Module I
Basic Introduction to Energy

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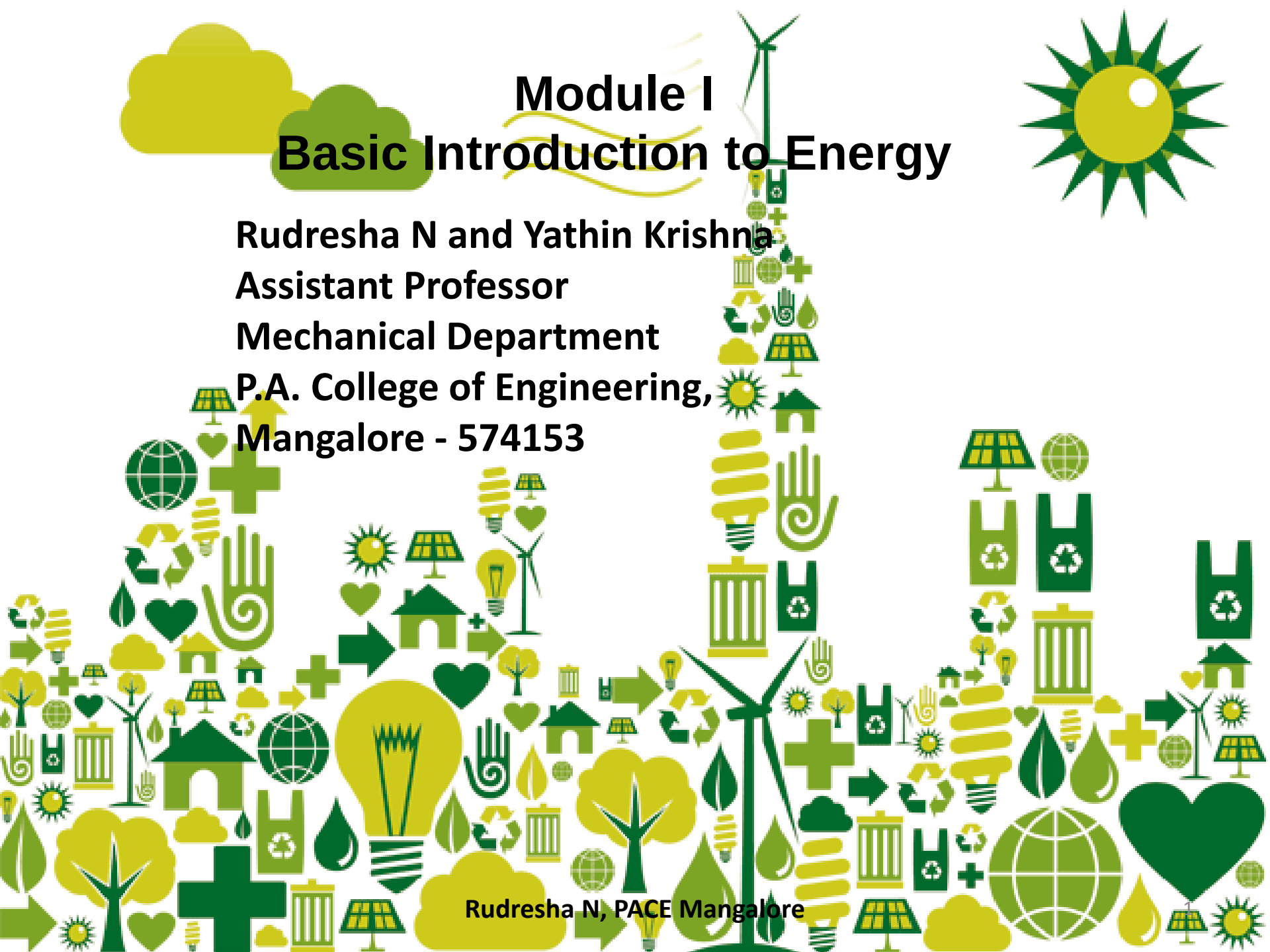


Energy

- Energy is the capacity to do work
- The SI unit of energy is the joule, which is the energy transferred to an object by the mechanical work of moving it a distance of 1 metre against a force of 1 Newton.

Power

- Power is the rate at which work is done, or energy is transmitted

Difference between Energy and Power

Energy	Power
Energy is the capacity to do work. Energy is power integrated over time.	Power is the rate at which work is done, or energy is transmitted
Unit: joules = watt-seconds	**Unit:** watt = joules/second
Example: I left a 60W light bulb on for 30 days, which raised my electric bill by 43.2 kWh (kilowatt-hours).	**Example:**My car's battery can provide 500 amps at 12 volts, which equals 6kW of power.
Forms Include: kinetic, potential, thermal, gravitational, electromagnetic, sound, light and elastic	**Different forms of power could be** electric power, which is the rate at which electrical energy is transferred by a circuit, human power, and optical power.

FORMS OF ENERGY

All forms of energy fall under two categories

POTENTIAL

Potential energy is stored energy and the energy of position (gravitational)

CHEMICAL ENERGY

Chemical energy is the energy stored in the bonds of atoms and molecules. Biomass, petroleum, natural gas, propane and coal are examples of stored chemical energy.

NUCLEAR ENERGY

Nuclear energy is the energy stored in the nucleus of an atom - the energy that holds the nucleus together. The nucleus of a uranium atom is an example of nuclear energy.

STORED MECHANICAL ENERGY

Stored mechanical energy is energy stored in objects by the application of a force. Compressed springs and stretched rubber bands are examples of stored mechanical energy.

