable development. The variables of sustainable development such as education, health care, women empowerment, etc. are influenced by energy. Thus for sustainable development nation-states need to have sustainable energy sources. A few Millennium Development Goals affected by the energy are:

- Goal 1: Eradicate extreme poverty and hunger
- Goal 2: Achieve universal primary education
- Goal 3: Promote gender equality and empower women
- Goal 4: Reduce child mortality Goal
- Goal 5: Improve maternal health
- Goal 6: Combat HIV/AIDS, malaria and other diseases
- Goal 7: Ensure environmental sustainability
- Goal 8: Develop a Global Partnership for Development

- viii) Availability of affordable and cheap energy would be helpful to control inflation of food and vegetables in the developing countries. Most of the inflation pressure and rising prices of vegetables are seen due to rise in prices of crude oil used in the tractors in the cultivation. Food inflation can be successfully controlled in the developing countries with the help of energy supply.

In these sessions you read about various sources of energy and role of energy in development now answer the questions given in Check Your Progress-1

Check Your Progress 1

- Note:** a) Answer the following questions in about 50 words.
b) Check your answer with possible answers given at the end of the unit.

- 1) What are various sources of conventional energy?

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1.4 SUSTAINABLE ENERGY AND ITS ASPECTS

The sustainable energy is that energy which meets the needs of the present generations without compromising the ability of the future generation. The sustainable energy is largely the renewable sources of energy. The four important aspects of sustainable energy are: (i) renewable energy; (ii) Energy Indicators; (iii) energy pricing; (iv) Energy and climate change.

- i) **Renewable Energy:** Energy that can be naturally replenished is renewable energy. This includes traditional biomass like firewood, agro-waste, dung and also new renewable like small hydro, biofuels, wind, solar, geothermal, tides, and geothermal heat. These are considered environmentally sustainable as they are low to zero carbon fuels. The actual share of modern renewable of solar and wind energy etc in India is significantly low. But the renewable energy's share of total electric capacity is more than twice that of the US, and India is among the top five countries in renewable capacity. Future strategies will have to enable more rapid expansion of the renewable energy programme.

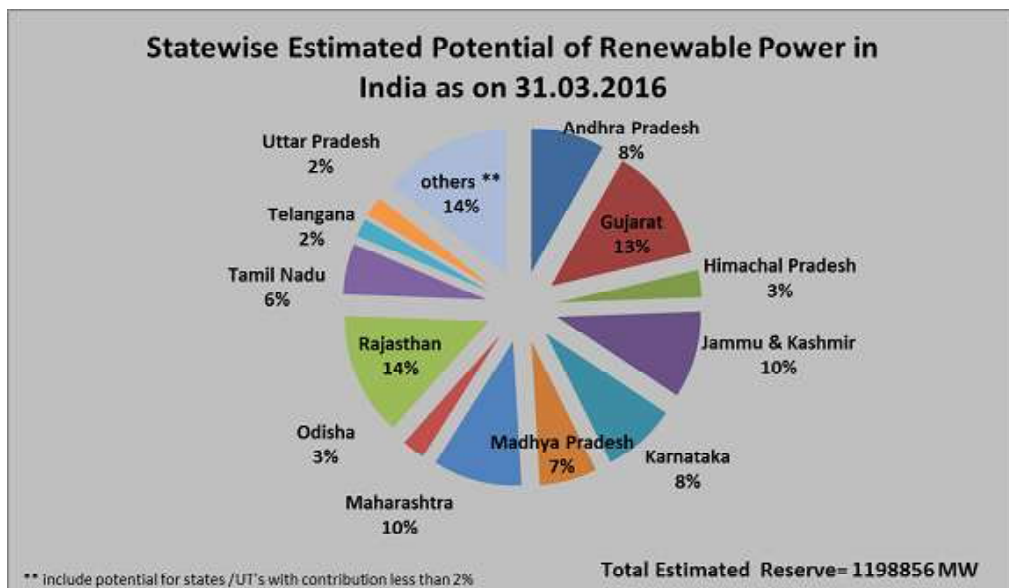
Why traditional biomass is low carbon fuel? Biomass has carbon. But this carbon is part of the current carbon cycle. The carbon that already exists in the atmosphere is absorbed during the growth of the plants. During photosynthesis the trees store carbon in their woody tissue and oxygen is released back to the atmosphere. As the wood is burned the carbon stored in the woody tissue combines with oxygen to produce carbon dioxide, this is emitted back and returned to the atmosphere. As a result a sustainable balance is maintained between carbon emitted and absorbed. The challenge is therefore to innovate to burn this fuel clean to minimize health impacts while benefiting from its low carbon potential.

Currently, the use of renewable energy is less than 20 percent of world primary energy supply till 2017, whereas, in India the use of renewable energy account for about 32 percent of primary energy consumption. The major share is that of traditional biomass mainly used for cooking followed by electricity generation from large hydro plants. The use of traditional biomass is so huge because of high level of poverty in the country.

There is high potential for generation of renewable energy from various sources- wind, solar, biomass, small hydro and cogeneration bagasse. The total potential for renewable power generation in India on 31.03.16 is estimated at 1198856 MW. This includes wind power potential of 102788 MW (8.57%) at 80m hub height, wind power potential of 302235 MW (25.21%) at 100 m hub height, SHP (small-hydro power) potential of 19749 MW (1.65%), Biomass power of 17,538 MW (1.46%), 5000 MW

(0.42%) from bagasse-based cogeneration in sugar mills, 2556 MW (0.21%) from waste to energy and solar power potential of 748990 MW (62.48%).

The geographic distribution of the estimated potential of renewable power as on 31.03.2016 reveals that Rajasthan has the highest share of about 14% (167276 MW), followed by Gujarat with 13% share (157158 MW) and Maharashtra with 10% share (119893MW), mainly on account of solar power potential.



Potential Constraints of Renewable Energy

If the world can make a rapid transition to a low to zero-carbon energy economy, more environmental space can be created for economic growth. However, the contribution of new renewable—wind, solar, tidal or geothermal—is as small as 0.5 percent of the world's primary energy usage. But importantly, renewable are already the third highest contributor to global electricity production—about 18 percent—after coal and gas. But this is because hydro-electricity generates about 16 per cent of the world's power and roughly 90 per cent of the power from renewable sources. The renewable energy market is growing. According to IEA, the wind energy sector has seen a growth of 24 per cent per annum and solar 6 per cent per annum between 1990 and 2005. Renewable need continued and sustained policy intervention.

Solar energy: The National Solar Plan of the Indian government states that India is well endowed with solar energy potential — about 5000 trillion Kwh of energy within its land area. Most parts receive 4-7 Kwh sqm per day. Solar power can help to meet peak power demand, and enable rural electrification. We can convert solar radiation into heat and electricity through solar thermal and solar photovoltaic process. These technologies though proven are expensive. Scale can reduce costs. Globally, between 1992 and 2006 the price of solar photovoltaic has declined by 50 per cent and this will continue.

Wind energy: In India, wind provides 70 per cent of renewable energy. In mid-2007, the country had roughly 10,000 MW of installed renewable

capacity—roughly 7.5 per cent of total installed capacity. According to the Integrated Energy Policy the total contribution of wind energy to India's energy mix will remain below 10 Mtoe. But this should be tapped wherever viable.

Hydrogen: Hydrogen is considered to be zero carbon energy. The overall efficiency of the hydrogen cycle, however, remains in doubt as Hydrogen production, liquefaction or compression, transportation, storage and final dispensation, entail huge amount of energy consumption and loss. Production of Hydrogen needs energy that can emit carbon. India has set up a Hydrogen Development Board to promote hydrogen based technologies. There are still significant barriers related to costs and technological viability of hydrogen in automotive or stationary applications. Metal hydrides that store hydrogen and release it for direct combustion have been developed for powering two/three-wheelers in the country but the technology has not yet been commercialized.

- ii) **Energy Indicators:** The availability of resources and the reliability of their supply are essential for a sustainable economic growth. All sectors of the economy including residential, commercial, transportation, service and agricultural sectors depend on secure, sufficient and efficient energy services. Job availability, industrial productivity, urban and rural development and all major economic activities are strongly affected by energy input. The most important form of energy, viz. electricity is an important and sometimes irreplaceable input to modern productive activities, communication, dissemination of information and other service industries.

Energy indicators are the medium to provide a snap shot of the energy scenario of the country. They help to understand the various aspects of energy and are capable of detecting the grey areas in the complete chain of energy flow. Energy and energy efficiency indicators are indispensable tools for identifying and understanding the key drivers of trends, and for prioritizing interventions to control energy consumption growth. Indicators are also effective in quantifying the potential impact and benefits of interventions. While defining and constructing energy indicators is rather flexible, their accuracy strongly depends on the quality and detail of available energy end-use data.

- iii) **Energy Pricing:** Expensive energy can also reduce demand for energy and improve efficiency. Cheap energy prices can encourage oil guzzling. But the majority of oil consumers do not pay prices that fully reflect the international market level as oil prices are controlled by the government. As a result fuel demand remains unaffected by the price rise.

High fuel prices can influence long term demand for fuel as well as GHG emissions. For instance, a 2009 World Bank study has found six countries (the U.S, Russia, China, Brazil, Mexico and Canada), that under tax fuels are responsible for more than 40 percent of transport oil GHG emissions. But a much larger number of countries that tax transport fuels high – including India, together account for lower – 28 percent of transport fuel GHG world emissions.

In India the government control on fuel-pricing has increased the burden of subsidies. Fuel pricing needs reforms to make its use more efficient and curb over consumption. For instance, cheap diesel can induce more driving, use of bigger SUVs and therefore increase overall fuel consumption. However, higher energy prices can constraint access of the poor to the modern energy systems needed to decrease poverty, improve health and increase productivity. Therefore, the fuel pricing policies should also try to make subsidies better targeted and ensure that the subsidies are not misused.

- iv) **Energy and Climate Change:** Rising energy consumption creates other problems also. Greenhouse gas emissions like carbon dioxide that trap heat and warm up the atmosphere are linked with the amount of fuel burnt. This increases global temperature and induces climate change.

Climate Combat

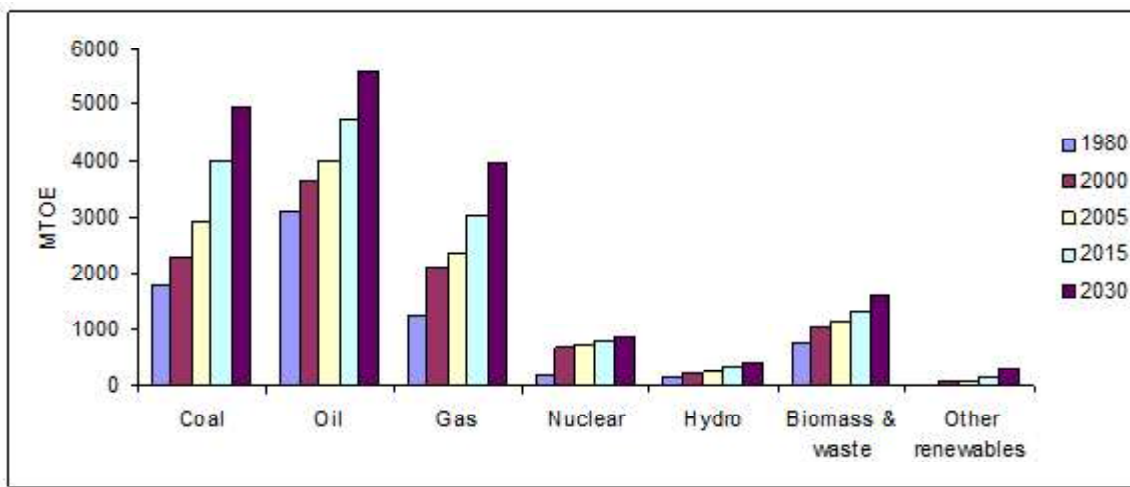
The world will have to limit greenhouse gas emissions so that the global temperature rise can be contained and limited to 2 degree C from the pre-industrial levels. The 2°C goal will require the world to reduce emissions by 50-85 per cent on 2000 levels by 2050. The Intergovernmental Panel on Climate Change (IPCC) has concluded that to stabilize at 2°C emissions just cannot increase after 2015, —meaning, globally emissions must plateau and then drastically reduce. To do this it has to reinvent and transform its strategies of energy use to be able to cap the GHG emissions.

Reducing fossil fuel energy consumption is a difficult challenge. As fossil energy remains abundant and cheap curbing its use becomes difficult. Fossil fuels supplies 80 percent of world primary energy demand according to IEA, and its use is expected to grow over the next 20–30 years if policies do not actively promote low-carbon emission sources. The only estimate of India's greenhouse gas inventory comes from the government's 2004 national communication to the UN Framework Convention on Climate Change (UNFCCC). According to this the energy sector alone contributes 61 per cent of the total stock. Therefore alternatives are critical. India has the opportunity to plan and grow differently. Decisions taken today that support low carbon pathways can make profound impacts.

1.5 ENERGY RELATED ISSUES AND CHALLENGES

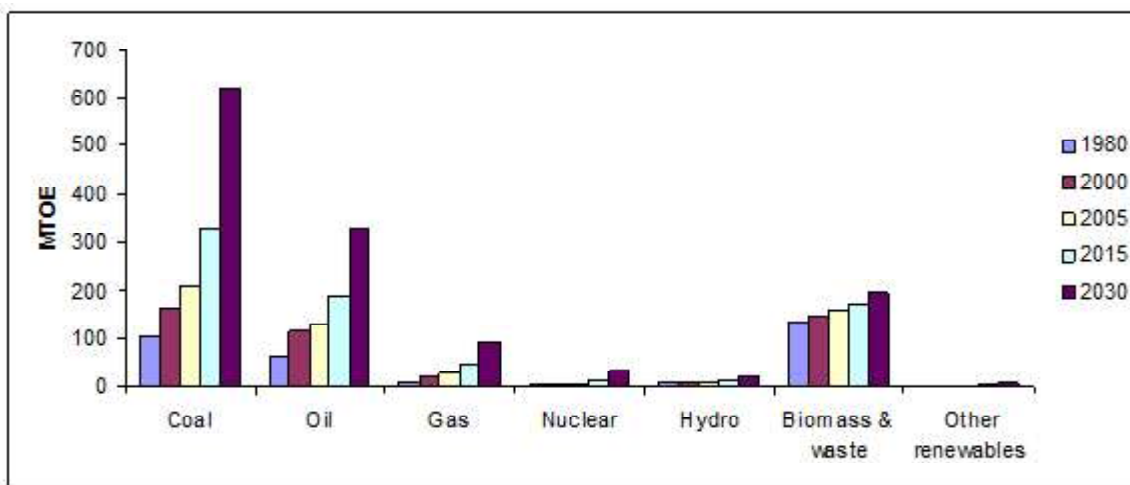
A few important issues relating to energy supply demand and utilization are:

- i) Global primary energy demand has grown phenomenally. International Energy Agency projects that this will continue to grow by more than half between 2005 and 2030. Fossil fuels will form 84 per cent of overall increase in global demand between 2005 and 2030. In the global fossil fuel basket, oil is the single largest fuel though coal has witnessed the biggest increase in consumption. Currently, the industrialized countries have the maximum share of energy consumption. The developing countries are also expected to see significant increase as their economies begin to grow.



Graph 1: Trend in world primary energy demand (Mtoe)

Source: *World Energy Outlook, International Energy Agency, 2007*



Graph 2: Trend in India's primary energy demand (Mtoe)

Source: *World Energy Outlook, International Energy Agency, 2007*

- ii) The second key issue related to energy is energy security. The insecurity in energy cost life. The horror of Bhopal gas leak will never go from the minds of the affected people. Therefore energy security in general and that to security of non-renewable energy in particular is an issue in both developed as well as developing countries.
- iii) Energy pricing and subsidies related issue is quite popular in the developing countries. The rise in prices of electricity cost the common men and they have to cut down their expenditures from other essential necessities. The rise in cooking gas prices also pinches the common men living below the poverty line both in rural and urban areas of the developing countries. Many state governments of India are giving energy subsidy.
- iv) Energy related pollution causes a lot of health problems. The use of conventional sources of energy in cooking such as cow dung cake, paddy husk and wood is causing a lot of health and eye illness. Similarly, the use of non-conventional sources of energy is causing pollution related heart problems in the urban areas of the developing countries.

- v) The poor supply of energy leading to rise in energy prices particularly increase in prices of diesel and petrol in urban areas of the developing countries. The increase in diesel prices affects the food price inflation.

In these sessions you read about sustainable energy and issues and challenges related to energy now answer the questions given in Check Your Progress-2

Check Your Progress 2

Note: a) Answer the following questions in about 50 words.

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

- 1) What are various aspects related to sustainable energy?

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- 2) Briefly describe two energy related issues and challenges.

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1.6 LET US SUM UP

In this chapter you have studied the various concepts, sources, types and issues and challenges related to energy. The unit has described the various sources of renewable and non-renewable sources of energy in detail. It has also described the sustainable sources of energy. The energy related issues such demand and supply of energy, pricing of energy, energy subsidies, etc. have also been described in the last part of the units.

1.7 REFERENCES AND SUGGESTED READINGS

Websites

- 1) https://www.unido.org/sites/default/files/2009-01/energy_development_and_security_0.pdf(accessed on 28/3/2018).
- 2) https://www.eia.gov/energyexplained/index.cfm?page=natural_gas_home(accessed on 4/3/2018).
- 3) <http://iopscience.iop.org/article/10.1088/1748-9326/3/1/015001/meta>(accessed on 4/4/2018).
- 4) <https://www.google.co.in/search?q=solar+energy&oq=solar+energy&aqs=chrome..69i57j0l5.5940j1j8&sourceid=chrome&ie=UTF-8>(accessed on 5/4/2018).

- 5) United Nations (2010): The Secretary-General's Advisory Group on Energy and Climate Change (AGECC), Energy for a Sustainable Future, Reports and Recommendations, 28th April 2010, United Nations, New York, also see [http://www.un.org/millenniumgoals/pdf/AGECCsummaryreport\[1\].pdf](http://www.un.org/millenniumgoals/pdf/AGECCsummaryreport[1].pdf)(accessed on 11/4/2018).
- 1) Alekseev, G. N. (1986). *Energy and Entropy*. Moscow: Mir Publishers.
- 2) Walding, Richard, Rapkins, Greg, Rossiter, Glenn (1999-11-01). *New Century Senior Physics*. Melbourne, Australia: Oxford University Press. ISBN 0-19-551084-4.
- 3) Smil, Vaclav (2008). *Energy in nature and society: general energetics of complex systems*. Cambridge, USA: MIT Press. ISBN 0-262-19565-8.
- 4) Energy Statistics 2017. Ministry of Statistics and Programme Implementation. Government of India. New Delhi
- 5) World Energy Outlook, 2007, International Energy Agency
- 6) World Energy Outlook, 2008, International Energy Agency
- 7) Integrated Energy Policy 2006, Government of India
- 8) India Solar Mission, Government of India, Ministry of non-conventional energy sources
- 9) India energy efficiency mission, Ministry of Power

1.8 CHECK YOUR PROGRESS – POSSIBLE ANSWERS

Check Your Progress 1

1) What are various sources of conventional energy?

Answer: The various sources of conventional energy are fossil fuels, thermal energy and hydroelectric energy. Fossil fuels are the most commonly used fuels those are wood, crop residue and cow dung cake; coal, petroleum and natural gas. These fossil fuels are non renewable sources of energy. If we do not use them judiciously they will exhaust and might create energy crisis in future. Therefore, conservation of these conventional sources of energy is essential.

2) Energy is essential for sustainable development-Explain.

Answer: Safe and clean energy which is non-pollutant is a pre-requisite of sustainable development. The variables of sustainable development such as education, health care, women empowerment, etc. are influenced by energy. Thus for sustainable development nation-states need to have sustainable energy sources. A few Millennium Development Goals affected by the energy are:

Goal 1: Eradicate extreme poverty and hunger

Goal 2: Achieve universal primary education

Goal 3: Promote gender equality and empower women

Goal 4: Reduce child mortality Goal

Goal 5: Improve maternal health

Goal 6: Combat HIV/AIDS, malaria and other diseases

Goal 7: Ensure environmental sustainability

Goal 8: Develop a Global Partnership for Development

Check Your Progress 2

1) What are various aspects related to sustainable energy?

Answer: The sustainable energy is that energy which meets the needs of the present generations without compromising the ability of the future generation. The sustainable energy is largely the renewable sources of energy. The four important aspects of sustainable energy are: (i) renewable energy; (ii) Energy Indicators; (iii) energy pricing; (iv) Energy and climate change.

2) Briefly describe two energy related issues and challenges.

Answer: Two important issues and challenges relating to energy are energy pricing and subsidies and energy related pollution: (i) Energy pricing and subsidies related issue is quite popular in the developing countries. The rise in prices of electricity cost the common men and they have to cut down their expenditures from other essential necessities. The rise in cooking gas prices also pinches the common men living below the poverty line both in rural and urban areas of the developing countries. Many state governments of India are giving energy subsidy. (ii) Energy related pollution causes a lot of health problems. The use of conventional sources of energy in cooking such as cow dung cake, paddy husk and wood is causing a lot of health and eye illness. Similarly, the use of non-conventional sources of energy is causing pollution related heart problems in the urban areas of the developing countries.

UNIT 2 NATURAL RESOURCE MANAGEMENT AND ENVIRONMENT

Structure

- 2.1 Introduction
- 2.2 The Meaning and Types of Natural Resources
- 2.3 Land
- 2.4 Water
- 2.5 Forest
- 2.6 Mining
- 2.7 Biodiversity
- 2.8 Exploitation and Conservation of Natural Resources
- 2.9 Management of Natural Resources
- 2.10 Let Us Sum Up
- 2.11 References and Suggested Readings
- 2.12 Check Your Progress - Possible Answers

2.1 INTRODUCTION

One of the most critical issues on the national and the global agenda is the need to preserve natural resources for future generations, while meeting present day requirements. Today, the entire world has awakened to the need for sustainable development by maintaining judicious use of the natural resources and adopting developmental models and policies which assure proper environmental protection. It is well known that humans across the globe are not only polluting nature and destroying it thorough an aggressive expansion of urbanization *vis-à-vis* consumerism. It was rightly pointed out by Mahatma Gandhi, that there is enough in nature for human need but not for human greed. Some 11,000 years ago, agriculture started in the lap of nature. In the beginning, it was a beautiful synergy between human technique and rhythmic nature, gradually this relationship became less friendly and finally it became tarnished. In the aftermath of the Second World War, unabated mechanization as well as increasing use chemicals have transformed our agriculture into a huge source of pollution of the environment.

The most basic natural resources needed for human life are now either growing scarce or are frequently polluted. For the most part, the reason for this is a two-fold development in the twentieth century-unprecedented population increase (mostly in the under-developed countries, where per capita consumption has grown only slowly at best), and unprecedented increases in per capita consumption in industrialized countries (where again, the populations are now stable or even declining). Thus the squeeze comes from two directions, and in neither case there is any likelihood of any early relief. While at one hand, in Asia, Africa and Latin America, populations continue to grow (although at a relatively lesser pace than in the late twentieth century); in the wealthy parts

of the world, consumption continues to grow at an increasing rate. And the 80 per cent, who lag behind in consumption aspire to the living standards of the wealthy. The earth, it seems, does not have the resources to support their dreams, and in fact may not have the resources to accommodate a 50 per cent increase in population among the poor, even at a present levels of consumption, or a 50 per cent increase in consumption among the wealthy.

In time, as humans gained more and more mastery over natural resources, populations could grow. People learned to cultivate crops, domesticate animals for food and their labour, smelt copper and iron to gain better tools, irrigate soil, and finally, in the greatest revolution of all, use falling water or the blowing wind or even the burning of organic fuels in engines to do most of the productive work, formerly done by hand tools or by their domesticated animals. In this long process they gradually gained a near complete dominance over their natural environment, and literally transformed the earth for their own benefit. Needless to emphasize, the most important basic resources for the support of the large number of humans today are soil, water, food, biodiversity (flora and fauna) and sources of energy.

After studying this unit, you should be able to:

- Explain the meaning and types of natural resources
- Identify the precise factors behind the denudation of this rich natural base, as well as the causal factors behind the degradation of the environment.
- Describe the impact of development on the natural resource management.

2.2 THE MEANING AND TYPES OF NATURAL RESOURCES

Nature has been defined as the omnipresent expanse, definite and indefinite, created and evolving, having all the biotic, abiotic and social dimensions, evolving within, and around life forms and life process. The following definition may be used for understanding the natural resources: “the sum total of all physical, chemical, biological and social factors which construct the surroundings of man is referred to as environment and each element of these surroundings constitutes a resource on which man thrives in order to develop a better life”.

Any part of our natural environment, such as land, water, air minerals, forest, rangeland, wild life, fish, micro organisms, or even human population – that man can utilize to promote the welfare, may be regarded as a natural resource. There are two types of natural resources, viz., exhaustible and inexhaustible. Exhaustible resources are limited in nature and liable to be degraded in quantity and quality by human activities. Examples are forests, soil, water and fossil fuels, etc. Inexhaustible natural resources are unlimited in nature, and they are not likely to be exhausted by human activities, like solar radiation, air, and precipitation.

Environment: the environment is everything which surrounds an organism and influences its life in many ways. It includes physical and biological components. The physical components of the environment are soil, water, air, light and temperature. These are termed abiotic components. The plants and animals are collectively referred to as biotic components. All these components of the environment work together, interact and modify the effects of one another.

Land and Soil: Land is an important resource because it covers about 30 % of the total area of the earth's surface and not all parts of this small percentage are habitable or productive. All other resources are provided by land and it is on land that buildings and industries are made. All agricultural activities that include horticultural operations; ranching, game farming, dairy, grazing, livestock operations, apiculture, field and forage crop production, animal husbandry, hunting, forestry, forest management/silviculture, fish farming, inland fisheries are done on land resource. Land is the home to many species of plants and ...the word, soil, is derived from a Latin word, solum, meaning ground. It is a stratified mixture of inorganic and organic materials, both of which are products of decomposition.

Water: about 70-73 per cent of the earth is covered by water. Water is available in the form of oceans, seas, rivers, lakes, ponds, pools, polar ice caps, and water vapour, and this forms the hydrosphere. The main component of the hydrosphere is water. Water exists in all the three forms, i.e., solid (snow), liquid (water), and gas (water vapour).

Air: this is an inexhaustible natural resource and essential for the survival of all the living organisms on earth. In the atmosphere, about 95 per cent of the air is present up to a height of 20 km above the earth's surface. The remaining 5 per cent of air is present up to a height of about 280 km. Air is a mixture of different gases; nitrogen and oxygen are the major components. Thus, the total volume of air present in the atmosphere consists of 78 per cent nitrogen, 21 per cent oxygen, while the remaining 1 per cent is made up of other gases, such as argon, neon, helium, krypton, xenon, and radon.

Minerals: the Earth's crust is rich in inorganic materials which include ores that are used on a large scale to yield metals such as iron, aluminium, copper, tin, nickel, silver, gold, and platinum. These minerals are useful in industrial and technological growth. Some of the metals are used as catalysts, e.g., vanadium, tungsten, and molybdenum. Some of the non metallic materials (minerals) are vital to industrial growth such as sand, fluxes, clay, salt, sulphur, phosphorus, diamonds, gems, coal, and by products of petroleum (petrol, kerosene, lubricants).

Flora and fauna: flora refers to plant species and fauna refers to animal species. The term biota includes both plants, as well as the domesticated and wild species of animals. Our country has a rich diversity of flora and fauna. There are over 45,000 plant species and 81,251 animal species. This represents about 7 per cent of world's flora and 6.5 per cent of world's fauna.

2.3 LAND

Humans largely live on the surface of the earth. They draw their sustenance from living organisms that dwell on, or near, the surface. Without the primary requisites of food and water, life cannot survive. Without productive soil (and the plant life supported by soil), the world cannot support half of its present biota, or even a tenth of its human population. For humans, the most important part of the earth's crust is the surface of the continental plates, or the areas of the earth largely covered by soil. A very few people could survive, if all the soils disappeared. They could gain protein from fish or crustaceans, and needed vitamins from hydroponically grown vegetables or ocean vegetation. Today, the fastest growing source of protein for humans is fish, with 30 per cent of the fish coming from

the fish farms, or aquaculture. But then much of the food from aquaculture comes directly from the grain that is fed to the fish. Thus, most people would die without the plants that grow in soil, and without the animal life that is directly or indirectly dependent upon continental plant life for survival.

What is soil? Any definition is arbitrary. Only the starting point is clear. Soil, by almost any definition, begins with the weathering of rocks. Water, glacial movements, freezing and thawing, chemicals, the roots of the plants, and even gravity itself breaks rocks into smaller and smaller particles. It is these particles of rock that contain the original nutrients needed for plant growth. But soil, as we presently understand it, is more than the bare particles of rock. It also includes the air and water that mix with rock particles; it includes decayed vegetation, or organic matter, and is home to a rich array of life, mostly microscopic, but also fungi, worms and insect larvae. These help break down cellulose, aerate soil, and liberate the needed nutrients.

Soils are fragile in many ways. Wind can blow away particles of soil and deposit them elsewhere, creating easily erodible loess soils. Water easily erodes barren top soil, moving it into streams, or ultimately into the oceans, or depositing it along river valleys or in ever growing deltas. Mineral salts contained in water from streams can so accumulate in irrigated soils as to render them unproductive. These hazards-erosion, salinisation, acidification, and exhaustion vary according to the climate and soil types. Modern agriculture is able to compensate for most of these hazards, viz. contours and no-till methods reduce water and wind erosion; extra irrigation water, well beyond the needs of a growing crop leach away much (but not all) of the accumulated salts. And of course, in highly efficient modern agriculture farmers annually provide most needed nutrients through chemical fertilizers. In fact the environmental problems arise because of very manipulation of the soil, primarily aimed at short-term benefits.

2.4 WATER

Water is the most abundant substance on the face of the earth. In some sense, it will never be scarce. The supply in the form of vapour, fluids, and solids, is almost constant. Animals and plants use water, but do not destroy it. This is also true of most industrial uses of water, which may involve the heating or the pollution of water. Yet, for many plants and animals, including the humans, water may be scarce. It is a problem of where, and in what form, water is present. Over 97 per cent of the earth's water is in the oceans and has too much of salt for the use of most of the land plants or animals. Of the 2.5 per cent that is fresh water, about two-third is locked up in the glaciers. This means that slightly less than 1 per cent of the earth's water is fresh and in liquid form. Again most of this fresh water is in aquifers, some all but inaccessible. But this still leaves a lot of accessible water, up to 2000 cubic meters for each person per year. This water can be used over and over again if it remains fresh (without salts) and clean (without pollutants). For all animals, the most important use of water is for drinking. Only in very rare cases are humans, anywhere, without access to some fresh water. They rarely die from thirst. But many die from polluted water. In fact around 1.2 billion of the world's population drinks water that is unsafe. Thus the problem lies not in access to drinking water, but to safe water. As per the United Nations estimates, unsafe polluted water kills 4 million

people a year, more than half of them children, with diarrhea being the leading cause.

The water for irrigation comes from two main sources-ground water and the streams. In northern India, up to half of the irrigation water now comes from private wells that tap into ground water or easily accessible aquifers. It is a simple fact that if the outflow from these sources exceeds the slow rate of recharging, these will eventually shrink, requiring ever deeper wells. Eventually, they will dry up. The same is true for the flowing streams. Rainwater either feeds them directly, in runoff, or indirectly, by way of groundwater or aquifers that find an outlet in springs. In dry periods, as the water table sinks, stream loses more and more water by seepage. In hot weather, they lose water by evaporation. Very often than not, this lowered flow coincides with the time crops need the most water for irrigation. And hence, dams came into picture. Previously, the ancient civilizations built low earthen dams, creating reservoirs to save at least some of the spring run-off. But to save most of the total run off necessitated construction of large dams, which could not just function as reserves of water for urban water systems, hydro-electric production, flood control, but more importantly will serve to maintain a uniform flow of water for irrigation throughout the year.

The drawback, as relates to present irrigation system is its inefficiency, for the simple reason that when water is moved by open, unlined canals, seepage and evaporation can steal up to half of the original water discharged from the source. Subsequently, when the water reaches the crops by flooding of ditches or by spray, more of the water is wasted by evaporation or by absorption by soil that does not contain crop roots. If moved to crops by concrete-lined canals with some type of cover, and fed to plants by a drip system, irrigation can reach maximum efficiency. Such a system could expand production by up to 50 per cent. But few countries can afford such capital costs, which are up to three times greater than in ditch irrigation. Drip irrigation also slows the process of salinisation. Because of evaporation, minerals in river water (as well as those leached out from the soil) can slowly accumulate in the irrigated soils, eventually curtailing and even putting an end to production. The present means of postponing this disaster is the use of extra water, water not needed by plants, to flush out as many salts as possible deeper into the sub-soil, thence into ditches, and finally into heavily polluted holding ponds or lakes. Without proper drainage, this extra flushing water can lead to waterlogged soil, with some of the salt backing up to the roots of the plants. Ultimately, no final answer exists for salinisation in certain soils and climates. The only remedy remains that the fields are left non-cropped for a significant duration, with the recovery time being determined by the amount and duration of the rainfall.

2.5 FOREST

Forests are the most visible and dramatic product of the soil. Trees grow on over half the land area of the earth. Only very dry soils, or very cold temperatures, preclude tree growth. Thick forests are such a dominant form of vegetation that they not only depend on a favourable climate, but do much to shape the climate. Forests perform invaluable ecological services, such as controlling soil erosion (trees slow down run-off and control soil erosion and landslides by retaining water in their root systems and by arresting the velocity of rain water through

their canopy cover), and also act as sinks for storing carbon dioxide emissions. Of all species, humans have had the greatest impact on the forests. Insects attack and sometimes kill trees, and today these most often are invasive species introduced through travel or trade. Deer may over browse trees, or kill all new tree growth. But only humans have deforested large areas of the earth, not only by cutting and burning, but also by the effects of acid rain, harmful pesticides, and imported diseases and fungi. Human interactions with forests take many forms. One, so evident, is getting rid of trees that are an impediment to agriculture. Another is the using up of trees as fuel or timber.

Humans also harvest the products of trees without destroying them, as in gathering the fruits, nuts, or sap (for rubber, tar, turpentine, else). Finally humans often select and plant trees in behalf of a harvest (eg. orange groves, apple orchards, rubber plantations, etc.). Throughout human history, the greatest use of trees has been for fuel (as is the case in India and in rest of the third world countries). And it is this use that has led to the most critical environmental problems, problems based on rapid population growth and traditional patterns of heating homes or cooking food or, as in India, cremating the dead. Interestingly, even the cultural patterns define the amount of the wood being used in cooking; viz. in India the traditional cuisine often requires elaborate and extended preparation.

There is probably no other area of India's environment that has been more viciously attacked and destroyed in the last century than the country's forests. As per government estimates, between 1951 and 1972, India lost 3.4 million hectares of prime forests to dams, agricultural extension, to roads and industries, which again amounts to an average rate of forest loss about 0.15 million hectares per year (State of India's Environment Report, 1982). However, data released in mid-1984 by National Remote Sensing Agency (NRSA) showed that India lost 1.3 mha of forests every year within the same intervening period (1972-73 to 1980-82). This above figure discounts the 2.5 million hectares of mangrove forests lost over the last 80 years. As per *The Last Frontier Forests: Ecosystems and Economies on the Edge*, a study conducted by World Resources Institute (WRI), about 99 per cent of India's original frontier forest (a term used to describe large intact natural forests) has already been lost, while 57 per cent of the remaining frontier forest cover is threatened. Overall, in India, the dense forests cover only 12 per cent of the land area, a figure well below the target of 33 per cent, with the average annual deforestation rate of 3,400 sqkm in the interim period 1980-90 (Anon 1997a).

Deforestation and degradation has been caused by commercial logging; clearing of forestland for settlements and agriculture; excessive exploitation of forests for fuel wood and food and overgrazing. The denudation of fir and spruce forests in Himachal Pradesh and Jammu and Kashmir for making package cartons for apples is an example of the commercial exploitation of forests taking place in the region (TERI 1992). Fuel wood constitutes the dominant source of energy in the region and population growth has contributed to increased exploitation of forests for meeting out growing energy demands. In addition, the limestone quarrying and the construction of dams have added to the loss of forestland.

2.5.1 Shifting or *Jhum* Cultivation

The mountain people of the Himalayan region, especially those in the Northeast, over the years had adopted traditional practices of replenishment in the region. One such method was *Jhum* cultivation which is basically 'rotational bush fallow' agriculture. This traditional tribal practice enabled regeneration of forests before the same land was cultivated again. The *Jhum* cycle was once considered to be as long as 25 years, but in the recent past, studies have shown that the cycle has shrunk to as short as 4-5 years (Barthakur 1981). As the *Jhum* cycle becomes successively shorter, the rate of soil erosion gets accelerated (Box 1). An assessment by the Forest Survey of India indicates that 1.73 million hectares of land has been affected by shifting cultivation in this region during the period 1987-1997 (FSI 2000). Nagaland and Mizoram together account for 65 per cent of the area under shifting cultivation in this region. Due to degradation of forest cover and pastures, farmlands which are dependent on them for nutrients and organic matter also deteriorate. This loss of extent and productivity of forests and pasturelands implies a threat to the well-being of rural communities who are dependent on the agro-pastoral economy for their livelihood. The impact of deforestation is felt most by local communities, particularly women and children, who as a result of receding forest cover have to travel increasingly longer distances and spend more time on fetching fuel wood and fodder, contributing to severe hardship, as is very aptly exemplified by Chipko Andolan, in Chamoli Garhwal (Box 1).

Box 1: Aftermath of current practice of shifting or *Jhum* cultivation: A Case Study

Increasing population pressure and declining land through degradation have resulted in a rapid shortening of the *agricultural cycle*, leading to (1) a drastic reduction in yield to the farmer; (2) a reduced relative agro-ecosystem and landscape stability (resistance and resilience) in the face of perturbation, leading to social disruption; (3) a decline in biodiversity due to weed takeover, biological invasion, and eventual site desertification; and (4) a drastic decline in soil fertility under short agricultural cycles imposed on the same site over a period of time, (5) this loss in soil fertility is accentuated by heavy hydrological losses due to runoff and leaching during frequent perturbations; (6) since herbaceous weed vegetation alone develops during the first 5-10 years of fallow regrowth, the weed potential gets intensified, leading to an arrested succession; and (7) biological invasion by exotic weeds is promoted (e.g., takeover by *Eupatorium* spp. and *Mikania micrantha*), (8) substantial CO₂ emitted into the atmosphere because of more frequent and extensive burns. All attempts made so far in finding an alternate to shifting cultivation have had little or no impact; however three different pathways for sustainable agriculture do exist:

- 1) **Incremental Change:** Maintaining a longer cycle length of 10 or more years where feasible and transferring better shifting cultivation technology from one area to another. Strengthening the tree component using biologically valuable and socially acceptable tree species (e.g., the nitrogen-fixing, *Alnus nepalensis* tree species in northeast India recoups about 600 kg of nitrogen lost during one cropping season or Sea buckthorn (*Hippophae salicifolia*, *H. rhamnoides*), wherever feasible;

- 2) **Contour Management:** Implementing the sloping agricultural land technology (SALT), which is based on planting field and perennial crops in 3-to 5- meter bands between double rows of nitrogen fixing trees and shrubs planted on contours for soil conservation. The crop species include rice, maize, tomatoes, and beans, whereas the perennials may be cocoa, coffee, banana, and citrus. The contour lines are planted with *Leucaena leucocephala*, *Flemingia macrophylla*, and *Desmodium rensonia*.
- 3) **Energy Intensive Agriculture:** Where feasible, on flat valley lands, more intensively managed monocropping systems could be developed, arising out of the existing traditional sedentary agriculture.