GRAVITATIONAL ENERGY

Gravitational energy is the energy of place or position. Water in a reservoir behind a hydropower dam is an example of gravitational potential energy. When the water is released to spin the turbines, it becomes motion energy.

KINETIC

Kinetic energy is motion - the motion of waves, electrons, atoms, molecules and substances

RADIANT ENERGY

Radiant energy is electromagnetic energy that travels in transverse waves. Radiant energy includes visible light, x-rays, gamma rays and radio waves. Solar energy is an example of radiant energy.

THERMAL ENERGY

Thermal energy (or heat) is the internal energy in substances - the vibration and movement of atoms and molecules within substances. Geothermal energy is an example of thermal energy.

MOTION

The movement of objects or substances from one place to another is motion. Wind and hydropower are examples of motion.

SOUND

Sound is the movement of energy through substances in longitudinal (compression/ rarefaction) waves.

ELECTRICAL ENERGY

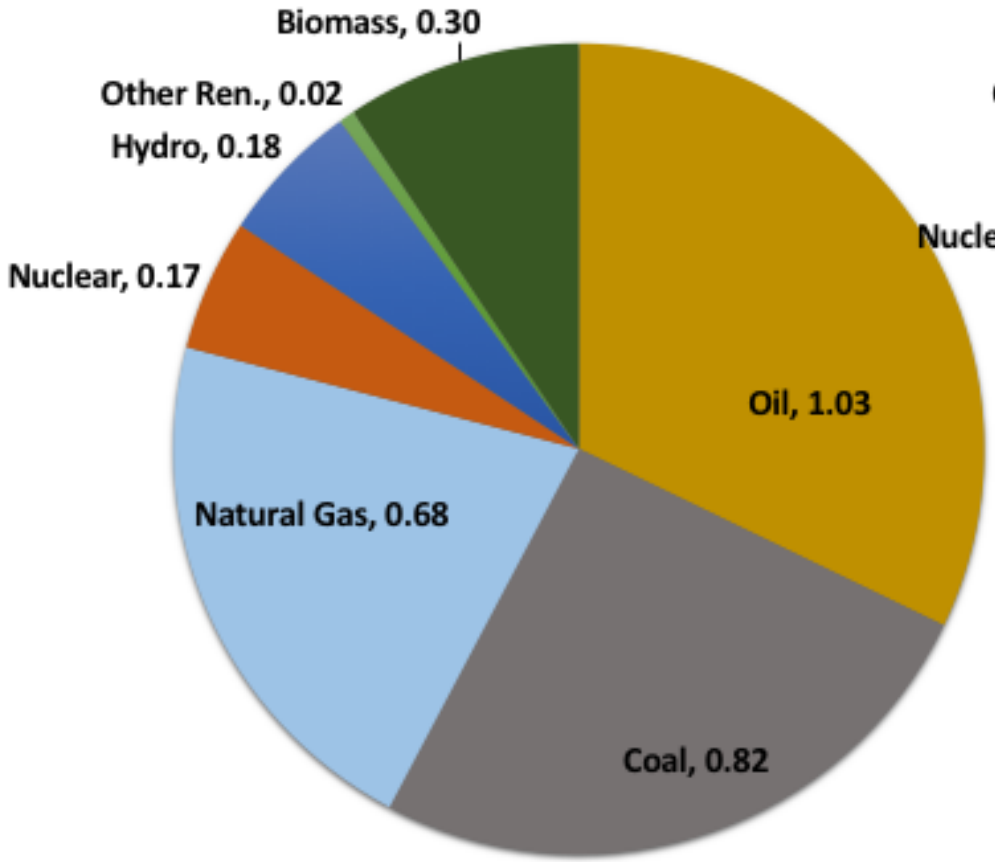
Electrical energy is the movement of electrons. Lightning and electricity are examples of electrical energy.