2.5.2 Deforestation and Availability of Minor Forest Produce

A large number of tribal populations depend on minor forest produce (MFP) for their survival. MFP covers products of the forest, except timber and firewood, for example flowers like *mahua*, seeds and leaves of *Sal* and *tendu*, resins, bamboos, lac, fruits, tubers, and so forth. Studies in Orissa, Madhya Pradesh, Himachal Pradesh and Bihar indicate that over 80 per cent of the forest dwellers depend on the forests for 25-50 per cent of their food requirement. In Orissa, 13 per cent of the forest population exclusively depends on MFP. Yet another 17 per cent is landless, which depends on the daily wage labour, primarily the collection of the MFP. Again for 39 per cent, MFP collection is a subsidiary occupation. Infact for the tribal population MFP rather stands for Major forest produce and not minor.

One consequence of deforestation is that the availability of MFP has decreased considerably. Normally the poorest among the forest dwellers eat mahua flowers, roots and tubers during the lean months and sell fruits like mangoes for additional income. But due to incessant deforestation availability of the mahua flowers, along with other MFPs has declined by almost half, viz. per capita availability of mahua flowers decreased from 200 kg per capita in the early 1960s to less than 100 kg, 2 decades later. Honey has all but disappeared from many forests, and high vitamin foods like gooseberries are no longer accessible to the poor. The result is low nutrition, lower earnings, as well as higher indebtedness (State of India's Environment Report, 2nd volume, CSE, New Delhi, p.91).

Box 2: The Chipko Andolan: The grassroots agitation against deforestation

The Chipko Andolan- the movement to hug trees is probably the world's most well-known grassroots Ecodevelopment movement. The Chipko movement was born in March 1973 in the remote hill town of Gopeshwar, Chamoli Garhwal (Uttarakhand), when representatives from a sports good factory situated in Allahabad reached Gopeshwar to cut 10 ash trees near Mandal village. When the villagers persistent calls to not to cut the trees fell in the deaf ears, they came up with the idea of hugging the earmarked trees. Few weeks later the same contractor empowered with fresh allotment from the forest department resurfaced at Rampur Phata, a good 80 kms away from the Gopeshwar township. However, as soon as the villagers learned of the attempt, they marched with drums and songs, gathering more people on the way. This time too, the idea of hugging the earmarked trees paid, with

the contractor being forced to return back. The Chipko movement reached its climax in 1974, when the women of remote village of Reni, some 65 kms from the border township of Joshimath, successfully foiled the exploitation attempt. That day their counterparts, the men folk were away in Joshimath protesting against the auction of a forest neighbouring the village; the contractor arrived to begin the felling. However, undaunted by the seer number of the men or their axes, the women of Reni, led by Gaura Devi, barred the path to the forest.

It needs to be emphasized here that the genesis of the Chipko movement has both an ecological and an economic background. The Alaknanda valley, in which the movement originated, was the scene of an unprecedented flood in 1970. The tragic aftermath of this flood left a deep impression on the hill folk and, with it, soon followed the appreciation of the vital ecological role that forests plays in their lives. At its heart, the movement is very much a feminist movement, which brings forth the salient role of the forest in the lives of the hill women; because it is they who are affected more by the loss of forest cover than their counterparts, with whom they very often had to fight, against felling of the trees.

Adapted from State of India's Environment, 1st Citizens' Report, Centre for Science and Environment, New Delhi, 1982, pp.42-43.

2.6 MINING

The pervasiveness of dust is the strongest indication that mining is not a benign activity. Unless it is carefully planned and thoughtfully carried out, mining can lead to (and it very often does) degradation of the landscape, pollution of the water, denude forests, defile the air, and degrade the very life of the inhabitants, who work or live in the vicinity. With increasing mechanization, the mining equipment have grown larger and more powerful, and thus with the use of power shovels, hydraulic excavators, massive dump trucks and conveyors, can move tens of thousands of tonnes of mineral or ores in a single day, thereby altering the entire landscape in a relatively very short period of time. Mining leads to not just the degradation of the mining site, but additionally means the conversion of land to such purposes as roads, railways and ropeways for mineral transport, townships for housing miners and other staff, infrastructure for administrative purposes, land for stockyard and for preliminary processing purposes, else. In effect, the total land affected by mining is many times larger than the simple lease area. The first stage of surface mining involves the removal of vegetation and the top soil. Since the mined areas are usually abandoned without the adoption of any reclamation measures, they become barren. The disposal of mining debris requires additional area, and thus renders the surrounding land infertile. Rainwater subsequently washes out the debris from waste dumps to adjoining agricultural fields and streams, making them polluted. Underground mining can similarly lead to subsidence of land. However, the most important fact remains that much of the mining activity in India is carried out in forested regions, with the obvious result-deforestation and erosion. In fact underground mining also significantly denudes forests, since the timber used for supporting the roofs of the mine galleries are procured from the forests only. The gross neglect of the surrounding ecosystem, including the health of the population in the vicinity of the mines is being described below (Box 1.3).

Box 3: Mining for uranium: A gruesome aftermath

Uranium is mined as an ore usually containing over 0.1 per cent of uranium oxide. Some 3.4 lakh tonnes of ore are required to generate 1,000 MW of power each year in light water reactors of Tarapur type. The most significant radiological hazard in uranium mining is represented by radon and its decay products. Inhalation of radon gas and its decay products in uranium mines irradiates the lungs and the respiratory tract, increasing the incidence of cancer in the miners. The incidence of procuring cancer gets compounded by the general poor health of the miners. The environmental cost of uranium mining could be described citing the example of Jaduguda uranium mill in Bihar. The ore is processed mechanically and chemically to extract the bulk of the uranium content to yield a concentrate of oxides called yellowcake. The mill tailings are dumped into a 25 ha pond. It is estimated that a 1,000 MW capacity nuclear power plant annually produces about 3.25 lakh tonnes of mine tailings. The tailings are decanted and the fluid is channeled into a nearby nullah. To this is also added the discharge from the mine, which contains uranium, radium and manganese. This effluent 50 meters downstream contains radium, manganese and sulphate above the derived water concentrations. By the time the effluents reach the Subarnarekha river, the uranium and radium concentrations in the aquatic system have both increased, the former by 2.5 times to 3.2 mg/m³.

Adapted from State of India's Environment, 2nd Citizens' Report, Centre for Science and Environment, New Delhi, 1984-85, p.288.

2.7 BIODIVERSITY

Biodiversity is the variation of life forms within a given ecosystem, biome, or, on the entire Earth. Biodiversity is often used as a measure of the health of biological systems. The biodiversity found on Earth today consists of many millions of distinct biological species, which is the product of nearly 3.5 billion years of evolution.

Biological diversity or biodiversity can have many interpretations, and it is most commonly used to replace the more clearly defined and long established terms, species diversity, and species richness. Biologists most often define biodiversity as the “totality of genes, species, and ecosystems of a region”. An advantage of this definition is that it seems to describe most circumstances and present a unified view of the traditional three levels at which biological variety has been identified, and they are genetic diversity, species diversity and ecosystem diversity.

One of the most pressing issues on the national and global agenda is the need to conserve biodiversity for future generations while trying to understand and document the indigenous knowledge of resource management practices. So far, this challenge, has been partially addressed by the national and global agencies, who have restricted themselves to conservation of biodiversity as outlined by the World Commission on Environment and Development (1987), which led to calls for sustainable development. As a result, the model of development was foisted upon the so called Third World for the last fifty years. A strong argument has been made that development dictated from outside rather anchored in the knowledge base of the target population is, in principle, modernization disguised,

and not fully concerned with local needs. This is evidenced by the continuing marginalization of already marginalized populations in Latin America and elsewhere at a global level, and similarly, marginalization of the tribal, pastoralists and marginal farmers in far flung and remote areas, especially in the mountains in India. Only recently, it has been realized by scholars and researchers that indigenous knowledge systems should constitute the core of development models in the Third World. Because indigenous knowledge has permitted its holders to exist in harmony with nature, allowing them to use it in a sustainable manner, it is seen as especially pivotal in discussions of sustainable resource use.

In agricultural systems, a diversity of crops and varieties is needed to combat the risks farmers face from pests, diseases, and variations in climate. Crop biodiversity also underpins the breadth of dietary needs and services that consumers demand as societies become wealthier. For some time, scientific experts have been concerned about declining diversity of crop genetic resources on farms. Many argue that the very processes that engendered the remarkable advances in agricultural productivity during the 20th century, such as the Green Revolution, also eroded the valuable stocks of genetic resources long maintained by farmers. Sampling these resources and housing them in gene banks, while fundamental, is only a partial solution. Ex situ conservation stops the evolutionary clock and raises proprietary concerns as genetic material is transferred out of the hands of its historical custodians for safeguarding. Economists often view the loss of diversity as an unavoidable, unintended consequence of technical change and specialization—a negative externality of progress. In the longer term, managing crop genetic diversity through a combination of strategies and approaches (in gene banks, breeding programs and on farms) is essential for sustained social and economic development.

Of all the forms of ongoing habitat destruction, the most consequential is the clearing of forests. It is believed that the maximum extent of the world's forests was reached six thousand to eight thousand years ago, at the very dawn of the agriculture. Today, however, only about 50 per cent of the original forest cover remains, which again is under intense pressure of denudation. Over 60 per cent of the temperate hardwood and mixed forest has been lost, as well as 30 per cent of conifer forest, 45 per cent of tropical rainforest, and 70 per cent of tropical dry forest. Inevitably, the reduction in the area of the forest results in reduction in the number of the species that can live sustainably within it. More precisely, as the area shrinks, the sustainable number of species falls by the sixth to third root of the area. A common intermediate value found in nature is the fourth root. At the fourth root, the reduction of a habitat to one-tenth its original area eventually causes the fauna and flora to decline by about one-half.

A frightening aspect of the area-species principle is that while removal of 90 per cent of the habitat area allows about half of the total number of species to hang on, removal of the final 10 per cent can wipe out the remaining half in one stroke. In fact, the prime cause of concern remains this very bare fact that throughout the world, habitats reduced to fragments this size or even smaller is increasing rapidly. World's 25 hotspots of biodiversity, which even though cover only 1.4 per cent of the total land surface, yet represents 43.8 per cent of all known species of vascular plants and 35.6 per cent of all the known mammals, birds, reptiles, and the amphibians, are not safe either. These twenty-five hotspots have already been reduced 88 per cent in area; it is feared that

some of these hotspots will altogether be wiped in few decades due to continued intrusion by human. Two of the hotspots are within India: the Western Ghats and the eastern Himalayas.

The earth supports an enormous variety of organisms. How many species are on earth today is beyond any measurement. About 1.75 million species are presently described, although the exact boundaries among species, subspecies, and varieties are not always clear. It is estimated that humans have probably observed, although not always classified, about 2.5 million species. Beyond that the guesses vary widely. The United Nations Environment Programme (UNEP), in what amounts to a mean among all guesses, usually estimates a total of 14 million species.

2.7.1 Indian Scenario

The Indian subcontinent is one of the most fascinating ecological and geographic regions in the world. Here lies the nearly rainless desert of Thar and one of the rainiest place on earth- Cherrapunjee; the hot, salty Rann of Kutch and the permanently snow-bound peaks of the Himalaya; the wet coastal regions of Kerala and the Islands of Andaman and Nicobar; the great lake of Chilka and the river system of Ganga-Brahmaputra. This variety of ecological conditions sustains a tremendous amount of diverse life forms (tables 1 & 2). About 15,000 species of plants (out of a world total of 1.5 million) have their homes in India. On two per cent of the world's land mass, we possess around five per cent of the known living organisms on earth. The fauna peculiar to India include the sloth bear, blackbuck, four-horned antelope and snakes belonging to the family *Uropeltidae*.

With over 1,200 species and about 900 subspecies of birds, India's avian diversity is unmatched except by Latin America. However, today a significant portion of this cornucopia is threatened by the pressure of human activity, both on land and forests. What makes matters worse is that knowledge of our wildlife is still largely incomplete, except for a few groups of organism such as birds. A little over 10 per cent of India's flora also faces extinction. The first comprehensive listing of endangered wildlife species in India was compiled in the Wildlife (Protection) Act, 1972, which provides for protection of threatened faunal species from indiscriminate hunting. Schedule I of the Act identifies 70 mammals, 22 reptiles and amphibians and 41 bird species as rare or highly endangered species, which are totally protected throughout the land.

The lion-tailed macaque, which inhabits the evergreen rainforests and *Sholas* of south India, is among one of the world's most endangered primates. Similarly the wolf, the jackal, the Indian fox and the wild dog represents the threatened carnivore. Among the felines, all the big cats-the tiger, the lion, the leopard, the snow leopard, as well as the small felines- the lynx, the marbled cat (killed for pelts) are critically endangered. Similarly, 5 out of the recorded 9 species of deer in India, are endangered, which includes one of the most endangered species, the Sangai or the Brow-antlered deer, limited to just around 40 odd individuals in the wild. Lack of foresight and ecological insight has led to disappearance of 4 out of 5 species of turtles previously found in India, more so as these species were 'fenced off' from their principle breeding sites through construction of the embankments. As regards the bird fauna, the principle cause remains not harvesting/hunting, but rather the habitat destruction, pollution of air

and water (usage of the pesticides) and the increasing drainage or the decrease in the over-all area of the wetlands. Presently a significant number of species of Hornbills, the bamboo partridge, all the Himalayan Pheasants, are critically endangered.

Table 1: A Comparative Statement of the Floral Diversity of India and the World

Sl. No.	Taxa	Species			Percentage of species in India as compared to the world
		India	World	Endemic	
1.	Bacteria	850	4,700	-	18.10
2.	Viruses	unknown	5,000	-	-
3.	Algae	2,500	40,000	-	6.25
4.	Fungi	23,000	47,000	-	48.94
5.	Lichens	1,940	17,000	-	11.41
6.	Bryophyta	2,843	16,000	-	17.77
7.	Pteridophyta	1,022	13,000	200	7.86
8.	Gymnosperms	64	750	-	8.53
9.	Angiosperms	17,000	250,000	4,950	6.80
10.	Total	49,219	392,700	5,150	12.53

Source: Anon 1997b

Table 2: A Comparative Statement of the Faunal Diversity of India and the World

Sl. No.	Taxa	Species			Percentage of species in India as compared to the world
		India	World	Endemic	
1.	Protista	2,577	31,290	619	8.23
2.	Mollusca	5,050	66,535	807	7.59
3.	Arthropoda	60,383	9,83,677	9	6.13
4.	Other invertebrates (including Hemichordata)	8,329	87,121	-	9.56
5.	Protochordata	116	2,173	-	5.34
6.	Pisces	2,546	21,723	78	11.72
7.	Amphibia	204	5,145	85	3.96
8.	Reptilia	446	5,680	152	7.85
9.	Aves	1,228	9,672	50	12.70
10.	Mammalia	372	4,629	37	8.03
11.	Total	81,251	1,217,645	1,837	6.67

Source: Anon 1997c

2.7.2 Crop Diversity Loss

India is recognized as one of the centres of diversity, especially for its rich genetic wealth of bamboo, fruit trees (mango, banana, and citrus), vegetables (eggplant, okra, cucurbits), legumes (mung bean, black gram, cowpeas), rice, pepper, cardamom, ginger, turmeric, sugarcane, jute, and various medicinal and aromatic plants. In addition, the country enjoys a rich diversity of wheat, maize, millets, oilseeds, among other, such as forage legumes and grasses. It is estimated that about 250 Indian species have wild relatives of agricultural and horticultural importance, and of these, about 60 are rare or highly endemic. However, with the advent of modern agriculture, more specifically with the introduction of High Yielding Varieties (HYVs), this rich genetic pool has shown signs of rapid depletion. Witnessing the success of the green revolution technologies in the plains, there has been a blind run to implement the same throughout the country. However, the same has met with failure in the mountain environment, since the technologies were built around the requirements of homogenous or near homogenous agricultural pattern (read mono-cropping) and climatic, edaphic, topographical conditions, as well as the irrigational, nutrient inputs prevailing or re-enforced in the plains, or were easier to disseminate, subsequent to the green revolution.

The introduction of the ‘miracle seeds’ of the green revolution, which led to large scale destruction of crop diversity is based on the concept that only one product of the plant is useful: the marketable one. The HYVs or rather the high response varieties of the green revolution considered only the grain as the useful product. In fact, the HYVs yielded large amounts of grain only if they were given inordinate amounts of inorganic fertilizers, in addition to the regular dose of pesticides. Added to all this was the inevitable greater need for frequent irrigation. Eventually this unnatural act leads to toxicity of various kinds and water logging of the soil. Monocultures are not ecologically sound, and not least sustainable. By simple definition monoculture principally means breeding identical plants. Biodiversity erosion, thus starts a chain reaction, for the simple reason, the disappearance of one species is related to extinction of a number of other con-joint, related or associated species, of which the human beings are totally oblivious. All in all, the displacement of indigenous/traditional varieties of crops (which could be extended to the indigenous livestock population too) does not merely leads to the loss of diversity, but it has more serious ecological consequences, which again undermines the productivity. Thus, conserving the native crop species is necessary for the simple ecological reasons (adapted from Shiva 1996):

- 1) Resilience against environmental stress
- 2) Cropping patterns based on diverse mixtures of crops reduce vulnerability to disease and pests. Genetic variation in crops also reduces such risks.
- 3) Races which have evolved under rain fed conditions are well adapted to long periods of water stress and to variation in the climate. In addition, when such varieties are grown in mixtures of as high as nine ‘Navdanya’ or even twelve crops ‘Barahanaja’ (as practiced in the hills of Garhwal Himalaya- the practice of cultivating multiple crops at a time is termed as Polyculture), the risks of crop failure are further reduced.

- 4) This insurance is not a trade-off against productivity because all crop outputs are included in measurements of yield; mixtures generally have higher yields than monocultures.

In this session you read about various natural resources. Now answer the questions given in the Check Your Progress 1

Check Your Progress 1

Note: a) Answer the following questions in about 50 words.

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

- 1) What do you mean by Natural Resources Management (NRM)?

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- 2) Write in brief what do you understand by environment?

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- 3) What do you understand by biodiversity?

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2.8 EXPLOITATION AND CONSERVATION OF NATURAL RESOURCES

A number of activities relating to development including construction activities of all kinds, forest based industries, hydel and irrigation projects, mining, oil drilling, pollution, resource extraction, and road and transportation put enormous pressure on natural resource base. There are some human induced activities, which relating to agriculture, fishery, expansion of forest villages, grazing/ increased domestic animals habitat, habitat depletion and exchange due to horticulture, monoculture forestry have led to different kinds of encroachment on natural resources.

- exploitation by local authorities as revenue resource
- fuel wood collection
- food gathering
- food hunting
- smuggling of timber/ forest produce
- trophies/ specimen collection of medicinal plants and orchids and
- unregulated trade / market forces.

Human induced disasters causing stress on natural resources

- floods
- major oil spills/ leakage
- wildlife depredation
- Epidemic
- forest fires due to humming and
- intentional forest fire.

Threats to NRM- wrong and faulty approaches

- diseases
- fire as management tool
- genetic uniformity
- hybridization
- inadequate water and food for wildlife
- increased competition
- introduction of exotic species
- lack of patronage of local / native species
- low population/ restricted range (protectionism).

Management of human resources

- change in people's life style
- conflicting / increasing demands
- dilution of traditional values
- erosion of indigenous knowledge
- generation gap
- human harassment
- ignorance / lack of awareness
- inadequate trained human resource
- inappropriate land use
- lack of effective management
- negative attitude
- tourism development.

Political and policy issues

- civil unrest / political movement
- change in use/ tenure/ legal status
- insurgency or armed conflict
- intercommunity conflict
- intervention failure
- lack of clear policy implementation
- lack of interdepartmental coordination
- lack of intervention
- military activities

Why Conservation?

The Indian region is a treasure house of wild genetic resources. Wild species and relatives of crop plants contain valuable genes that are of immense genetic value in crop improvement programmes. The important wild related species and types in various crop groups, prevailing under different phytogeographic zones in the country needs particular attention in the agro-biodiversity management system for sustainable use, to help maintain food, nutritional, and agricultural economic security. The main objectives of biodiversity conservation are

- the conservation of biological diversity
- the sustainable use of components of biodiversity.

India's efforts at Biodiversity Conservation

Dr. M.S. Swaminathan (1983) suggested the following conservation measures

- cultivated varieties in current use
- obsolete cultivars
- primitive cultivars or land races
- wild species and weedy species closely related to cultivated varieties
- wild species of potential values to man
- special genetic stock developed by man
- fair and equitable sharing of benefits arising from the utilization of genetic resources.