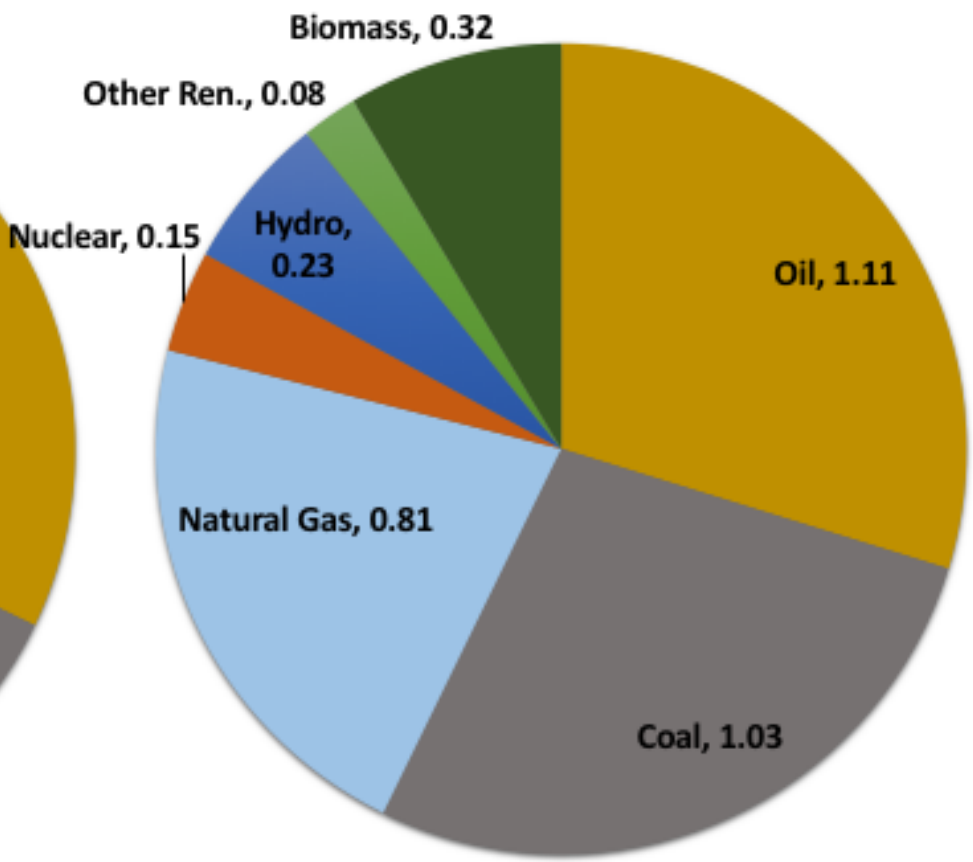
Primary Energy Source as Sun

- Sun is the main primary energy source of our planet
- Other Primary Energy Sources are:

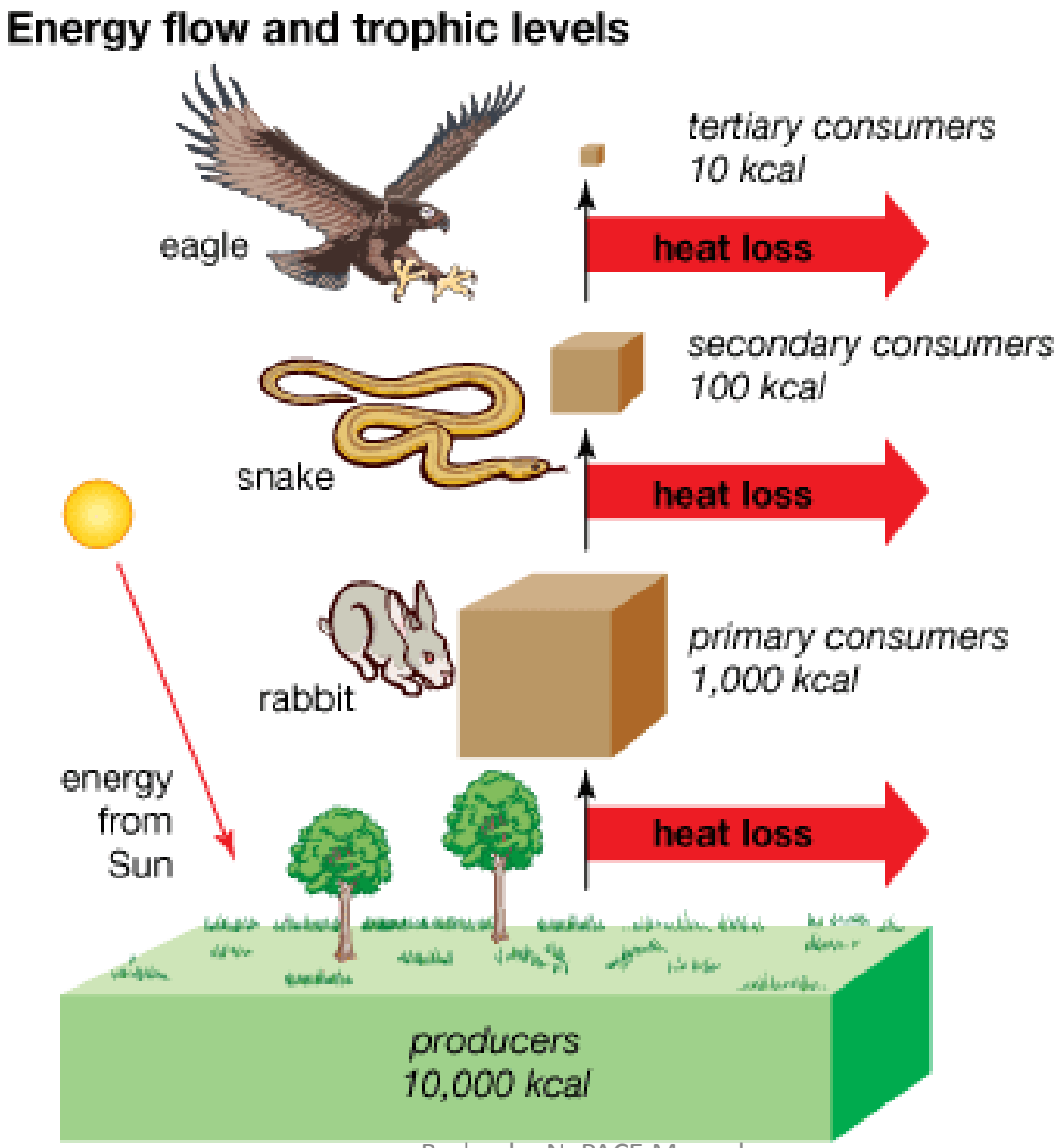
❖ Coal
❖ Natural Gas
❖ Oil
❖ Nuclear
❖ Hydro
❖ Bio-mass
❖ Other Renewable Energy.