In-situ Conservation

- This includes conservation of plant and animals in their native ecosystems, or even in a man-made ecosystem, where they naturally occur.
- It applies only to wild fauna and flora.
- It aims at preservation of land races with wild relatives in which genetic similarities exists.

Ex-situ Conservation

- This is done through the establishment of gene banks.
- It is the chief mode for preservation of genetic resources.

- Generally, seeds or *invitro* maintained plants cells, tissue, and organs are preserved under appropriate conditions.

The drawbacks of *ex-situ* conservation are

- loss of viability over passage of time and susceptibility to insect or pathogen attack
- inability to maintain distinct clones except for inbred and apomicts species
- non applicability to vegetative propagated crop.

2.9 MANAGEMENT OF NATURAL RESOURCES

There is an urgent need to think deeply about the destruction of natural resources. With the exponential increase in human population and increased technological advancement, the natural resources get relentlessly exploited. There is a need for optimization of its usage. This is possible only when we adopt the concepts

Figure 1: Complex and Dynamic Resources Management Systems

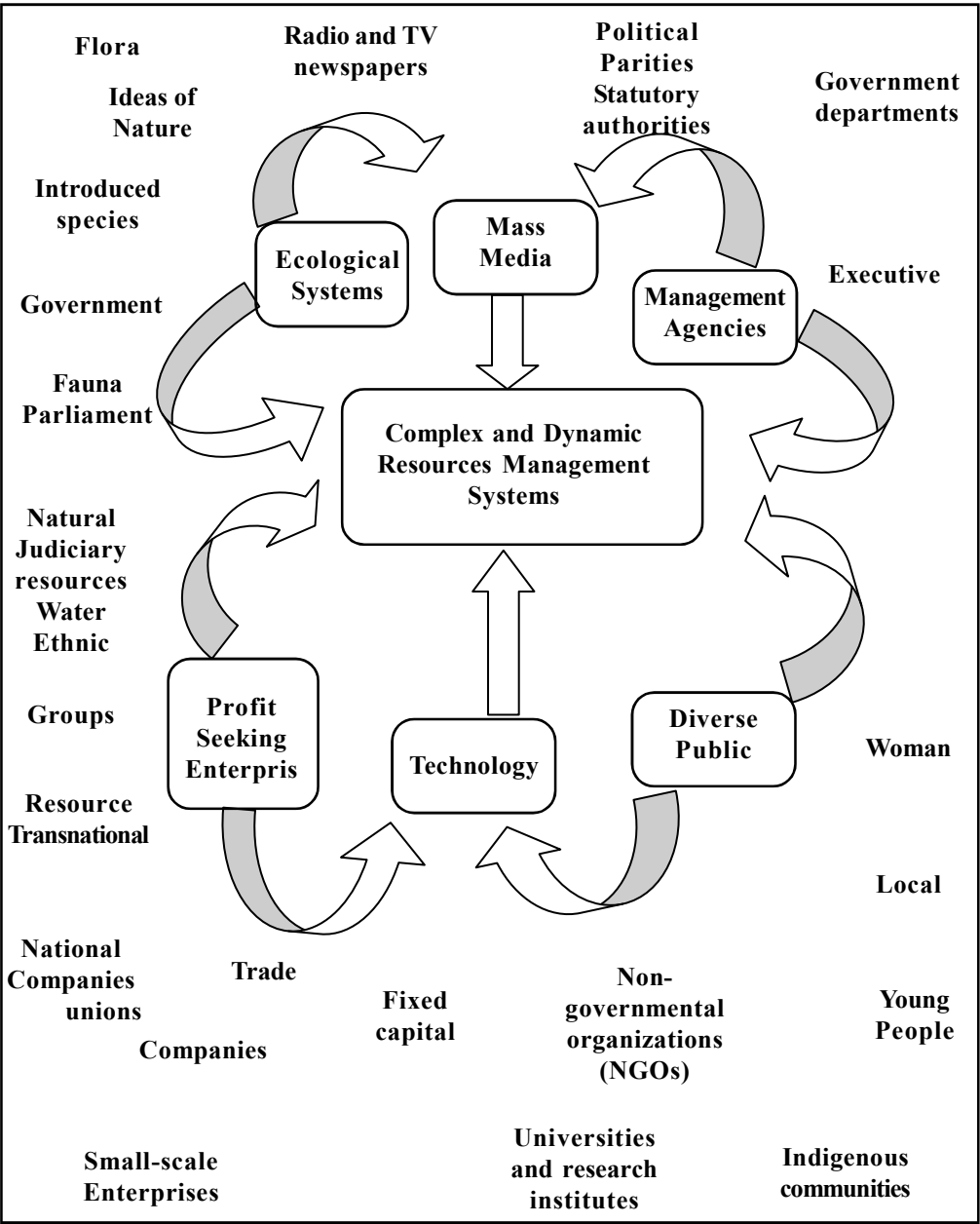


Figure 1: Resource Management Chart

of management and conservation of natural resources. Management and conservation mean scientific utilization of resources while maintaining their sustained yield and quality. India produces only half of the national requirement of petroleum products and it imports the rest from other countries. Natural gas is the most popular petroleum product and its consumption during last two decades has increased tenfold. If we need to save fossil fuels from total exhaustion, we should encourage the usage of non conventional resources of energy, such as solar energy, wind energy, biomass energy, etc. Biogas is a natural gas. It is produced from animal, water and weeds and other plants. India comes first in developing and using biogas technology. It is a cheap, non polluting and labour saving fuel. Biogas can be used for cooking and lighting, and in vehicles.

According to the world conservation strategy on natural resource management (NRM), it is the management of human use of the biosphere, lithosphere, and hydrosphere so that it may yield the greatest sustainable benefit to the present generation while maintaining its potential to meet the needs and aspiration, not the greed, of future generation. With the current rate of development, population growth, and migration, communities are increasingly unable to meet their sustained needs, growing demand for fuel wood and other forest products, pollution due to industrialization, and a market for rare animal species and medicinal plants have all threatened the biological diversity; and thereby have hampered sustainable human development. Further, the race for development and cultivation of improved varieties in larger areas has threatened the biodiversity to a considerable extent. The complex dynamics of resource management system can be well understood by the flowchart (figure 1) and various issues and dimensions involved in resource management are represented in figure 2.

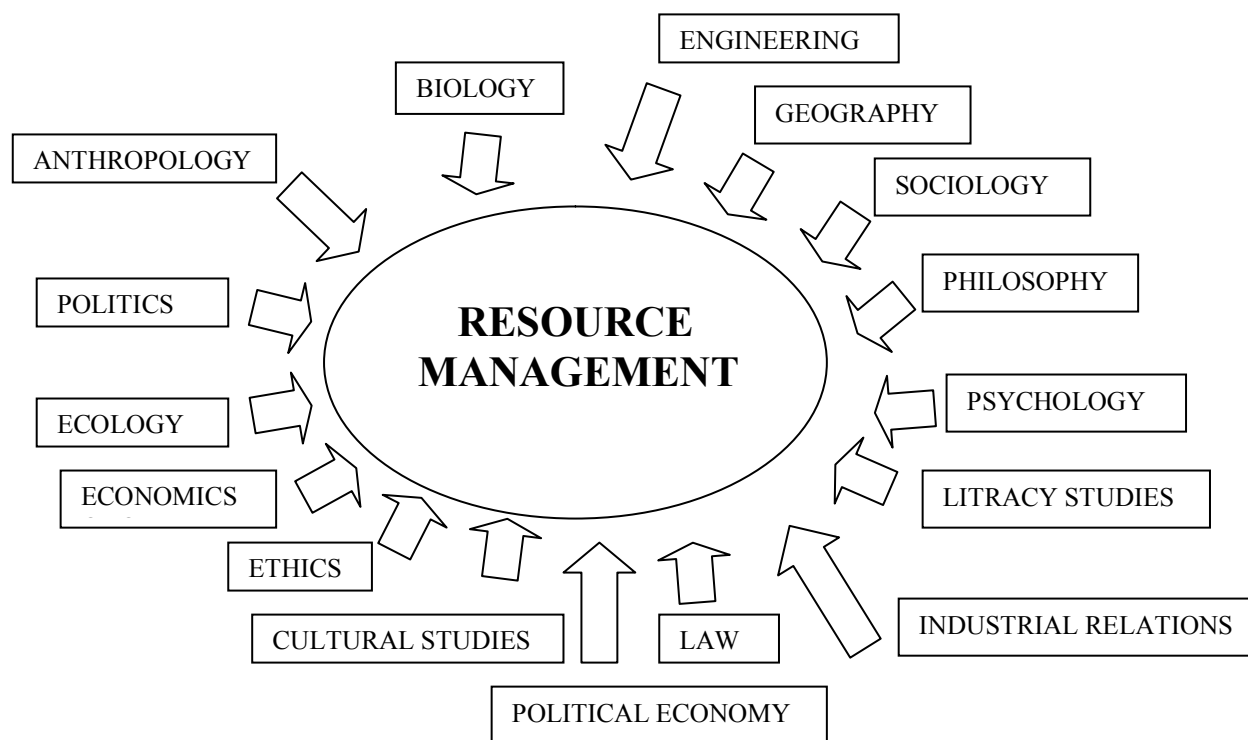


Figure 2: Various issues/dimensions involved in resource management

2.9.1 Meaning and Need for Resource Management

The main driving forces of resource consumption are population and economic growth, and the pattern of development, broadly defined to include technological level, economic structure, and the patterns of production and consumption. The projected 50 per cent growth in the global population over the next fifty years will put a significant pressure on the environment. If, over the next fifty years, the population of the developing countries achieves levels of material wealth similar to today's levels in industrialized countries, world consumption of resources would increase by a factor ranging from two to five. Without dramatic technological improvements or changes in the patterns of consumption, growth in resource use and environmental impacts due to increased population and economic growth in developing countries are likely to outweigh technological efficiency gains in industrialized countries.

Human wealth is based on the use and consumption of natural resources, including materials, energy and land. Continued increase in resource use and the related environmental impacts can have a multitude of negative effects leading to ecological crises and security threats. The sustainable use and management of natural resources have, therefore, come into focus and has been the subject of many policy discussions over more than a decade, beginning with the summit in Rio de Janeiro in 1992.

Over the past 50 years, humans have changed ecosystems more rapidly and extensively than in any comparable period in human history, largely to meet rapidly growing demands for food, fresh water, timber, fibre and fuel. This has resulted in substantial gains in human wellbeing and economic development, but these gains have been achieved at growing costs in the form of the degradation of many ecosystems (Millennium Ecosystem Assessment, 2005). What is driving our material and energy use to the extent that it is becoming a global environmental problem and a threat to future generations? There is no simple answer to this question, because a number of interdependent socioeconomic and environmental factors are at play. Nevertheless, there are three basic factors which determine the growth of resource consumption, and the resulting environmental impacts of human production and consumption patterns.

2.9.2 Dynamics of Resource Management

Public policy in India has, for long, appreciated that access to shared or common natural resources (NR) is crucial to local livelihood strategies. Many of the rural poor depend directly on shared NR, yet they often live in ecologically marginal areas and have limited and insecure rights to NR. A recurrent question in the rural development debate has been: how are poverty and access to NR linked and what are the policy implications of these linkages? A principal conclusion has been that decentralised NR management regimes will enhance both sustainability and equitable access to NR by the poor. Policy has focused principally on institutional frameworks conferring rights, responsibilities and roles in decentralized NR management (DNRM). In India, two formal institutional systems have been identified as having the legitimacy and potential to enhance rural livelihoods: partnership models. In the last decade there have been significant moves towards formal NR management partnerships between the public administration and local user groups. The two most institutionally evolved examples, for which Guidelines have been promulgated, are Joint Forest

Management (JFM) and Watershed Management (WM). A Constitutional Amendment passed in 1993 aimed to strengthen local government, collectively called Panchayati Raj Institutions, at District, Block and Village levels. Some of the seats at these levels are reserved for marginal and vulnerable community members, and for women. Village level Panchayats have become responsible for preparing plans for the management of NR within their boundaries. The support for decentralization is based less on any proven success than on ideological convictions related to the importance of local involvement and self determination in the development process. There is, however, a growing realism about the strong centralizing forces within the polity and bureaucracy that inhibit meaningful transfer of access and control over NR. Equally, earlier optimism regarding collective action has been tempered by failed participatory common resources are not considered worth collective action.

The decentralization agenda has however led to changes in the institutional arrangements for managing shared NR. Through partnership models, and indirectly through Panchayati Raj, communities have been given some autonomy in deciding priorities for NR management, funds to develop NR assets and guidelines to promote community mobilization. These decentralization initiatives represent major achievements in challenging the previous dominance of line department control over all aspects of NR management. The objective of sustainable, equitable and efficient DNRM is, however, far from being realized as our examination of the source of political demand for decentralization and the content of the programmes and projects themselves revealed.

Management of Forests

The world forest is derived from the Latin word *foris* meaning outside, the reference being to a village boundary, or fence and it must have included all uncultivated and uninhabited land. Today, a forest is any land managed for the diverse purpose of forestry, whether covered with trees, shrubs, climbers, etc., or not. The Indian word, jungle, has been adopted in the English language to describe a collection of trees, shrubs, climbers, etc., that are not grown in a regular manner, as contrasted with a forest, which is any vegetation under systematic management. Technically, a forest is defined below.

- a) Generally, a forest is an area set aside for the production of timber and other forest produce, or maintained under woody vegetation for certain indirect benefits which it provides, e.g., climatic or protective.
- b) From an ecological point of view, a forest is a plant community predominantly of trees and other woody vegetation, usually with a closed canopy.
- c) From a legal point of view, it is an area of land proclaimed to be a forest under a forest law.

Forestry is the theory and practice of all that constitutes the creation, conservation, and scientific management of forests, and the utilization of their resources to provide for the continued production of the required goods and services. Forests are a very striking feature of the land surface. They vary greatly in composition and density, and stand in marked contrast with meadows and pastures. The scenic effect of forests changes with the seasons like the patterns in a kaleidoscope. Certain forests are evergreen, like the Deodar forests of Kashmir, while others are deciduous, becoming leafless either before the advent of winter

when vegetative activity almost ceases, such as the oak forests of the Himalayas, or else just before the onset of intense dry summer, to reduce transpiration to the minimum, like the Teak forests of Central India. The falling leaves in some species become bright orange or golden yellow. In others, the young foliage is pink. Such autumnal and verbal tinges are in vivid contrast with the general green or straw-coloured background, and are extremely pleasing. Unlike animals, plants do not have the power of locomotion. They also cannot construct shelters or generate heat to withstand the adverse effects of the environment of which they are captives. Therefore, to survive they wear the evidence of this fact in the form of structural adaptations, such as leaflessness in summer to minimize transpiration, thorns to ward off browsers, poisonous sap, etc.

The forests of a country are a natural asset of immense value. Unlike its minerals resources, including fossil fuels, which in course of time either get exhausted or their utilization will become uneconomic due to increased costs for obtaining and processing them, the forests, if of adequate extent, ideally dispersed, scientifically managed and judiciously utilized can be kept perpetually productive and useful, conferring many benefits, direct and indirect, on the people. Thus, forests are a renewable resource. Directly, forests meet the needs of small timber, fuel, bamboos and a variety of other products, including fodders which are indispensable requirements of the people living in close proximity of the forests. They also provide the facility of grazing for their livestock, and yield a variety of products of commercial and industrial value such as structural timber, charcoal, and raw materials for making paper, newsprint, rayon, panel products, *bidi* leaves, gums, resin, dyes, tans, and a number of other economic products including medicinal drugs. Forests also provide employment to a large population engaged in their protection, tending, harvesting and regeneration as also in ancillary occupations processing forest raw material and marketing them. These are productive functions of the forests.

Management of State Forests

No forest should be permitted to be worked without the government having approved the management plan, which should be in a prescribed format and in keeping with the national forest policy. In order to meet the growing needs for essential goods and services which the forests provides, it is necessary to enhance the forest cover and productivity of the forests through the application of scientific and technical inputs. Production forestry programmes while aiming at enhancing the forest cover in the country and meeting national needs should also be oriented to narrowing, by the turn of the century, the increasing gap between demand and supply of fuel wood. No such programme, however, should entail clear felling of adequately stocked natural forests.

Rights and concessions: the rights and concessions, including grazing, should always remain related to the carrying capacity of forests. The capacity itself should be optimized by increased investment, silvicultural research and development of the area. Stall feeding of cattle should be encouraged. The requirements of the community which cannot met by the rights and concessions so determined should be met by development of social forestry outside the reserved forests.

The holders of customary rights and concessions forest areas should be motivated to identify themselves with the protection and development of forests from

which they derive benefits. The rights and concessions from forests should primarily be for the *bonafide* use of the communities living within, and around forest areas specially the tribal communities.

Division of forest lands for non forest purposes: forest land or land with tree cover should not be treated merely as a resource readily available to be utilized for various projects and programmes, rather, as a national asset which requires proper safeguards for providing sustained benefits to the entire community.

Wildlife conservation: forest management should take special care of the needs of wildlife conservation, and forest management plans should include prescriptions for this purpose. It is specially essential to provide 'corridors' linking the protected areas in order to maintain genetic continuity between artificially repeated sub sections of migrant wildlife.

Tribal people and forests: there exists a symbiotic relationship between the tribal people and the forests, which means that both depend on each other for their survival and existence. Therefore, the primary task of all agencies responsible for forest management, including the forces development corporations should be to associate the tribal people closely in the protection, regeneration and development of forests as well as to provide gainful employment to the people living in and around the forests.

Shifting cultivation: Shifting cultivation is affecting the environment and productivity of the land adversely. Alternative avenues of income, harmonized with the right land use practices, should be devised to discourage shifting cultivation.

Forest based industries: as far as possible a forest based industry should raise the raw material needed for meeting its raw material requirements. Forest based industries must, not only provide employment to the local people on priority, but involve them fully in raising trees and raw material.

Forest extension: forest conservation programmes cannot succeed without the willing support and cooperation of the people, a direct interest in forests, their development and conservation, and awareness of the value of trees, wildlife, and nature in general.

Forestry education: forestry should be recognized both as a scientific discipline as well as a profession. Agriculture universities and institutions dedicated to the development of forestry education should formulate curricula and courses for imparting academic and professional excellence, keeping in view the manpower needs of the country.

Forestry research: with the increasing recognition of the importance of forests for environmental health, energy, and employment, emphasis must be laid on scientific forestry research necessitating adequate strengthening of the research base, as well as new priorities for action.

Management of Soil Resources

Rapid deterioration of soil health and degradation of soil environment as a consequence of persistent nutrient depletion and operating process of erosion, salinisation, acidification, and desertification have been of concern to soil

scientists in recent years, as these are posing a threat to the potentiality of our soil resources to support the increasing food demands in the future.

Soil Degradation

- Physical: soil erosion, water logging, desertification, compaction, crusting, overgrazing
- Chemical: nutrient runoff, acidification, salinisation, alkalisation, loss of organic matter, nutrient imbalance, nutrient depletion, accumulation of toxicants.
- Biological: monoculture, pesticides and herbicides, disposal of industrial waste, toxic containing sewage water, genetic manipulation

Approaches towards soil conservation

- The primary purpose of soil conservation is to prevent soil erosion and heal the damage where it has not advanced too far to respond to curative methods.
- The land should wear a vegetative cover throughout the year.
- Engineering and agronomic practices should be applied conjointly.

Reclamation of eroded lands

- Ravines should be provided with sufficient and suitable vegetative cover.
- Instead of agriculture, these lands should be reclaimed for forestry, pasture, or horticulture.
- Their deficiency in nutrients and moisture for plants growth should be improved.
- Further misuse of such land should be prevented, over transplanting by man, and fenced cattle trails for example.
- Vegetative cover provided, should be protected against reckless destruction by local population.

Measures for controlling soil erosion deposition hazard

- Plantation at wind breaks and shelterbelts
- Sand dune stabilization
- Stubble mulching
- Wind string cropping
- Primary and secondary tillage
- Conserving soil moisture.