Primary Energy Sources

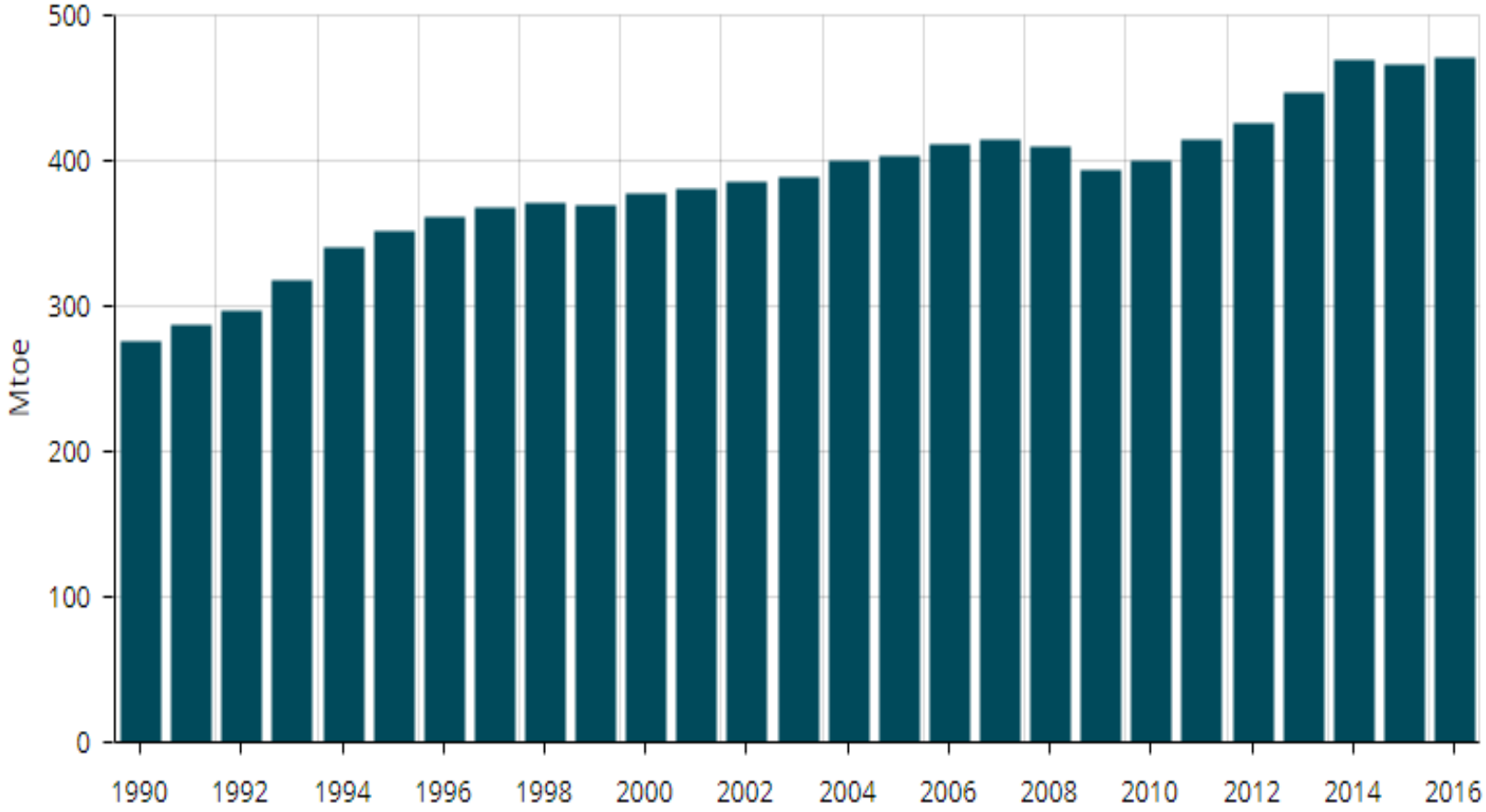




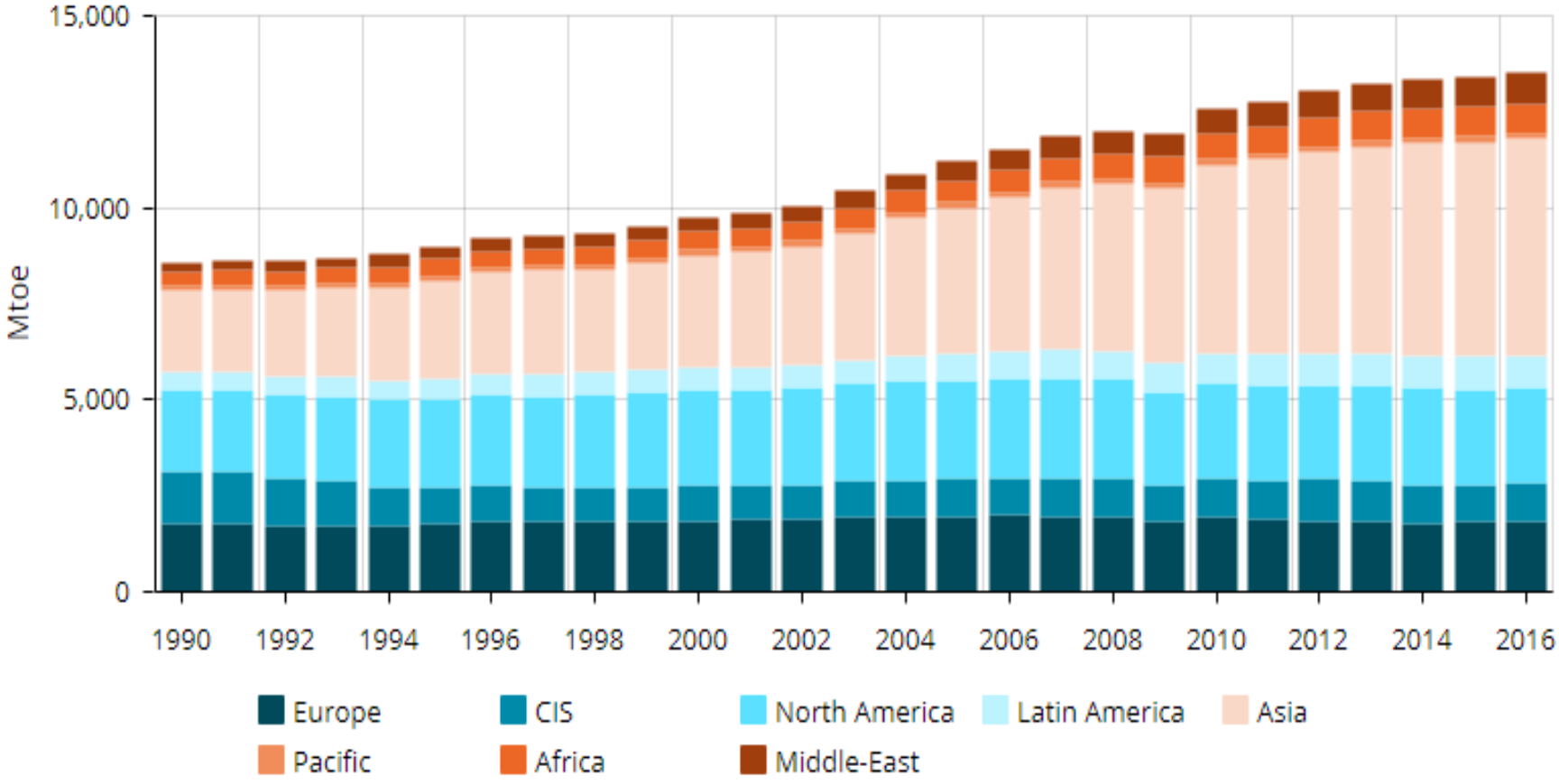
Energy Flows



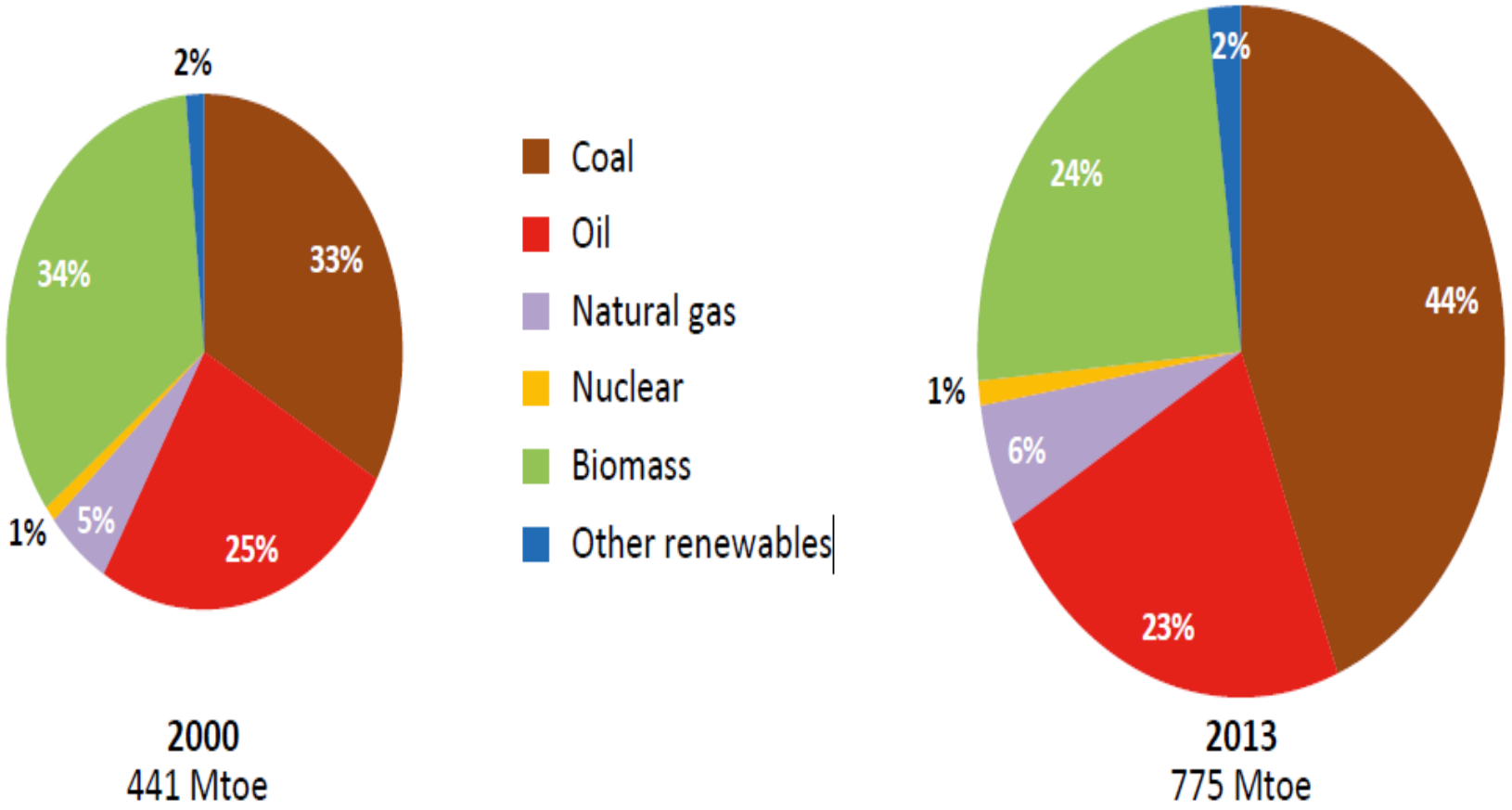
World energy Production



World Energy Consumption