The Management of Water Resources

Ground water has been exploited in India quite substantially in the past few decades for irrigation. However, unlike surface water resources, there has been a conspicuous lack of scientific assessment of groundwater resources. Availability of this important natural resource has been taken for granted; utilization of ground water has not been commensurate with the available potential in a state, e.g., about 86 per cent in Gujarat and 3 per cent in Assam, indicating considerable regional imbalance. India has 4 per cent of the world's water resources. The

present water demand of India's agriculture is nearly 83 per cent of the total water use in the country and shall not change appreciable by the end of the century. The Ministry of Environment (1992) had made projections for water demand of various utility sectors for 2000 and 2025 AD.

Use of most of this allocated water for agriculture is confined to 33 per cent irrigated area and the remaining 67 per cent is still dependent on monsoon rains. The disproportionate use of water in certain pockets results in wastage. Excessive use of water makes the field more vulnerable to soil erosion. Irrigation, thus, can be identified as the most important single activity responsible for agriculture induced environmental stress, although other activities such as deforestation for expanding agriculture, production oriented agronomic practices, use of fertilizers, and plants protection chemicals have their individual contribution.

Approaches towards water conservation

Management at surface water resources such as

- canal water
- run-off water
- *khadins*
- *nadis*, Tanks
- Gully
- plugging
- water harvesting dams
- water spreading
- percolation tank

Management of ground water resources

The ground water resources in arid region have four major problems

- 65 per cent area has saline ground water with total soluble salt content over 3200 ppm
- deep static water level
- poor yield from wells
- due to over exploitation, static water level is declining, soluble salt content have increased, and the yield is reduced.

The following methods are available for artificially recharging aquifers

- water spreading
- recharging through pits
- wells and shafts
- pumping to induce recharge from surface water bodies.

Extension approaches for NRM

- Creation of natural resources like forests, water bodies etc.
- Conservation of resources in an ecology niche.
- Regeneration of natural resources by organizing self-propelling processes.

- Preservation through social fencing.
- Recycling of waste water by products.
- Rejuvenation of degraded or age old resource base.
- Protection of target species.
- Pollution control through policy formulation.
- Elimination of negative factors operating in the eco-systems.
- Social fencing for protection, preservation.
- Integration of biotic, abiotic and social factors.
- Rationalization in the use of dwindling resources.
- ITK and ITW: appropriate use and application.
- Watershed management to generate livelihood and conserve natural resources.
- Monitoring : Benefit monitoring evaluation (BME)
- Auditing is required to get accounts of depletion, and to suggest interventions
- People's participation: this is the most important and critical way to accomplish any objective in NRM.

In this session you read about the management of natural resources. Now answer the questions given in the Check Your Progress 2

Check Your Progress 2

Note: a) Answer the following questions in about 50 words.

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

1) What are the important roles of forests in our society?

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2) Write five major extension approaches which are very much needed for NRM.

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3) What are the right approaches to soil conservation?

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4) How can you manage surface water resources?

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2.10 LET US SUM UP

In this unit we dealt with various concepts and issues relating to the Natural Resource Management and Environment. We also discussed how these challenges have been partially addressed by global and national agencies. We explained how the exploitation of natural resources causes threats to the biodiversity, and various conservation issues and initiatives taken at global and national levels. The sustainable development approach, based on the complex dynamics of resource management, is the desired goal and objective of all national and international bodies. We also discussed how the decentralization agenda has led to changes in the institutional arrangements for managing shared natural resources including the sustainable management of the forests, soil resources and water resources.

2.11 REFERENCES AND SUGGESTED READING

Anonymous 1997. The State in a Changing World, World Development Report 1997, Oxford University Press, Washington, pp. 232-233.

Anonymous 1997. National Action Plan on Biodiversity, Ministry of Environment and Forests, Govt. of India, New Delhi, p. 32.

Andres, Suzanna, *et. al* (1982). The world Environmental Hand Book: A Directory of Government Natural Resource Management Agencies in 144 Countries, World Environment Centre, New York.

Barthakur, IK 1981. Shifting cultivation and economic change in the north-eastern Himalaya. In: Lall, JS (Ed), *The Himalaya: Aspects of Change*, Oxford University Press, Delhi. pp. 447-460.

Cambell & Sayer (2003). Integrated natural resource management: linking productivity. *The environment & development*. CABI Publishing in association with the Centre for International Forestry Research (CIFOR), pp. 315.

Champion, H G and S K Seth (1968): *A Revised Survey of the Forest Types of India*, Govern-ment of India Publications, New Delhi.

Farooquee, Nehal A., B.S. Majila and C.P. Kala. (2004). Indigenous Knowledge Systems and Sustainable Management of Natural Resources in a High Altitude Society in Kumaun Himalaya, India. *Journal of Human Ecology*, 16(1): 33-42.

Farooquee Nehal A. and R.K. Maikhuri (2009). Communities and their agrobiodiversity: priorities for agriculture in Uttarakhand Himalaya, India *Outlook on Agriculture*, 38 (4): 383-389.

- FSI (2000). *State of Forest Report 1999*. Forest Survey of India (Ministry of Environment and Forests), Government of India, Dehradun. 113 pp.
- FSI (2001): *State of Forest Report 2001*, Forest Survey of India, Ministry of Environment and Forests, Government of India, New Delhi.
- (2003): *Status of Forest Report, Forest Survey of India*, Ministry of Environment and Forests, Government of India, New Delhi.
- GoI (2002): *Draft National Biodiversity Strategy and Action Plan (NBSAP)*, Ministry of Environment and Forests, Government of India, New Delhi.
- Guha, R (1989): *The Unquiet Woods: Ecological Change and Peasant Resistance in the Hima-laya*, Oxford University Press, New Delhi.
- Jana, M.M. (1995). *Environmental Degradation and Developmental Strategies in India*, Ashish Publishing House, New Delhi.
- Kothari, A, N Singh and S Suri (1996): ‘*People and Protected Areas: Towards Participatory Conservation in India*’, Sage, New Delhi.
- Puri, G.S., (1960). *Indian Forest Ecology*. Oxford Book & Stationery co. New Delhi.
- Saxena, K.G., Rao, K.S., Sen, K.K., Maikhuri, R.K. and Semwal, R.L., (2001). Integrated Natural Resource Management: Approaches and Lessons from the Himalaya. *Conservation Ecology* 5, 14 [URL: [http:// www.consecol.org/ vol15/ iss2/art14](http://www.consecol.org/vol15/iss2/art14)].
- Steffen, W., Jager, J., Carson, D.J. and Bradshaw, C. (eds.), (2002). *Challenges of a Changing Earth*. Springer, Berlin.
- Shiva, V. (1996). Case study of Western Himalaya. In: Gujral, GS and Sharma, VS (Eds), *Changing Perspectives of Biodiversity Status in The Himalaya*, British Council Division, British High Commission, New Delhi, India, pp. 186.
- TERI (1992). Energy, environment and sustainable development in the Himalayas. Proceedings of the National Workshop on Energy and environmental issues in Mountain development, held on 24-25 September 1991 in Shimla, India.

2.12 CHECK YOUR PROGRESS – POSSIBLE ANSWERS

Check Your Progress 1

- 1) What do you mean by Natural Resources Management (NRM)?

Answer: The following definition may be used for natural resources: “the sum total of all physical, chemical, biological and social factors which construct the surroundings of man is referred to as environment and each element of these surroundings constitutes a resource on which man thrives in order to develop a better life”. Any part of our natural environment, such as land, water, air minerals, forest, rangeland, wild life, fish, micro organisms, or even human population – that man can utilize to promote the welfare, may be regarded as a natural resource.

2) Write in brief, what do you understand by environment?

Answer: The environment is everything which surrounds an organism and influences its life in many ways. It includes physical and biological components. The physical components of the environment are soil, water, air, light, and temperature. These are termed as abiotic components. The plants and animals are collectively referred to as biotic components. All these components of the environment work together, interact, and modify the effect of one another.

3) What do you understand by biodiversity?

Answer: Biodiversity is the variation of life forms within a given ecosystem, biome, or for the entire Earth. Biodiversity is often used as a measure of the health of biological systems. Biological diversity or biodiversity can have many interpretations and it is most commonly used to replace the more clearly defined and long established terms, species diversity and species richness. Biologists most often define biodiversity as the “totality of genes, species, and ecosystems of a region”.

Check Your Progress 2

1) What are the important roles of forest in our society?

Answer: A forest is considered as an ecological kingdom, where many animals and the ecosystem live in perfect balance. The green cover produces enough oxygen, and, as well, carbon dioxide, for photosynthesis. The wild animals and other beings get enough protection from the solar heat, temperature, and the leaf cover formed on the earth gives cooling effect to the earth. The rivers and lakes in the forests give enough food and shelter for the animals and also the water for drinking for sustaining life. While the dense forests atmosphere acts as enormous sink for green house gases.

2) Write five major extension approaches which are very much needed for NRM.

- 1) Creation of natural resources like forests, water bodies, etc.
- 2) Conservation of resources in an ecology niche.
- 3) Regeneration of natural resources by organizing self-propelling processes.
- 4) Preservation through social fencing.
- 5) Recycling waste water by products and social fencing for protection, preservation.

3) What are the right approaches to soil conservation?

Answer: The right approaches towards soil conservation are:

- 1) The primary purpose of soil conservation is to prevent soil erosion and heal the damage where it has not advanced too far to respond to curative methods.
- 2) The land should wear a vegetative cover throughout the year.
- 3) Engineering and agronomic practices should be applied conjointly.
- 4) How can you manage surface water resources?

Answer: Surface water resources can be managed in different ways: canal water, run-off water, *khadins*, nadis, tanks, gully, plugging, water harvesting dams, water spreading, percolation tanks, etc.

UNIT 3 SUSTAINABLE DEVELOPMENT

Structure

- 3.1 Introduction
- 3.2 Sustainable Development: Concept and Definition
- 3.3 Components of Sustainable Development
- 3.4 Indicators of Sustainable Development
- 3.5 Measures to Promote Sustainable Development
- 3.6 Sustainable Development Goals
- 3.7 Let Us Sum Up
- 3.8 References and Suggested Readings
- 3.9 Check Your Progress - Possible Answers

3.1 INTRODUCTION

Sustainable development has become a buzzword in different fora, seminars, and workshops. You might have read and heard about this concept. In this unit you will know more about the concept. Sustainable development stands for meeting the needs of present generations without compromising the ability of future generations to meet their own needs – in other words, a better quality of life for everyone, now, and for generations to come. It offers a vision of progress that integrates immediate and longer term objectives, local and global actions, and regards social, economic and environmental issues as inseparable and interdependent components of human progress.

After studying this unit, you should be able to:

- explain the meaning of sustainable development
- describe various components of sustainable development
- discuss various indicators of sustainable development
- suggest measures for the promotion of sustainable development.

3.2 SUSTAINABLE DEVELOPMENT: CONCEPT AND DEFINITION

Sustainable development has become a buzzword in different fora, seminars, workshops. It is found much in environmental and economics literature these days. The concern for sustainable development is becoming increasingly louder with the rapidity of economic growth. Around the globe, throughout history, most modern human institutions have evolved in ways that are at best, oblivious, and, at worst, positively hostile to the health of environment. Economic development, till today, is based on two fallacious premises: (1) it considers needs of mankind alone, and ignores the interdependent ecosystem, and (2) it treats the environment as a commodity. Man strives ceaselessly for riches. He is enslaved and obsessed by technological advancement, and by obtaining higher GNP. This obsession has despoiled the environment and is tending to ruin the carrying capacity (i.e., capacity of the ecosystem to support life) of Mother

Earth. The land is scarred and eroded; the waters of rivers, lakes and oceans are so contaminated with industrial waste, that it is nearly unfit for either industrial use or for human consumption. The air is filled with gaseous and particulate pollutants that are toxic to life. Pesticides used to promote agricultural production and public health has severely poisoned the environment. Each agent of production and consumption regards the disposal cost of waste as zero and uses the environmental sector as long as it permits him to improve his own welfare. He does not have to pay anything to anybody. The environment is still regarded as common property, each agent acting as if he owns it. The reckless use continues, without any heed to the damage inflicted, and causes degraded environmental standards, unhealthy and detrimental to all.

“Our Common Future” marks the beginning of the sustainable development concept that has generated all the literatures. New books on sustainable development have been appearing with increasing rapidity since the United Nations Conference on Environment and Development (the Earth Summit), held in Brazil in 1992. Divergent economic theorists like E. F. Schumacher of Britain, environmentalists like Barry Commoner and Lester R. Brown, population analysts like Paul Ehrlich, politicians like Willy Brandt of Germany and Jimmy Carter of the United States, all played significant roles in formulating ideas. The era of modernization has created an atmosphere of excitement of instant economic growth. In fact, all sectors of developing countries seem to be vibrating with economic buoyancy. There is expansion of trade, investment, market, and increase in Gross National product (GNP), productivity, per capita income, profit, efficiency, salary, etc, across the globe. The free trade system could more tellingly be called the free ride system, because the producers do not have to include in their product costs all the indirect costs they cause society, such as pollution of the land, sea and air, ozone holes, disappearing topsoil, exploding health costs, allergies, global warming, destruction of species, pesticides in food, antibiotic-resistant bacteria, crime, unemployment, escalating social costs, etc. Many of the most common, and most damaging products on the market, would never be manufactured if they were priced at their real costs to society as a whole. The road to success in global business today is to find a way to pass on as many of your costs as possible to the public, preferably to another country’s public. The most profitable companies at this time are those that are most successful at getting someone else to pay the real costs of their doing business. Present economic process maximizes only the profits to the shareholders, while all the other stakeholders are left bearing the costs, for example, cleaning up the environment and dealing with unemployment.

The term, sustainable development, was coined by the Brundtland Commission which defines sustainable development as development that “meets the needs of the present without compromising the ability of future generations to meet their own needs”. Sustainable development is defined as balancing the fulfilment of human needs with the protection of the natural environment so that these needs can be met not only in the present, but in the indefinite future. Sustainable development is a pattern of resource use that aims to meet human needs while preserving the environment. The field of sustainable development is conceptually divided into four general dimensions: social, economic, environmental, and institutional. The first three dimensions address key principles of sustainability, while the final dimension addresses key institutional policy and capacity issues.

There is, now, a worldwide movement of environmentalism parallel to the more enthusiastic global movement of economic growth. Every section of people around the globe now expresses some amount of concern towards the deterioration of environmental standards. The rise in economic welfare is increasingly accompanied by a considerable decline in the quality of environment and loss of ecological stability. Some groups of environmentalist are very pessimistic while the other group of environmental scientists is very optimistic. But the fact remains that there is acid rain, global warming, the greenhouse effect, erosion and sterility of soil, degradation of land, environmental pollution, and ozone layer depletion. There is widespread desertification in one hemisphere and deforestation in another hemisphere of the globe. Deeper and wider concern for environmental degradation springs from two major sources.

- 1) Rise in material production effluents and use of synthetic materials
- 2) Increased demand for environmental goods.

The first refers to the problems of environmental externality and the second, to depletion of natural resources. In addition to the increased supply of economic goods, there is also an increased demand for environmental goods. Environmental goods signify any external environmental conditions that affect human welfare. The following elements are connected with the human welfare

- absence of all types of pollution
- availability of clean water and air
- quality of natural environment (outdoor recreation, etc)
- quantity of natural environment(forest, wildlife)
- Availability of public utility systems
- average space availability for inhabitants

In this session you read about meaning of the concept sustainable development and its need for development. Now answer the questions given in the Check Your Progress 1.

Check Your Progress 1

- Note:** a) Answer the following questions in about 50 words.
- b) Check your answer with possible answers given at the end of the unit.

- 1) What is the need for sustainable development?

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- 2) What do you mean by sustainable development?

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3.3 COMPONENTS OF SUSTAINABLE DEVELOPMENT

In this section you will read about the various components of sustainable development. The three main components of sustainable development discussed here are

- i) interconnectedness of the system
- ii) sustainable development path
- iii) intergenerational approach.

i) Interconnectedness of the System

Traditionally we use numbers to show progress: “Employment rose 0.8 percent in January”, or, “The economy grew by 2% last year”, “Air pollution has declined by 0.2 per cent”, “Dowry death has increased by 1.3%”, etc. However, the traditional numbers only show changes in one part of the community without showing the various links between the community’s economy, society, and environment. It is as if a community was made of three separate parts: (i) an economic part, (ii) a social part, and (iii) an environmental part. In this view, the parts do not overlap like the picture below (figure-1)

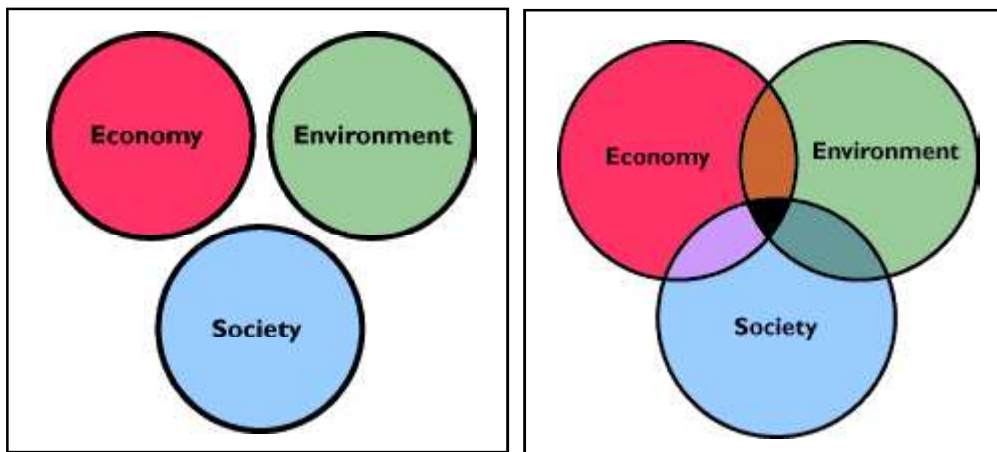


Figure.1: Interconnectedness of the three systems

However, when society, economy, and environment are viewed as separate, unrelated parts of a community, the community’s problems are also viewed as isolated issues. This piecemeal approach has a number of negative side effects. Sustainable development depends on the links between the economy, the environment and the society. Figure-1, above, is frequently used to show the interconnectedness of three systems. Understanding the three parts and their links is the key to understanding sustainability, because sustainability is about more than just quality of life. It is about understanding the connections and achieving balance among the social, economic, and environmental pieces of a community.

Sustainable development is a dynamic concept, as a wide array of views fall under its umbrella. There may be as many definitions of sustainability and sustainable development. All the definitions have to do with

- living within the limits
- understanding the interconnections among economy, society, and environment
- equitable distribution of resources and opportunities.

Sustainable development involves the simultaneous pursuit of economic prosperity, environmental quality and social equity. “Sustainable community development is the ability to make development choices which respect the relationship between the three E’s, i.e.-economy, ecology, and equity.

- o **Economy** - economic activity should serve the common good, be self-renewing, and build local assets and self-reliance.
- o **Ecology** - humans are part of nature, nature has limits, and communities are responsible for protecting and building natural assets.
- o **Equity** - the opportunity for full participation in all activities, access, benefits and decision-making of a society.

Figure-2 illustrates all three dimensions of sustainable development. Sustainable development cannot ignore any of the three. If we ignore the social dimension, the development process may be viable, if we ignore the environmental dimension, development process may be equitable and if we ignore the environmental dimension, the development process may be bearable, but not sustainable.