Energy Demand in India

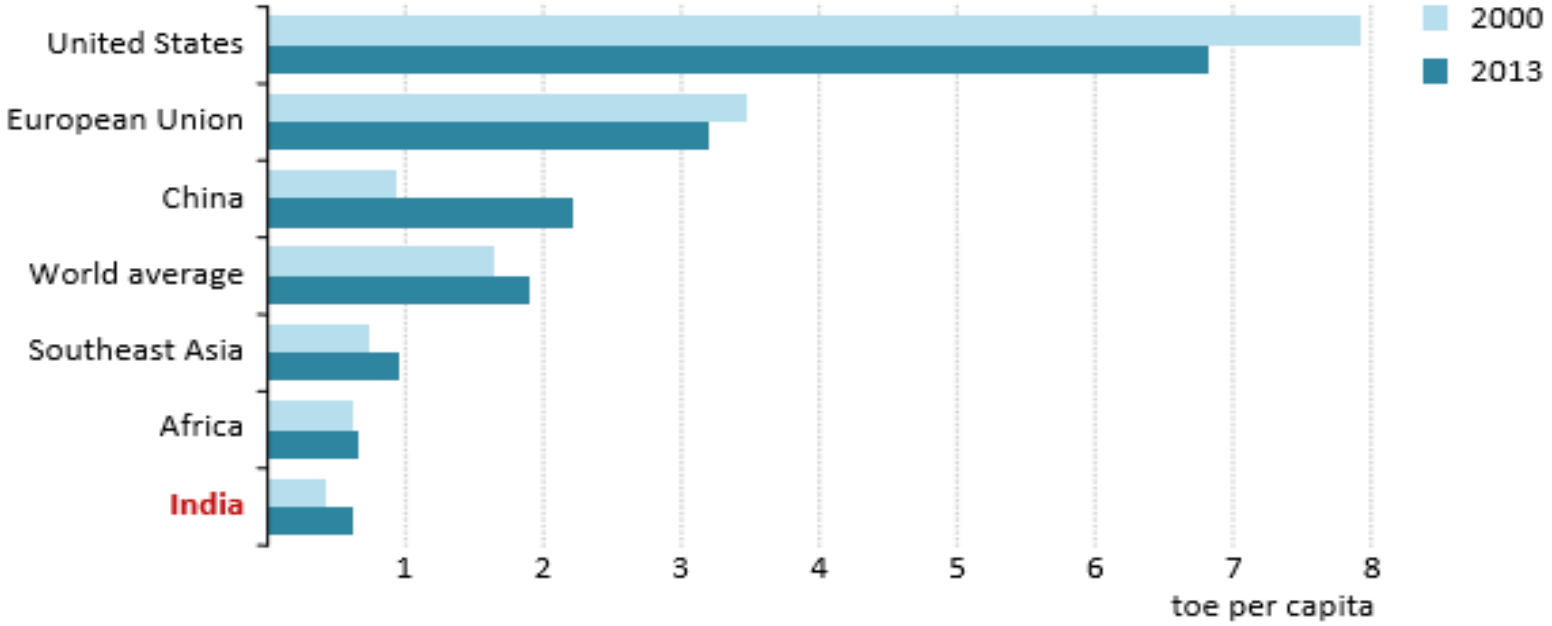


Key energy trends in India

Demand

India has been responsible for almost 10% of the increase in global energy demand since 2000. Its energy demand in this period has almost doubled, pushing the country's share in global demand up to 5.7% in 2013 from 4.4% at the beginning of the century.

Figure 1.1 ▷ Per-capita energy consumption in India and selected regions



Note: toe = tonnes of oil equivalent.