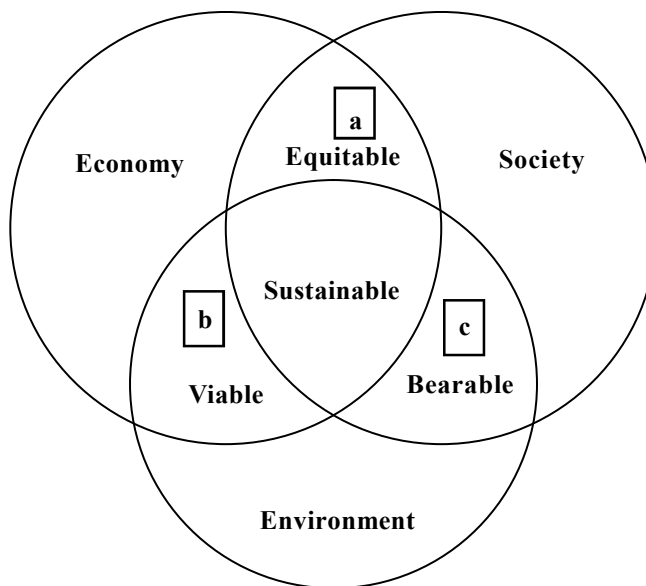


Figure. 2: Sustainable Development

In other words, the search for equity (a) neglects environmental aspects and the search for viability; (b) neglects social dimension and the search for bear ability; (c) ignores economic efficiency. Thus, a sustainable development process is that trajectory which is a synergy of efficiency, equity, and social acceptability. Sustainable development shows a compassionate concern for the posterity and for the world as a whole. It contends that social development, environmental soundness, and economic growth are not contradictory or incompatible. Healthy environment and good society are, rather, prerequisites for sustainable development. Sustainable development is based on a broader economic system which fulfils inter-generational equity criteria. Its objectives are focused on the future, not the

ii) The Path of Sustainable Development

Sustainability implies irreversibility in the process of development. It necessitates the maintenance of the level of wellbeing so that it improves, and, at the least, never allows a decline over time. Thus, sustainable development has three interdependent and mutually reinforcing pillars: (i) economic development, (ii) social development, and (iii) environmental protection. It does not focus solely on environmental issues. We should differentiate between green development and sustainable development. The proponents of green development prioritize environmental sustainability over economic and cultural considerations. But cultural diversity is as necessary for humankind as biodiversity is for nature. It is one of the roots of development understood not simply in terms of economic growth but also as a means to achieve a satisfactory social, intellectual, emotional, moral and spiritual existence. In this sense, cultural diversity is the fourth policy area of sustainable development. Developing countries are not only rich in biodiversity but also in cultural diversity. In Figure.3 illustrates the path of sustainable development. It shows that Path N is non-sustainable and non-survivable. Development path E is efficient but non-sustainable. But path S is sustainable. Path E looks more attractive, but Path S is not impressive in the early stage. Path E has a maximum point after which it curls down. But Path-S is slow and steady, having no maximum survival limit.

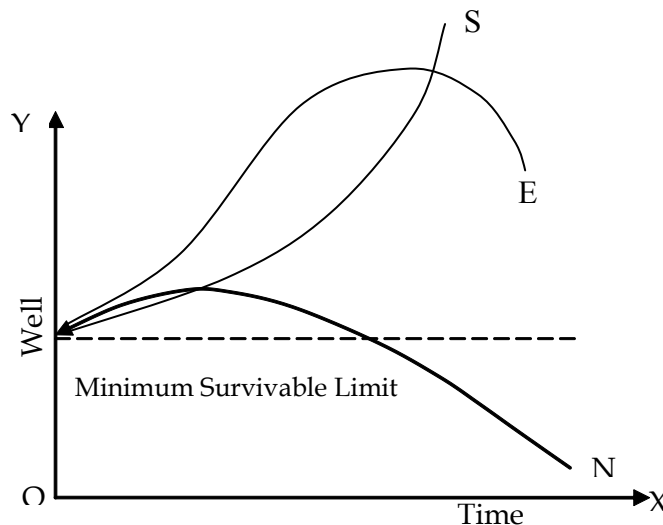


Figure 3: Sustainable Development Path

Source: Das (2009) *Sustainable Development Path*

Sustainability is related to the quality of life in a community - whether the economic, social, and environmental systems that make up the community are providing a healthy, productive, meaningful life for all community residents, present and future. It involves following three questions -

- i) How has your community changed, economically?
- ii) How has your community changed, socially?
- iii) How has your community changed, environmentally?

Thus, the field of sustainable development can be conceptually broken into three constituent parts: environmental sustainability, economic sustainability, and socio-political sustainability. Sustainable development integrates the imperatives of developmental and environmentalism. It highlights the long term doomsday scenario and puts emphasis on economic, social, and ecological integration. It has three objectives.

- i) Economic efficiency
- ii) Social acceptability
- iii) Ecological sustainability.

Sustainability is an issue for all communities, from small rural villages that are losing their natural environment, upon which their livelihoods depend, to large metropolitan areas where crime and poverty are decreasing the quality of life. Sustainability does not mean static equilibrium where nothing ever changes. Nor does it mean a utopia where nothing bad ever happens. Sustainability is not about maintaining the *status quo* or reaching perfection. It is not a community where nothing ever goes wrong. Sustainability does not mean that businesses never fail, or that people never go hungry, or that pollution never happens. A sustainable development process seeks to maintain and improve the economic, environmental, and social characteristics of an area so that its members can continue to lead healthy, productive, enjoyable lives at present and in future. Sustainability implies that when problems arise, we look for solutions that take into account all three dimensions of the community instead of applying a quick fix in one area that causes problems in another. It is not anti growth nor does it imply unlimited growth. Rather, at some point, a sustainable community stops getting larger but continues to change and improve, to develop in ways that enhance the quality of life for all its inhabitants.

iii) Intergenerational Approach

Sustainable development improves the economy without undermining the social or environmental imperatives. Sustainable development focuses on improving our lives without continually increasing the amount of energy and material goods that we consume. A sustainable community does not consume resources energy and raw materials faster than the regenerative capacity of the natural systems. We are currently living unsustainable lives. If we are not careful how we use and dispose of resources, our children, grandchildren and great-grandchildren will have a poorer, more polluted world to live in. A sustainable community interacts with four types of capital: natural, human, social, and built capital. All four types of capital need to be cared for. A sustainable community wisely manages all its capital - using and improving the social, natural and built capital in ways that allow that capital to continue to support that community in the future. Sustainability requires that human activity only uses nature's resources at a rate at which they can be replenished naturally. An unsustainable situation occurs when natural capital (the sum total of nature's resources) is used up faster than it can be replenished.

Inherently, the concept of sustainable development is intertwined with the concept of carrying capacity. In fact natural capital, social capital, and economic capital are often complementary. Carrying capacity is the size of

the population that can be supported indefinitely upon the available resources and services of supporting natural, social, human, and built capital. Living within the limits of an ecosystem depends on three factors:

- i) the amount of resources available in the ecosystem
- ii) the size of the population, and
- iii) the amount of resources each individual consumes.

Thus, there is urgent need to develop an ecosystem approach, or inter generational approach for the management of natural capital and social capital. Ultimately, an ecosystem approach tends to evolve and change from a consumptive economy to an economy oriented towards conservation, maintenance of capital stock, and recycling of materials. Impoverishment of an ecosystem means the impoverishment of the entire society that depends upon it. Thus, an ecosystem approach is a compassionate concern for posterity and for the planet as a whole. Mere economic growth is not enough to bring welfare to mankind. Man is an organic being, whose total development depends, to a large extent, on the non-economic, sociological, psychological factors, and, on a meaningful sustainable balance between him and the environment (social and natural) in which he lives.

There are many contradictions and inconsistencies in the goal of sustainable development. It poses a great dilemma and a great challenge. Confronting the challenge is very costly, but not facing the challenge is really disastrous for the whole society. Therefore, the idea of sustainable development should be less idealistic and more practical. We do not have to choose between an environmentally healthy and economically robust nation. Both are compatible. We can have both. We are intelligent enough have the ability to develop enough new technologies and can change our behaviour enough to confront all the problems facing us, and to create optimal solutions.

In this session you read about various components of sustainable development. Now answer the questions given in the Check Your Progress 2.

Check Your Progress 2

Note: a) Answer the following questions in about 50 words.

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

- 1) Interconnectedness is important for sustainable development-Explain.

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- 2) What do you mean by ‘sustainable development path’?

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3.4 INDICATORS OF SUSTAINABLE DEVELOPMENT

Indicators of sustainable development are more in the nature of indices that reflect the state of overall concepts or social goals such as human development, sustainable development, the quality of life, or socioeconomic welfare. Indicators provide early warnings about non sustainable trends of economic activity and environmental deterioration. They are the ‘nutshell’ indicators favoured by policy makers. Sustainable development indicators proliferated in the wake of the Rio Earth Summit’s call for indicators of sustainable development (United Nations 1994, Agenda 21). Let us discuss a few selected indices of sustainable development.

Important indicators of sustainable development are:

- i) Gross Sustainable Development Product
- ii) Environmental Kuznets Curve
- iii) Social Indicators for Sustainable Development

3.4.1 Gross Sustainable Development Product

Among different aggregation methods, green accounting is a common physical or monetary averaging. It is most commonly applied. The concept of Green GDP has been modified as Gross Sustainable Development Product (GSDP), which is defined as the total value of production after giving due care to social capital and natural capital of a region over a specified period of time. It is designed to replace the Gross Development Product (GDP) as the primary indicator of the economic performance of a nation. It takes into account:

- the economic impact/costs of environmental degradation
- impacts of changes in quality systems on national income and wealth
- global concerns and their impacts on the economy and ecology and society
- the welfare, economic development, and quality of life of future generations
- expenditures on pollution abatement and clean-ups
- the status of each resource and the stocks and productive capacities
- the depreciation or appreciation of natural assets
- the ecological processes and biological diversity
- the costs of economic growth, resources uses of present and future generations.

The measurement of GSDP shows that consumption levels can be maintained without depleting and depreciating the quality and quantity of services for the present and future. It indicates the solutions to the problems as well as the directions to take, such as:

- invest in technology, R and D
- increase productivity and end-use efficiency
- modify social services, educational programs
- slow down or increase economic growth

- remediate components of major quality systems; and
- rectify present shortcomings of income and wealth accounts.

The measurement of GSDP also gives a proper and sound signal to the public, government and industry about the rate and direction of economic growth. It identifies environmental, health, and social quality; it identifies sustainable and unsustainable levels of resource and environmental uses; it measures the success or failure of sustainable development policies and practices; and it identifies resource scarcity. The primary goal of a sustainable local community is to meet its basic resource needs in ways that can be continued in the future.

3.4.2 Environmental Kuznets Curve

Some forms of pollution appear first to worsen and later to improve as countries' incomes grow. The world's poorest and richest countries have relatively clean environments, while middle-income countries are the most polluted. Because of its resemblance to the pattern of inequality and income described by Simon Kuznets (1955), this pattern of pollution and income has been labelled an 'Environmental Kuznets Curve' (EKC). Grossman and Krueger (1995) and the World Bank (1992) first popularized this idea, using a simple empirical approach. They regress data on ambient air and water quality in cities worldwide on a polynomial in GDP per capita and other city and country characteristics. They then plot the fitted values of pollution levels as a function of GDP per capita, and demonstrate that many of the plots appear inverse U-shaped, first rising and then falling. The peaks of these predicted pollution-income paths vary across pollutants, but 'in most cases they come before a country reaches a per capita income of \$8000' in 1985 dollars (Grossman and Krueger, 1995, p. 353). In simple terminology, the EKC shows the relationship between the environmental degradation and the per capita income. The proponents of EKC are of the opinion that in the early stages of economic growth, degradation and pollution increase, but beyond some level of per capita income, the trend reverses, so that at high-income levels, economic growth leads to environmental improvement. This implies the environmental impact indicator is an inverted U shaped function of per capita income.

In the years since these original observations were made, researchers have examined a wide variety of pollutants for evidence of the EKC pattern, including automotive lead emissions, deforestation, greenhouse gas emissions, toxic waste, and indoor air pollution. Some investigators have experimented with different econometric approaches, including higher-order polynomials, fixed and random effects, splines, semi- and non-parametric techniques, and different patterns of interactions and exponents. Others have studied different groups of jurisdictions and different time periods, and have added control variables, including measures of corruption, democratic freedoms, international trade openness, and even income inequality (bringing the subject full circle back to Kuznets's original idea). Some generalizations across these approaches emerge. Roughly speaking, pollution involving local externalities begins improving at the lowest income levels. Fecal coliform in water and indoor household air pollution are examples. For some of these local externalities, pollution appears to decrease steadily with economic growth, and we observe no turning point at all. This is not a rejection of the EKC; pollution must have increased at some point in order to decline with income eventually, and there simply is no data from the earlier period. By contrast, pollutants involving much-dispersed externalities tend to

have their turning points at the highest incomes or even no turning points at all, as pollution appears to increase steadily with income. Carbon emissions provide one such example. This, too, is not necessarily a rejection of the EKC; the turning points for these pollutants may come at levels of per capita income higher than in today's wealthiest economies.

Another general empirical result is that the turning points for individual pollutants differ across countries. This difference shows up as instability in empirical approaches that estimate one fixed turning point for any given pollutant. Countries that are the first to deal with a pollutant do so at higher income levels than following countries, perhaps because the following countries benefit from the science and engineering lessons of the early movers. Most researchers have been careful to avoid interpreting these reduced-form empirical correlations structurally, and to recognize that economic growth does not automatically cause environmental improvements. All the studies omit country characteristics correlated with income and pollution levels, the most important being environmental regulatory stringency. The EKC pattern does not provide evidence of market failures or efficient policies in rich or poor countries. Rather, there are multiple underlying mechanisms, some of which have begun to be modelled theoretically. An example of EKC of sulphur emission is given below in Figure.1.

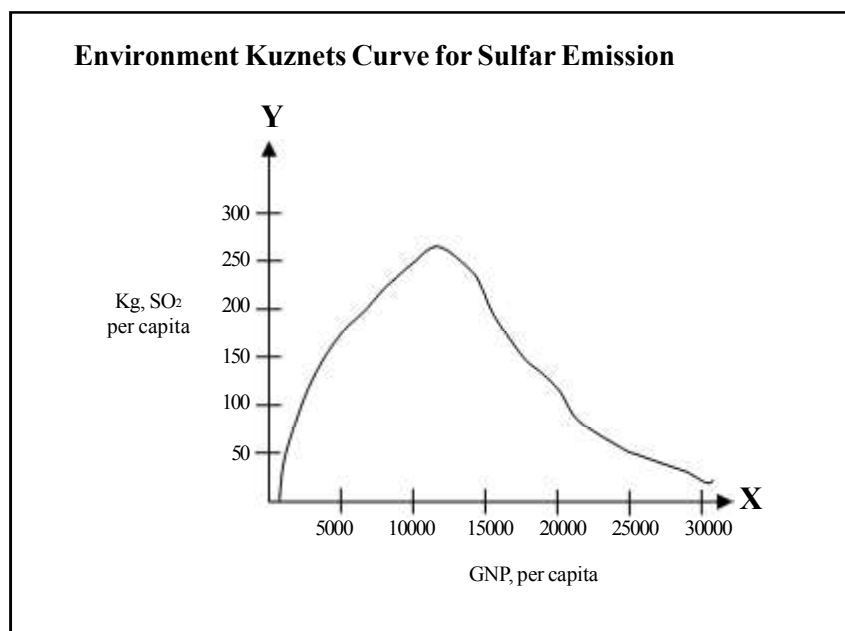


Figure 4

Source: <http://www.ecoeco.org/pdf/stern.pdf>

3.4.3 Social Indicators of Sustainable Development

The social indicators of sustainable development as framed by the United Nations Commission on Sustainable Development (CSD) in 1995 are broadly categorized as:

- i) poverty
- ii) governance
- iii) health
- iv) education

- i) Poverty:** Poverty is considered as one of the key indicators of sustainable development. Nations with a high percentage of people living the poverty line can not sustain their level of development. The sub themes as well as the core and other indicators to be covered in the area of poverty are given in Table 1.

Table 1: Poverty Indicators for Sustainable Development

Sub Themes	Core Indicators	Other Indicators
Income Poverty	Proportion of population living below poverty line	Proportion of population below \$1 a day
Income Inequality	Ratio of share in national income o highest to lowest quintile	—
Sanitation	Proportion of population using an improved sanitation	—
Drinking Water	Proportion of population using an improved water sources	—
Access to Energy	Share of household without electricity or other modern energy services	—
Living Conditions	Proportion of urban population living in slums	Percentage of population using solid fuel for cooking

Source: *Indicators of Sustainable Development: Guidelines and Methodologies*, United Nations, New York, 2007

- ii) Governance:** Governance is the second key indicator of sustainable development. Good governance is an essential element of sustainable development. The sub themes of the governance in sustainable development are corruption and crime. The indicators are given in Table 2.

Table 2: Governance Indicators for Sustainable Development

Sub Themes	Core Indicators	Other Indicators
Corruption	Percentage of population having paid bribe	—
Income Inequality	Number of international homicides per 1,00,00 population	—

Source: *Indicators of Sustainable Development: Guidelines and Methodologies*, United Nations, New York, 2007

- iii) Health:** The key indicators of sustainable health care are mortality, health care delivery, nutritional status and health status and risks. The core areas of these health care themes are delineated in Table 3.

Table 3: Health Indicators for Sustainable Development

Sub Themes	Core Indicators	Other Indicators
Mortality	Under Five Mortality Life Expectancy at Birth	Proportion of population below \$1 a day
Health Care Delivery	Percentage of population with access to primary health care facilities Immunization against child hood diseases	Contraceptive prevalence rate
Nutritional Status	Nutritional status of children	—
Health Status and Risks	Morbidity of major diseases such as HIV/AIDS, malaria, tuberculosis	Prevalence of tobacco use Suicide rate

Source: *Indicators of Sustainable Development: Guidelines and Methodologies*, United Nations, New York, 2007

- iv) **Education:** As far as education is concerned, sustainable education includes educational levels and literacy. The core indicators of education are given in Table 4.

Table 4: Education Indicators for Sustainable Development

Sub Themes	Core Indicators	Other Indicators
Educational Level	Gross intake ratio to last grade of primary education	
	Net enrolment rate in primary education	
	Adult secondary (tertiary) schooling attainment level	—
literacy	Adult literacy rate	—

Source: *Indicators of Sustainable Development: Guidelines and Methodologies*, United Nations, New York, 2007

- v) **Demography:** The two vital demographic indicators of sustainable development are population growth and the dependency ratio. The indicators of demographic themes for sustainable development are given in Table – 5. The high fertility rates and higher dependency ratios retard development. Therefore, sustainable development goals become difficult to attain.

Table 5: Demographic Indicators for Sustainable Development

Sub Themes	Core Indicators	Other Indicators
Population growth rate	Total Fertility Rate main tourist regions and destinations	Ratio local residents to tourists in
Dependency ratio	Dependency ratio	—

Source: *Indicators of Sustainable Development: Guidelines and Methodologies*, United Nations, New York, 2007

In this session you read about various indicators of sustainable development. Now answer the questions given in the Check Your Progress 3.

Note: a) Answer the following questions in about 50 words.

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

1) What do you mean by Gross Sustainable Development Product?

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2) What is the Environmental Kuznets Curve?

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3.5 MEASURES TO PROMOTE SUSTAINABLE DEVELOPMENT

Sustainable development is an important development agenda of the 21st century and is one of the vital paradigm shifts in development. Countries have to take appropriate measures for the promotion of sustainable development. Therefore, the United Nations has emphasized its institutional framework for sustainable development. In its institutional framework for sustainable development, it has mentioned that for the attainment of sustainable development, good governance, sound economic policies, social democratic institutions responsible to the needs of the people, and improved infrastructure are the basis for sustained economic growth, poverty eradication, and employment generation.

Some suggested measures for the promotion of sustainable development follow.

- 1) The conservation of land, water and energy resources is fundamental for the promotion of sustainable development. Appropriate action has to be taken for the conservation of scanty resources. Conservation of resources by the present generation will provide future generation with widest range of possibilities.
- 2) The development of technologies and approaches which will minimize the environmental damages. Such development requires scientific knowledge and continuous investment.
- 3) Political and public support is critical to implement environmental targets.
- 4) Increasing the scope of public participation in environmental issues and, in particular, in planning processes.

- 5) Some countries have initiated good practices which are concomitant with the promotion of sustainable development:
 - a) in Brazil, the bio-fuels programme has saved the country \$100 billion in external debt-a fact that makes such fuels attractive in many countries
 - b) in China, the promotion of vehicles that are more efficient.
 - c) in South Africa, the implementation of carbon capture and storage technology brings benefits in terms of technology transfer.

The United Nations has strengthened and integrated the three dimensions of sustainable development policies and programmes, and to promote the full integration of sustainable development objective with social development issues.

3.6 SUSTAINABLE DEVELOPMENT GOALS

The United Nations is serious about the sustainable development issues and challenges facing different countries. On 25th of September, 193 countries of the United Nations General Assembly adopted the 2030 Development Agenda named as Transforming Our World: The 2030 Agenda for Sustainable Development. The 17 identified Sustainable Development Goals associated with 169 targets and 304 proposed indicators are as follows:

- 1) End poverty in all its forms everywhere.
- 2) End hunger, achieve food security and improved nutrition and promote sustainable agriculture.
- 3) Ensure healthy lives and promote well-being for all at all ages.
- 4) Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.
- 5) Achieve gender equality and empower all women and girls.
- 6) Ensure availability and sustainable management of water and sanitation for all.
- 7) Ensure access to affordable, reliable, sustainable and modern energy for all.
- 8) Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.
- 9) Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.
- 10) Reduce inequality within and among countries.
- 11) Make cities and human settlements inclusive, safe, resilient and sustainable.
- 12) Ensure sustainable consumption and production patterns.
- 13) Take urgent action to combat climate change and its impacts.
- 14) Conserve and sustainably use the oceans, seas and marine resources for sustainable development.

- 15) Protect, restore, and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification and halt and reverse land degradation and halt biodiversity loss.
- 16) Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.
- 17) Strengthen the means of implementation and revitalize the global partnership for sustainable development.

The developing countries have largely discounted the future value of natural resources, ecology and environment at the cost of their lust for achieving higher economic growth rate. India with a score 58.1 ranks 116th out of the 157 nations in the Sustainable Development Goals Index-2017, behind countries such as Nepal(105th), Bhutan(83th) and China(71st). Pakistan ranked 126 (Table 6).

Table 6: Sustainable Development Goals Index, 2017

Countries	Score	Rank
Sweden	85.6	1
Denmark	84.2	2
Finland	84	3
Norway	83.9	4
Czech Republic	81.9	5
Germany	81.7	6
Austria	81.4	7
Switzerland	81.2	8
Slovenia	80.5	9
India	58.1	10

Source: <http://sdgindex.org/assets/files/2017/2017-SDG-Index-and-Dashboards-Report—full.pdf> (accessed on 11/3/2018)

In this session you read about various measures to be taken to promote sustainable development. Now answer the questions given in the Check Your Progress 4.

Check Your Progress 4

Note: a) Answer the following questions in about 50 words.

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

- 1) What are the important measures for the promotion of Sustainable Development?

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2) Write a few good practices for sustainable development?

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3.7 LET US SUM UP

In this unit, we dealt with the definition of economic growth and characteristics of economic development. We discussed the merits and demerits of different measures of economic development. We dealt with the definition and components of sustainable development. We analyzed sustainable development path, sustainable community ecosystem approach. We analyzed different indicators of sustainable development: Green Economic GDP, Gross Sustainable Development Product, Genuine Progress Indicator and Global Living Planet Index. Finally, we discussed the role of indigenous knowledge in sustainable development.

3.8 REFERENCES AND SUGGESTED READINGS

Pearce, P.W. and Atkinson, G. (1992): *Measuring Sustainable Development*, CRERGE University College of London.

Grossman, G. and Krueger, A. (1995): "Economic growth and the environment", *Quarterly Journal of Economics*, 110, pp 353–77.

Kuznets, S. (1955): "Economic growth and income inequality", *American Economic Review* 45, pp 1–28.

Vandana, Shiva (2000): *Stolen Harvest*, South End Press, pp 61–62

Tobla, M.K. (1984): *Sustainable Development*, Butterworth, London.

Panchauri, R.K. (1977): *Energy and Economic Development in India*, Prager Publisher, New York.

Brown, L.R. (1981): *Building a Sustainable Society*, W.W. Norton, New York.

Kothari, R. (1982): *Environment and Development in Asia and the Pacific: Experiences and Prospects*, UNEP.

Meadows, D.H., et. al. (1972): *The Limits to Growth*, Signet, New York.

<http://www.wri.org/project/sd-pams>

http://www.un.org/esa/sustdev/documents/WSSD_POI_PD/English/POIchapter11.htm

<http://www.ecoeco.org/pdf/stern.pdf>

3.9 CHECK YOUR PROGRESS - POSSIBLE ANSWER

Check Your Progress 1

- 1) What is the need for sustainable development?

Answer: The need for sustainable development arises for two important reasons. Those are: (i) the current system of development considers development of mankind alone and ignores the interdependent ecosystem; and (ii) it treats environment as a commodity.

- 2) What do you mean by sustainable development?

Answer: According to the Brandt and Commission “Sustainable development” is that which “meets the needs of the present without compromising the ability of future generations to meet their own needs.” It has three components: a) Economy - economic activity should serve the common good, be self-renewing, and build local assets and self-reliance. b) Ecology - humans are part of nature, nature has limits, and communities are responsible for protecting and building natural assets. c) Equity - the opportunity for full participation in all activities, access, benefits, and decision-making of a society. It has three objectives: i. Economic efficiency, ii. Social acceptability, and iii. Ecological sustainability

Check Your Progress 2

- 1) What do you mean by Gross Sustainable Development Product?

Answer: The Gross Sustainable Development Product is the total value of production after giving due care to the social capital and natural capital of a region over a specified period of time.

- 2) What is the Environmental Kuznets Curve?

Answer: In simple terminology, the EKV shows the relationship between the environmental degradation and the per capita income. The proponents of EKV are of the opinion that in the early stages of economic growth, degradation and pollution increases, but beyond some level of per capita income, the trend reverses, so that at high income levels, economic growth leads to environmental improvement. This implies the environmental impact indicator is an inverted U shaped function of per capita income.

Check Your Progress 3

- 1) What are the important measures for the promotion of sustainable development?

Answer: The conservation of land, water and energy resources is fundamental to promotion of sustainable development. Appropriate action has to be taken for the conservation of scanty resources. Development of technologies, which would minimize the environmental damages, such development requires scientific knowledge and continuous investment. Increasing

awareness of the public and policy makers on environmental quality and natural resources issues is critical to sustainable development.

2) Write a few good practices for sustainable development.

Answer: Some countries have initiated good practices which are concomitant with the promotion of sustainable development:

- a) In Brazil, the bio-fuels programme has saved the country \$100 billion in external debt-a fact that makes such fuels attractive in many countries.
- b) In China, the promotion of vehicles that are more efficient and have similar “footprints” has the potential to address both energy security concerns and infrastructure constraints in a fast growing economy.
- c) In South Africa, the implementation of carbon capture and storage technology brings benefits in terms of technology transfer.

UNIT 4 CLIMATE CHANGE

Structure

- 4.1 Introduction
- 4.2 Climate Change: Concept and Definitions
- 4.3 Sources of Climate Change
- 4.4 Consequences and Impact of Climate Change
- 4.5 Climate Change and Sustainable Development
- 4.6 Measures to Overcome the Effect of Climate Change
- 4.7 Climate Change Debates
- 4.8 National Action Plan on Climate Change
- 4.9 Let Us Sum Up
- 4.10 References and Suggested Readings
- 4.11 Check Your Progress Possible Answers

4.1 INTRODUCTION

We experience or get information about intense storms, frequent floods, severe drought, melting glaciers etc. For several years, climate change was considered as sceptic's argument. But, today it has been accepted as a reality. This was possible due to the significant contribution made by various scientists engaged in climate science research particularly contribution by the French mathematician, Joseph Fourier highlighting the problem popularly known as greenhouse effect; the British scientist John Tyndall in terms of measuring the absorption of radiation by different gases; and the Swedish scientist, Svante Arrhenius who calculated the effects to our global temperature if we burnt enough fossil fuels to double the amount of carbon dioxide in the atmosphere. Presently, studying climate system is much more advanced due to the advancement in information and communication technology aided by space technology.

In this unit, we shall define climate change also explain natural as well as anthropogenic factors responsible for climate change. We will also discuss about the probable consequences and impacts of climate change both at global as well as at national level. The unit also critically analyse the adverse impacts of climate change on sustainable development. The next section i.e. 4.7 briefly discuss about the mitigation and adaptation strategies to minimise the effect of climate change. Finally, we will also discuss about climate change debates specifically about Kyoto Protocol, the failure of Copenhagen Summit and India's Action Plan on Climate Change

After reading this unit you will be able to:

- Define climate change;
- explain natural and human induced factors responsible for climate change;
- Describe various evidences of climate change;
- describe the adverse impact of human activities on climate change; and
- analyse the probable consequences and impact of climate change at global as well as national level.

- suggest some mitigation and adaptation measures to overcome the effects of climate change.
- highlight major climate change related debates that are taking place at International level and National Action plan on climate change implemented in India.

4.2 CLIMATE CHANGE: CONCEPT AND DEFINITION

In simpler terms, climate change may be expressed as any substantial change in the Earth's climate that lasts for an extended period of time. Normally, minimum thirty years' time period are being considered for analysing or predicting any climatic condition of a place. Two major elements of climate are temperature and precipitation. According to the Inter-Governmental Panel on Climate Change (IPCC), climate change refers to

“any change in climate over time, whether due to natural variability or as a result of human activity” (IPCC, 2001a).

The United Nations Framework Convention on Climate Change (UNFCCC) in Article 1 defined it as:

“climate change refers to a change in climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time period” (IPCC, 2001a).

4.3 SOURCES OF CLIMATE CHANGE

Do you know climate change had happened many a times on the Earth's history since its origin? Then, you must be thinking that why we are making so much hue and cry about this. This is because climate change in today's context is anthropogenic or in simpler term created by human activities. Evidences suggest that earlier climate change occurred due to natural processes. Various natural sources responsible for climate change during different geological periods of earth's history were solar variability, change in earth's orbit and tilt, plate tectonic and biological evolution. In this section, we will discuss in details climate change due to anthropogenic activities that have been taking place in recent times.

4.3.1 Climate Change due to Anthropogenic Activities

As mentioned in the beginning of the unit, today's climate change is primarily due to anthropogenic activities. But, do you know how we have arrived on such conclusion? There was lots of scientific research that took place over the last two hundred years that helped in concluding about the present climate change is due to anthropogenic activities. Let us discuss these scientific developments in brief.

Scientific Study to Establish Human Induced Climate Change: As we know, today's climate change is due to presence of excessive greenhouse gases in the atmosphere due to human activities. This led to increase in temperature on the earth surface due to greenhouse effect. Do you know the scientist who identified

the problem created by greenhouse effect? The French mathematician, Joseph Fourier highlighted the greenhouse effect. Fourier realized that the earth's temperature is determined not only by the radiation absorbed by, and emitted from the earth, but also by the existence of the atmosphere. The atmosphere absorbs some of the radiated heat and acts as a blanket over the Earth that maintains the temperature higher than it would otherwise be.

The next major breakthrough was made in 1860 by the British scientist John Tyndall in terms of measuring the absorption of radiation by different gases. This led to the remarkable discovery that the most prevalent gases in the atmosphere i.e. oxygen and nitrogen weren't absorbing any of the energy at all. Only the minor gases in the atmosphere, i.e., carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O) and water vapour, were doing so. These gases are called greenhouse gases (GHG).

The Swedish scientist, Svante Arrhenius was the first person to estimate the extent to which increases in atmospheric carbon dioxide increase Earth's surface temperature. This is also known as Arrhenius effect. Presently, studying climate system is much more advanced due to the advancement in information and communication technology aided by space technology.

Global Warming and Anthropogenic Activities: Till now, you might have realised that global warming is most commonly associated with human interference, specifically the release of excessive amounts of greenhouse gases. These gases, act like a greenhouse around the earth. This means that these gases allow the heat from the Sun to enter into the atmosphere, but do not allow the heat to escape back into space. In other words, more increase in the greenhouse gases, the larger is the percentage of heat trapped inside the earth's atmosphere. You might be knowing that the earth would have not been inhabitable without the presence of some naturally occurring greenhouse gases (GHG). This is because without these gases, no heat would be trapped in the atmosphere, so the earth would be extremely cold. It is estimated that the average temperature of the earth would be about -17°C without greenhouse effect which is not at all the condition for the growth of biota. Naturally occurring greenhouse gases (not fluorinated gases) are good in naturally occurring amounts; it's when people start contributing excessive amounts of these that greenhouse gases become a problem. With excessive greenhouse gas build-up, the earth's atmosphere warms to unnatural temperatures.

Let us understand how various human activities contribute in increasing these GHGs.

4.3.2 How do Human Activities Contribute to Climate Change?

Different anthropogenic activities lead to emissions of four principal greenhouse gases: carbon dioxide, methane, nitrous oxide and the halocarbons (a group of gases containing fluorine, chlorine and bromine). These gases accumulate in the atmosphere and have been increasing with the passage of time. The most significant aspect about the increases in all of these gases is that they have occurred in the industrial era which is not more than 300 years old. This is because of influence of human activities particularly in recent centuries. It is so significant that it has been affecting all the living organisms on the earth.

Carbon dioxide has been increasing from the utilization of fossil fuels in transportation, building heating/ cooling and in the manufacture of cement and other goods. Deforestation releases CO₂ and reduces its uptake by plants. Carbon dioxide is also released in natural processes such as the decay of plant matter.

Methane has increased as a result of human activities related to agriculture, natural gas distribution and landfills. Methane is also released from natural processes that occur, for example, in wetlands.

Nitrous oxide is emitted by human activities such as fertilizer use and fossil fuel burning. Natural processes in soils and the oceans also release N₂O.

Halocarbon gas concentrations have increased primarily due to human activities. Principal halocarbons include the chlorofluorocarbons (e.g., CFC-11 and CFC-12), which were used extensively as refrigeration agents and in other industrial processes before their presence in the atmosphere was found to cause stratospheric ozone depletion.

We will discuss in detail about these gases and their major sources in the next module which exclusively discuss about role human being on climate change.

4.4 CONSEQUENCES AND IMPACT OF CLIMATE CHANGE

These above mentioned change have differential impacts in terms of geographical locations, sectors of economy and socio-economic groups. Therefore, some of the major impacts/ consequences of climate change are mentioned for two levels. One is at macro scale i.e. at global level and the other at micro-level i.e. at national level.

Some of the major observations of Fifth Assessment Report (2013) by IPCC are given below:

4.4.1 Observations of Changes in Climate at Global Level

Some of the highlights of the 5th Assessment Report are as follows:

- Each of the last three decades has been successively warmer at the earth's surface than any preceding decade since 1850.
- Ocean warming dominates the increase in energy stored in the climate system, accounting for more than 90% of the energy accumulated between 1971 and 2010. Further uptake of carbon by the ocean will increase ocean acidification.
- Over the last two decades, the Greenland and Antarctic ice sheets have been losing mass, glaciers have continued to shrink almost worldwide, and arctic sea ice and northern Hemisphere spring snow cover have continued to decrease in extent.
- The rate of sea-level rise since the mid-nineteenth century has been larger than the mean rate during the previous two millennia. Over the period 1901–2010, global mean sea level rose by 0.19 m (0.6 ft).
- The atmospheric concentrations of carbon dioxide (CO₂), methane, and nitrous oxide have increased to levels unprecedented in at least the last

800,000 years, primarily from fossil-fuel emissions and secondarily from net land-use-change emissions. The ocean has absorbed about 30% of the emitted anthropogenic carbon dioxide, causing ocean acidification.

- Total radiative forcing is positive and has led to an uptake of energy by the climate system. The largest contribution to total radiative forcing is caused by the increase in the atmospheric concentration of CO₂ since 1750.
- Warming of the climate system is unequivocal. Many of the temperature changes observed since the 1950s are unprecedented over decades to millennia. It is extremely likely (95%–99%) that human influence has been the dominant cause of the observed warming since the mid-twentieth century.
- Climate models have improved since the Fourth Assessment Report. Models reproduce observed continental-scale surface temperature patterns and trends over many decades, including the more rapid warming since the mid-twentieth century and the cooling immediately following large volcanic eruptions.
- Continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system. Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions.
- Changes in the global water cycle will not be uniform. The contrast in precipitation between wet and dry regions and between wet and dry seasons will increase.
- Global mean sea level will continue to rise. The rate of sea-level rise will very likely exceed that observed during 1971–2010, due to increased ocean warming and increased loss of ice mass from glaciers and ice sheets.

Source: Climate Change 2013, The Physical Science Basis, Summary for Policy Makers, Working Group I, Contribution to the Fifth Assessment Report of the IPCC.

4.4.2 Observations of Changes in Climate at National Level

In India, Ministry of Environment, Forest and Climate Change is the nodal agency which has been sending reports to UNFCCC. Till now, it has already sent two reports titled as India's First and Second National Communications to the United Nations Framework Convention on Climate Change in 2004 and 2012 respectively. The future impacts of climate change, identified by the Government of India's National Communications (NATCOM) in 2004 include:

- Decreased snow cover, affecting snow-fed and glacial systems such as the Ganges and Brahmaputra. About 70% of the summer flow of the Ganges comes from melt water
- Erratic monsoon with serious effects on rain-fed agriculture, peninsular rivers, water and power supply
- Drop in wheat production by 4-5 million tonnes, with even a 1°C rise in temperature
- Rising sea levels causing displacement along one of the most densely populated coastlines in the world, threatened freshwater sources and mangrove ecosystems

- Increased frequency and intensity of floods. Increased vulnerability of people in coastal, arid and semi-arid zones of the country
- Studies indicate that over 50% of India's forests are likely to experience shift in forest types, adversely impacting associated biodiversity, regional climate dynamics as well as livelihoods based on forest products.

Check Your Progress 1

Note: a) Answer the following questions in about 50 words.

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

- 1) State any three major impacts of climate change in India as predicted by NATCOM.

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4.5 CLIMATE CHANGE AND SUSTAINABLE DEVELOPMENT

As mentioned above, the rapid increase in greenhouse gases within such a small period of human history is a problem because it is changing the climate faster than the rate at which many living organisms may be able to adapt. Recent assessments have confirmed that, due to greenhouse gas emissions, global temperature has gone up by 10°C since 1850. If these emissions are not seriously reduced, probability is that global temperatures would rise between 20° and 30°C over the next 50 years. Scientists are already seeing some of these changes occurring more quickly than they had expected. According to the IPCC, eleven of the twelve hottest years occurred between the years 1995 and 2006.

As a consequence of this, the earth's ice sheets such as Greenland and Antarctica have begun to melt resulting in extra water which could potentially raise the sea levels significantly. This rise in sea level would lead to submergence of many island countries in Pacific, Atlantic and the Indian Ocean. Apart from this, majority of megacities, popularly coined as Bombay to Boston would also submerge under sea water. In addition to this, weather can become extreme. This means more intense major storms, more rain followed by longer and drier droughts posing a challenge for agriculture and loss of water supplies which is directly related to livelihood of majority of population in the world and more specifically to the developing countries. In brief it would be one of the major threats to sustainability of the earth and its inhabitants.

This has been highlighted by Human Development Report 2007/08 and World Development Report 2010. According to Human Development Report 2007/08 entitled 'Fighting Climate Change: Human Solidarity in a Divided World' which 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.”

Climate change will undermine international efforts to combat poverty. Seven years ago, political leaders around the world gathered to set targets for accelerated progress in human development. The Millennium Development Goals (MDGs) defined a new ambition for 2015. Much has been achieved, though many countries remain off track. Climate change is hampering efforts to deliver the MDG promise.

Looking to the future, the danger is that it will stall and then reverse progress built-up over generations not just in cutting extreme poverty, but in health, nutrition, education and other areas. The report identified five key areas through which climate change could stall and then reverse development in general and human development in specific:

- **Agricultural production and food security:** Climate change will affect rainfall, temperature and water availability for agriculture in vulnerable areas. For example, drought affected areas in Sub-Saharan Africa could expand by 60–90 million hectares, with dry land zones suffering losses of US\$26 billion by 2060 (2003 prices). Other developing regions, including Latin America and South Asia will also experience loss in agricultural production, undermining efforts to cut rural poverty. The additional number affected by malnutrition could rise to 600 million by 2080.

- **Water stress and water insecurity:** Changed run-off patterns and glacial melt will add to ecological stress, compromising flows of water for irrigation and human settlements in the process. An additional 1.8 billion people could be living in a water scarce environment by 2080. Central Asia, Northern China and the northern part of South Asia face immense vulnerabilities associated with the retreat of glaciers in the Himalayas. Seven of Asia’s great river systems will experience an increase in flows over the short term, followed by a decline as glaciers melt. The Andean region also faces imminent water security threats with the collapse of tropical glaciers. Several countries in already highly water-stressed regions such as the Middle East could experience deep loss in water availability.