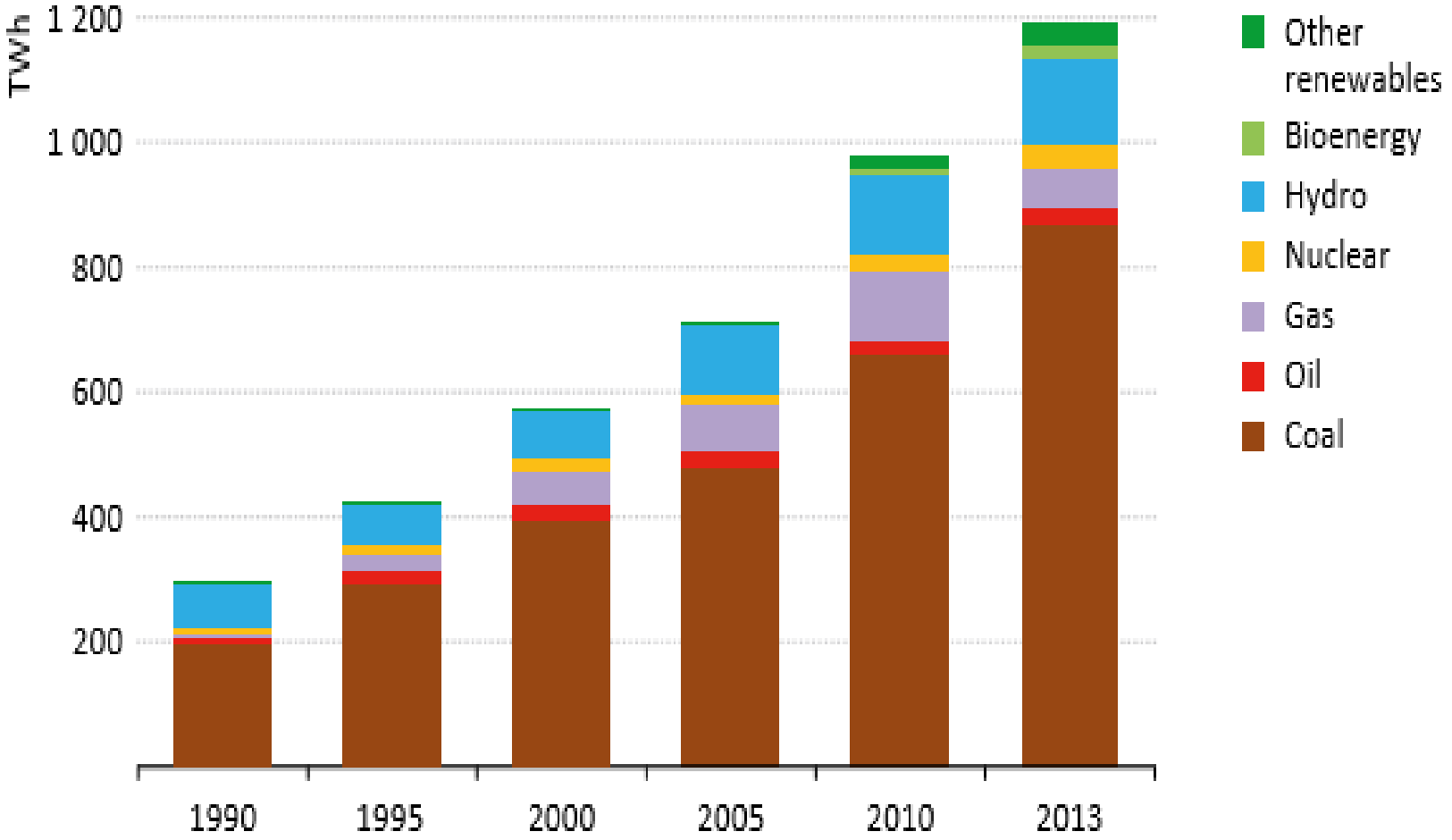
Electricity

On the supply side, India has some 290 gigawatts5 (GW) of power generation capacity, of which coal (60%) makes up by far the largest share, followed by hydropower (15%) and natural gas (8%). The mix has become gradually more diverse: since 2000, almost 40% of the change in installed capacity was non-coal.

Industrial consumers are also affected by unreliable and unpredictable power supply: around half of the industrial firms in India have experienced power cuts of more than five hours each week (FICCI, 2012). Elevated end-use industrial tariffs, allied to unreliable supply, lead many industrial and commercial consumers to produce their own electricity.

FICCI = Federation of Indian Chambers of Commerce and Industry

Figure 1.7 ▷ Total electricity generation in India by fuel



Note: Other renewables includes solar PV and wind.

- Over 85% of India's coal plants use subcritical generation technology, and the average efficiency of India's coal-fired fleet is just under 35%, below that of China or the United States.

- Poor coal quality (high ash content) and the relatively high ambient temperatures in India also play a role in lower efficiency levels.

- In some cases, generation has also run below capacity due to a lack of available transmission capacity. The creation of a national grid (the five regional grids were interconnected by end-2013) and continued progress in inter-state and inter-regional links has been and remains critical, given that resources and capacity for power generation are often not located close to the main centres of demand.

- Despite steps to encourage investment, including private investment, in transmission projects, expansion of the network has generally lagged behind that of generation; projects face numerous obstacles, notably over clearances.

- In 2011, the Central Electricity Authority (CEA) estimated that over 120 transmission projects were held up because the developer was unable to secure the necessary land and rights-of-way.

Access to modern energy

The population without access is concentrated in a relatively small number of states: almost two-thirds are in two north-eastern states, Uttar Pradesh and Bihar.

India's rural electrification programme, the Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY), was launched in 2005 and aimed to provide electricity to villages of 100 inhabitants or more and free electricity to people below the poverty line. The effective implementation of RGGVY has faced several challenges and there are strong variations in outcomes between states, as well as questions over the definition of access.

In July 2015, RGGVY was subsumed within a new scheme, the Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY). The main components of this scheme are the separation of distribution networks between agricultural and non-agricultural consumers to reduce load shedding, strengthening local transmission and distribution infrastructure, and metering.