- **Rising sea levels and exposure to climate disasters:** Sea levels could rise rapidly with accelerated ice sheet disintegration. Global temperature increases of 3–4°C could result in 330million people being permanently or temporarily displaced through flooding. Over 70 million people in Bangladesh, 6 million in Lower Egypt and 22 million in Vietnam could be affected. Small island states in the Caribbean and Pacific could be affected by catastrophic damage. The warming of seas will also give rise to intense tropical storms. With an average of 344 million people currently exposed to tropical cyclones, highly intense storms can have devastating consequences for a large number of countries. The one billion people currently living in urban slums on fragile hillsides or flood-prone river banks face acute vulnerabilities.

- **Ecosystems and biodiversity:** Climate change is already transforming ecological systems. Around one-half of the world's coral reef systems have suffered 'bleaching' as a result of warming seas. Increasing acidity in the oceans is another long-term threat to marine ecosystems. Ice-based ecologies have also suffered devastating climate change. While some animal and plant species will adapt, for many species the pace of climate change is too rapid: climate systems are moving more rapidly than they can follow. With 3°C of warming, 20–30 percent of land species could face extinction.

Millennium Ecosystem Assessment, 2005, observed that out of 24 listed ecosystem services under three major categories i.e. provisioning, regulatory and cultural ecosystem services fourteen services have been substantially declining and there are five services that have mixed outcomes-some part of the earth it is declining and in some part it has increased. In a way we could say that there are areas where out of 23 services, there is a decline in 19 services. (cited from World Development Report 2010, p.125.)

- **Human health:** Rich countries are already preparing public health systems to deal with future climate shocks, such as the 2003 European heat wave and more extreme summer and winter conditions. However, the greatest health impacts will be felt in developing countries because of high levels of Climate Change Poverty and the limited capacity of public health systems to respond. Major killer diseases could expand their coverage. For example, an additional 220 – 400 million people could be exposed to malaria, which is a disease that already claims around 1 million lives annually. Dengue fever is already in evidence at higher levels of elevation than has previously been the case, especially in Latin America and parts of East Asia. Climate change could further expand the reach of the disease. (Cited from Human Development Report, 2010, p. 9-10).

None of these five separate drivers will operate in isolation. They will interact with wider social, economic and ecological processes that shape opportunities for human development.

4.6 MEASURES TO OVERCOME EFFECTS OF CLIMATE CHANGE

In climate change discourse, there are two approaches to address human induced climate change. These are mitigation and adaptation. Mitigation has the long history in the climate policy, whereas the adaptation has recently gained importance.

The Concept of Mitigation and Adaptation: The concept 'mitigation' in general means the reduction of the atmospheric GHGs, and hence, we can avoid the likelihood of the occurrence of the climatic variability and extreme events. IPCC defines mitigation as "*an anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases.*" On the other hand, the notion 'adaptation' in general refers to the individual, communities, and societies to adjust their activities, life courses and location to take an opportunity, to get advantage from the fluxes of the social-ecological systems. The climate change literature views it as "*the adjustment in human and natural systems to actual or expected climatic stimuli, which can reduce the negative impacts and take advantage of the positive*" (UNFCCC 1992).

The Need for Mitigation and Adaptation: As mentioned above, climate change has severe non-linear impacts on the wellbeing of the human society. Many developing nations have already experienced weather related extreme events in terms of floods, droughts, heat waves and tropical cyclones that are more frequent or intense than previous experiences. In general, it affects different sectors, such as fresh water resources and their management, food and fibre and forest products, coastal system and low lying areas, and health etc. The resulting impacts will have significant consequences on the environment, production systems and livelihood from future climate variability and change. Importantly, the developing nations are facing more burdens as compared to the developed nations (Stern, 2006; and Mendelsohn et al., 2006). Meanwhile, Stern has estimated “if we don’t act, the overall damage cost will be equivalent to at least 5 percent of GDP now and forever, and if wider range of risks and impacts is taken into account, the estimates of damage could rise to 20 percent of the GDP or more” (Stern, 2006).

Mitigation and Adaptation Measures by AR5 for Policy Makers

IPCC Fifth Assessment Report has given the following major suggestions related to mitigation and adaptation. There are two broad suggestions related to mitigation and adaptation. Under these two broad suggestions, there are five important specific suggestions. Let us discuss broad suggestions as well as specific suggestions given under broad suggestions.

1) Future Pathways for Adaptation, Mitigation and Sustainable Development

Adaptation and mitigation are complementary strategies for reducing and managing the risks of climate change. Substantial emissions reductions over the next few decades can reduce climate risks in the 21st century and beyond, increase prospects for effective adaptation, reduce the costs and challenges of mitigation in the longer term and contribute to climate-resilient pathways for sustainable development.

1.1 Climate Change Risks Reduction by Mitigation and Adaptation:

Without additional mitigation efforts beyond those in place today, and even with adaptation, warming by the end of the 21st century will lead to high to very high risk of severe, widespread and irreversible impacts globally (high confidence). Mitigation involves some level of co-benefits and of risks due to adverse side effects, but these risks do not involve the same possibility of severe, widespread and irreversible impacts as risks from climate change, increasing the benefits from near-term mitigation efforts.

1.2 Characteristics of Adaptation Pathways:

Adaptation can reduce the risks of climate change impacts, but there are limits to its effectiveness, especially with greater magnitudes and rates of climate change. Taking a longer-term perspective, in the context of sustainable development, increases the likelihood that more immediate adaptation actions will also enhance future options and preparedness.

1.3 Characteristics of Mitigation Pathways:

There are multiple mitigation pathways that are likely to limit warming to below 2°C relative to pre-industrial levels. These pathways would require substantial emissions reductions over the next few decades and near zero emissions of CO₂ and other long-lived greenhouse gases by the end of the

century. Implementing such reductions poses substantial technological, economic, social and institutional challenges, which increase with delays in additional mitigation and if key technologies are not available. Limiting warming to lower or higher levels involves similar challenges but on different timescales.

- 2) **Adaptation and Mitigation:** Many adaptation and mitigation options can help address climate change, but no single option is sufficient by itself. Effective implementation depends on policies and cooperation at all scales and can be enhanced through integrated responses that link adaptation and mitigation with other societal objectives.

2.1 Common Enabling Factors and Constraints for Adaptation and Mitigation Responses: Adaptation and mitigation responses are underpinned by common enabling factors. These include effective institutions and governance, innovation and investments in environmentally sound technologies and infrastructure, sustainable livelihoods and behavioral and lifestyle choices.

2.2 Response Options for Adaptation: Adaptation options exist in all sectors, but their context for implementation and potential to reduce climate-related risks differs across sectors and regions. Some adaptation responses involve significant co-benefits, synergies and trade-offs. Increasing climate change will increase challenges for many adaptation options.

2.3 Response Options for Mitigation: Mitigation options are available in every major sector. Mitigation can be more cost-effective if using an integrated approach that combines measures to reduce energy use and the greenhouse gas intensity of end-use sectors, decarbonize energy supply, reduce net emissions and enhance carbon sinks in land-based sectors.

2.4 Policy Approaches for Adaptation and Mitigation, Technology and Finance: Effective adaptation and mitigation responses will depend on policies and measures across multiple scales: international, regional, national and sub-national. Policies across all scales supporting technology development, diffusion and transfer, as well as finance for responses to climate change, can complement and enhance the effectiveness of policies that directly promote adaptation and mitigation.

2.5 Trade-offs, Synergies and Interactions with Sustainable Development: Climate change is a threat to sustainable development. Nonetheless, there are many opportunities to link mitigation, adaptation and the pursuit of other societal objectives through integrated responses (high confidence). Successful implementation relies on relevant tools, suitable governance structures and enhanced capacity to respond (medium confidence).

(Source: Climate Change 2014, Synthesis Report, Summary for Policy Makers, Contribution to the Fifth Assessment Report of the IPCC, pp. 1)

Note: a) Answer the following questions in about 50 words.

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

1) Why there is a need for mitigation and adaptation of climate change?

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4.7 CLIMATE CHANGE DEBATES

There are so many debates and developments as far as climate change is concerned since Rio Earth Summit, 1992. But, we would discuss two important developments i.e. Kyoto Protocol and the Copenhagen Summit.

4.7.1 Kyoto Protocol

It's a United Nations sponsored agreement among nations to reduce their greenhouse gas emissions. This protocol emerged from the United Nations Framework Convention on Climate Change which was signed by almost all the nations which attended Rio Earth Summit, 1992. The Framework pledges to stabilize GHG concentrations "at a level that would prevent dangerous anthropogenic interference with climate system." The Protocol was initially adopted on 11th December 1997 in Kyoto, Japan and entered into force on

16th February 2005. As of November 2009, 187 states have signed and ratified the protocol. The most notable non-member of the Protocol is the United States, which is a signatory of UNFCCC and was responsible for 36.1% of the 1990 emission levels.

Under the Protocol, 37 industrialized countries (called "Annex I countries") commit themselves to a reduction of four greenhouse gases (GHG) i.e. carbon dioxide, methane, nitrous oxide, sulphur hexafluoride) and two groups of gases i.e. hydrofluorocarbons and perfluorocarbons produced by them, and all member countries give general commitments. Annex I countries agreed to reduce their collective greenhouse gas emissions by 5.2% from the 1990 level. Emission limits do not include emissions by international aviation and shipping, but are in addition to the industrial gases, chlorofluorocarbons, or CFCs, which are dealt with under the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer. The benchmark 1990 emission levels were accepted by the Conference of the Parties of UNFCCC (decision 2/CP.3) were the values of "global warming potential" calculated for the IPCC Second Assessment Report. These figures are used for converting the various greenhouse gas emissions into comparable CO₂ equivalents when computing overall sources and sinks.

The biggest question is that 'Will Kyoto make any difference?' But it appears that if any of the big economies will meet their Kyoto targets by 2012. Even if they did, it would only make a tiny dent in the world's ever increasing output

of GHG's. Therefore, century long lifespan of atmospheric CO₂ means that the planet is already committed to a substantial amount of greenhouse warming. Even if we turn off every fuel-burning machine on earth tomorrow, climate modelers tell us that the world would warm at least another 0.5°C as oceans slowly release the heat that they have collected in recent decades. The bottom line is that we cannot bring down our greenhouse gas emissions in check until changes in technology and lifestyle enable us to pull us back far beyond our current emission levels. We need to find some safe methods to remove enormous amounts of carbon or both.

4.7.2 Copenhagen Summit

The United Nations Climate Change Conference 2009, commonly known as the Copenhagen Summit, was held at Copenhagen, Denmark, from 7th - 18th December. According to the Bali Road Map, a framework for climate change mitigation beyond 2012 was to be agreed there. The Copenhagen Accord was drafted by the US, China, India, Brazil and South Africa on December 18th, and judged a “meaningful agreement” by the United States government. It was “taken note of”, but not “adopted”, in a debate of all the participating countries the next day, and it was not passed unanimously. The document recognized that climate change is one of the greatest challenges of the present day and that actions should be taken to keep any temperature increases to below 2°C. The document is not legally binding and does not contain any legally binding commitment for reducing CO₂ emissions. With no firm target for limiting the global temperature rise, no commitment to a legal treaty and no target year for peaking emissions, countries most vulnerable to climate impacts have not got the deal they wanted.

Early on Saturday 19th December, delegates approved a motion to “take note of the Copenhagen Accord of December 18th, 2009”. This was due to the opposition of countries such as Bolivia, Venezuela, Sudan and Tuvalu who registered their opposition to both the targets and process by which the Copenhagen Accord was reached. The accord recognizes the scientific case for keeping temperature rises below 2°C, but does not contain commitments for reduced emissions that would be necessary to achieve that aim. One part of the agreement pledges US\$ 30 billion to the developing world over the next three years, rising to US\$100 billion per year by 2020, to help poor countries adapt to climate change. Earlier proposals, which would have aimed to limit temperature rises to 1.5°C and cut CO₂ emissions by 80% by 2050, were dropped. The Accord also favours developed countries’ paying developing countries to reduce emissions and degradation, known as “REDD”.

Despite widely held expectations that the Copenhagen summit would produce a legally binding treaty, the conference was plagued by negotiating deadlock and the “Copenhagen Accord” is not legally enforceable. The Copenhagen Accord asked countries to submit emissions targets by the end of January 2010, and paves the way for further discussions to occur at the 2010 UN climate change conference in Mexico. By early February, 67 countries had registered their targets. Countries such as India and Association of Island States made clear that they believed that Copenhagen Accord could not replace negotiations within the UNFCCC. Other commentators consider that “the future of the UN’s role in international climate deals is now in doubt.” Indian journalist Praful Bidwai puts the blame on both developed and a few developing countries such as India, arguing that the “Copenhagen Accord is an illegitimate, ill conceived, collusive

deal between a handful of countries that are some of the world's greatest present and future emitters." He argues that India's policy is driven by elites determined to maintain high-consumer lifestyles which will have devastating effects for the vast majority of India's poor.

4.8 NATIONAL ACTION PLAN ON CLIMATE CHANGE

India released its National Action Plan on Climate Change (NAPCC) on 30th June 2008. The entire action plan advocates broadly two pronged strategy. Firstly, to develop adaptation to climate change and secondly further enhancement of the ecological sustainability of India's development path. In other words, the NAPCC outlines a strategy by which India will adapt to climate change, while maintaining a high growth rate, protecting poor and vulnerable sections of society and achieving national growth objectives. NAPCC proposed eight missions and 24 initiatives to minimize the climate change effects. These initiatives are aimed at promoting technologies and actions in the sectors pertaining to energy generation, transport, renewable energy, disaster management and capacity building etc. However, detailed action plans for each mission, and any clear targets are missing from the report. The real challenge is to implement these below mentioned eight missions into actions at diverse grass root level situations in India. The proposed eight missions are as follows:

- National Solar Mission
- National Mission for Enhanced Energy Efficiency
- National Mission on Sustainable Habitat
- National Water Mission
- National Mission for Sustaining the Himalayan Ecosystem
- National Mission for a "Green India"
- National Mission for Sustainable Agriculture
- National Mission on Strategic Knowledge for Climate Change

As our country is full of diversity, climate change would have differential impacts on different geo-ecological conditions. Therefore, it is pertinent to have different action plan for different regions apart from national level missions. In this context, attempt has been made by different states to develop state level climate change action plan. But if we analyze all these state plans, it has been found that it has still remains as a document and nothing significant has been implemented.

State Level Action Plans on Climate Change in India

The Prime minister in his address to Ministers of Environment and Forest from various states on 18th August 2009 called upon all the states to prepare a State level Action Plan on Climate Change consistent with the strategy outlined in the NAPCC. The State level plans will enable communities and ecosystems to adapt to climate change effectively and help to achieve the objectives of NAPCC. Accordingly, a programme for the preparation of state level plans has been initiated in almost all the states of India.

Check Your Progress 3

Note: a) Answer the following questions in about 50 words.

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

1) List eight missions identified under National Action Plan on Climate Change.

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4.9 LET US SUM UP

Climate change refers to a change in climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time period. Major natural sources of climate change are solar variability, changes in Earth's orbit and tilt, plate tectonics, and biological evolution. Climate change threatens to erode human freedoms and limit choice. Climate change is hampering efforts to deliver the MDG promise. Unfortunately, despite of various efforts at international level, till now, no consensus has emerged and there are strong differences among developed and developing countries. Remedial measures to overcome or reduce the effects of climate change can be addressed by undertaking both adaptation and mitigation measures. This unit also discusses the climate change protocol and national action plan.

4.10 REFERENCES AND SUGGESTED READINGS

Christopherson, R. W. and Birkeland, G. H. 2015. 'Chapter 11 Climate Change' in *Geosystems An Introduction to Physical Geography*, Harlow, England: Pearson Education Limited

Government of India. 2009. "National Action Plan on Climate Change" Ministry of Forest & Environment, Government of India.

INCCA. 2010. *Climate Change and India: A 4x4 Assessment - A Sectoral and Regional Analysis for 2030's*. Ministry of Environment and Forest, Government of India, New Delhi.

IPCC, 2013. *Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S. K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

IPCC, 2014: *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

Metz, B. (2010) Controlling Climate Change, Cambridge, U.K.: Cambridge University Press

Mohapatra, S. and Bahinipati, C. S. 2016. Climate Change, Block 1, Unit 1-4, MSD 17 Challenges to Sustainable Development, Post Graduate Diploma in Sustainability Science, Indira Gandhi National Open University, New Delhi.

Mohapatra, S. 2018. Climate Change: Evidences and Causes, Module 33, Climatology, Geography E-PG Pathsala

Mohapatra, S. 2018. Climate Change: Evidences and Causes, Module 33, Climatology, Geography E-PG Pathsala

Shukla, P. R., Subodh, K. S., Ravindranath, N. H., Garg, A. and Bhattacharya, S. 2003. *Climate Change and India: Vulnerability Assessment and Adaptation*, Hyderabad: University Press (India) Pvt. Ltd.

UNDP. 2007. “Fighting Climate Change: Human Solidarity in a Divided World”. Human Development Report 2007/08 New York: UNDP.

van der Linden, Hanson, C. E. (eds.) 2007. IPCC ‘Summary for Policy Makers’. Climate Change 2007: Impacts, Adaptation and Vulnerability, Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, UK: Cambridge University Press.

World Bank. 2010. World Development Report 2010 titled “Climate Change and Development”. Oxford: Oxford University Press.

Web Links

<https://www.ipcc.ch/report>

<http://www.ncdc.noaa.gov>

<http://unfccc.int/resource/docs/natc/indnc2.pdf>

<http://unfccc.int/resource/docs/natc/indnc1.pdf>

4.11 CHECK YOUR PROGRESS POSSIBLE ANSWERS

Check Your Progress 1

- 1) State any three major impacts of climate change in India as predicted by NATCOM.

Answer: The three major impacts of climate change in India as predicted by NATCOM are:

- Decreased snow cover, affecting snow-fed and glacial systems such as the Ganges and Brahmaputra. About 70% of the summer flow of the Ganges comes from melt water
- Erratic monsoon with serious effects on rain-fed agriculture, peninsular rivers, water and power supply
- Drop in wheat production by 4-5 million tonnes, with even a 1°C rise in temperature

Check Your Progress 2

1) Why there is a need for mitigation and adaptation of climate change?

Answer: The climate change has severe non-linear impacts on the wellbeing of the human society. Many developing nations have already experienced weather related extreme events in terms of floods, droughts, heat waves and tropical cyclones that are more frequent or intense than previous experiences. In general, it affects different sectors, such as fresh water resources and their management, food and fibre and forest products, coastal system and low lying areas, and health etc. The resulting impacts will have significant consequences on the environment, production systems and livelihood from future climate variability and change.

Check Your Progress 3

1) List eight missions identified under National Action Plan on Climate Change.

Answer: The proposed eight missions are as follows:

- National Solar Mission
- National Mission for Enhanced Energy Efficiency
- National Mission on Sustainable Habitat
- National Water Mission
- National Mission for Sustaining the Himalayan Ecosystem
- National Mission for a “Green India”
- National Mission for Sustainable Agriculture
- National Mission on Strategic Knowledge for Climate Change

MDV 103: ISSUES AND CHALLENGES OF DEVELOPMENT

Block	Unit Nos	Unit Titles
1		BASIC ISSUES IN DEVELOPMENT
	1	Population
	2	Poverty
	3	Inequality
	4	Unemployment
2		SECTORAL ISSUES IN DEVELOPMENT
	1	Agriculture
	2	Industry
	3	Services
	4	Infrastructure
3		SOCIAL ISSUES IN DEVELOPMENT
	1	Education and Development
	2	Health and Development
	3	Gender and Development
4		EMERGING ISSUES IN DEVELOPMENT
	1	Energy and Development Nexus
	2	Natural Resource Management and Environment
	3	Sustainable Development
	4	Climate Change
5		GOVERNANCE
	1	Governance – An Overview
	2	Participatory and Decentralized Governance
	3	Good Governance: Attributes and Challenges
	4	E-Governance and Development