Table 1.1 ▷ Number and share of people without access to electricity by state in India, 2013

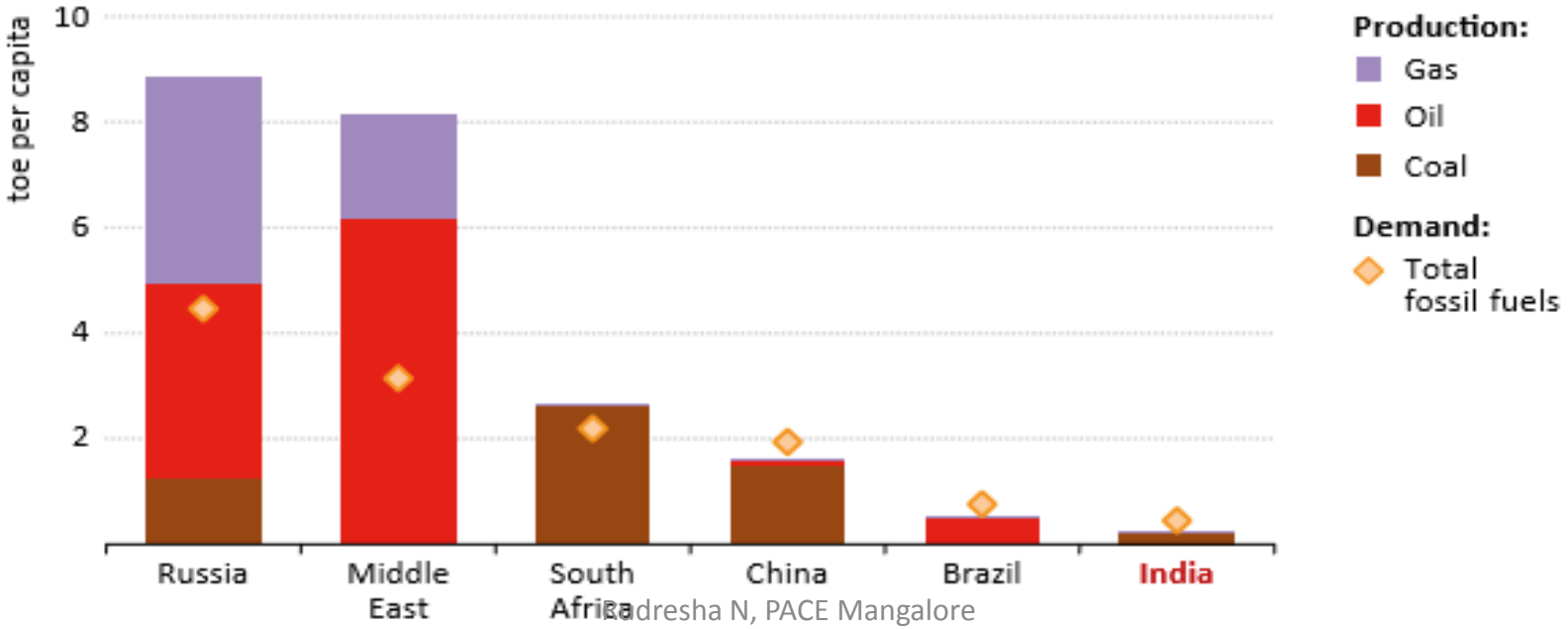
	Population without access (million)			Share of population without access		
	Rural	Urban	Total	Rural	Urban	Total
Uttar Pradesh	80	5	85	54%	10%	44%
Bihar	62	2	64	69%	19%	64%
West Bengal	17	2	19	30%	7%	22%
Assam	11	0	12	45%	9%	40%
Rajasthan	10	0	11	22%	2%	17%
Odisha	10	0	11	32%	4%	27%
Jharkhand	8	0	9	35%	4%	27%
Madhya Pradesh	7	1	8	16%	3%	12%
Maharashtra	6	1	6	11%	2%	7%
Gujarat	2	2	3	7%	6%	6%
Chattisgarh	2	0	3	14%	6%	12%
Karnataka	1	0	1	5%	1%	3%
Other states	3	2	6	2%	2%	2%
Total	**221**	**16**	**237**	**26%**	**4%**	**19%**

Source: National Sample Survey Office, (2014); Central Electricity Authority, (2014a); IEA analysis.

Energy production and trade

India's domestic production of fossil fuels, considered on a per-capita basis, is by far the lowest among the major emerging economies, meaning that India has a structural dependence on imported supply. In addition, combustion of coal and oil products contributes to pressing air quality problems in many areas, as well as to global greenhouse gas (GHG) emissions.

Figure 1.8 ▷ **Fossil-fuel production and demand per capita by selected countries, 2013**



Coal

India has the third-largest hard coal reserves in the world (roughly 12% of the world total), as well as significant deposits of lignite. Yet the deposits are generally of low quality and India faces major obstacles to the development of its coal resources in a way that keeps pace with burgeoning domestic needs. In 2013, India produced almost 340 million tonnes of coal equivalent (Mtce), but it also imported some 140 Mtce – roughly 12% of world coal imports (61% from Indonesia, 21% from Australia, 13% from South Africa). With a view to limiting reliance on imports, the government announced plans in early 2015 to more than double the country's coal production by 2020.

At present, more than 90% of coal in India is produced by open cast mining. This method has relatively low production costs and is less dangerous than deep mining, but has a large, adverse environmental footprint in the form of land degradation, deforestation, erosion and acid water runoff.

The difficulty in expanding coal production in recent years has been related to a number of factors, including delays in obtaining environmental permits, land acquisition and rehabilitation and resettlement issues, infrastructure constraints (limited transport capacity to connect mines, dispatch centres and end-use destinations), insufficient coal-washing facilities to remove the ash and technological limitations (notably for underground mining).

Oil and oil products

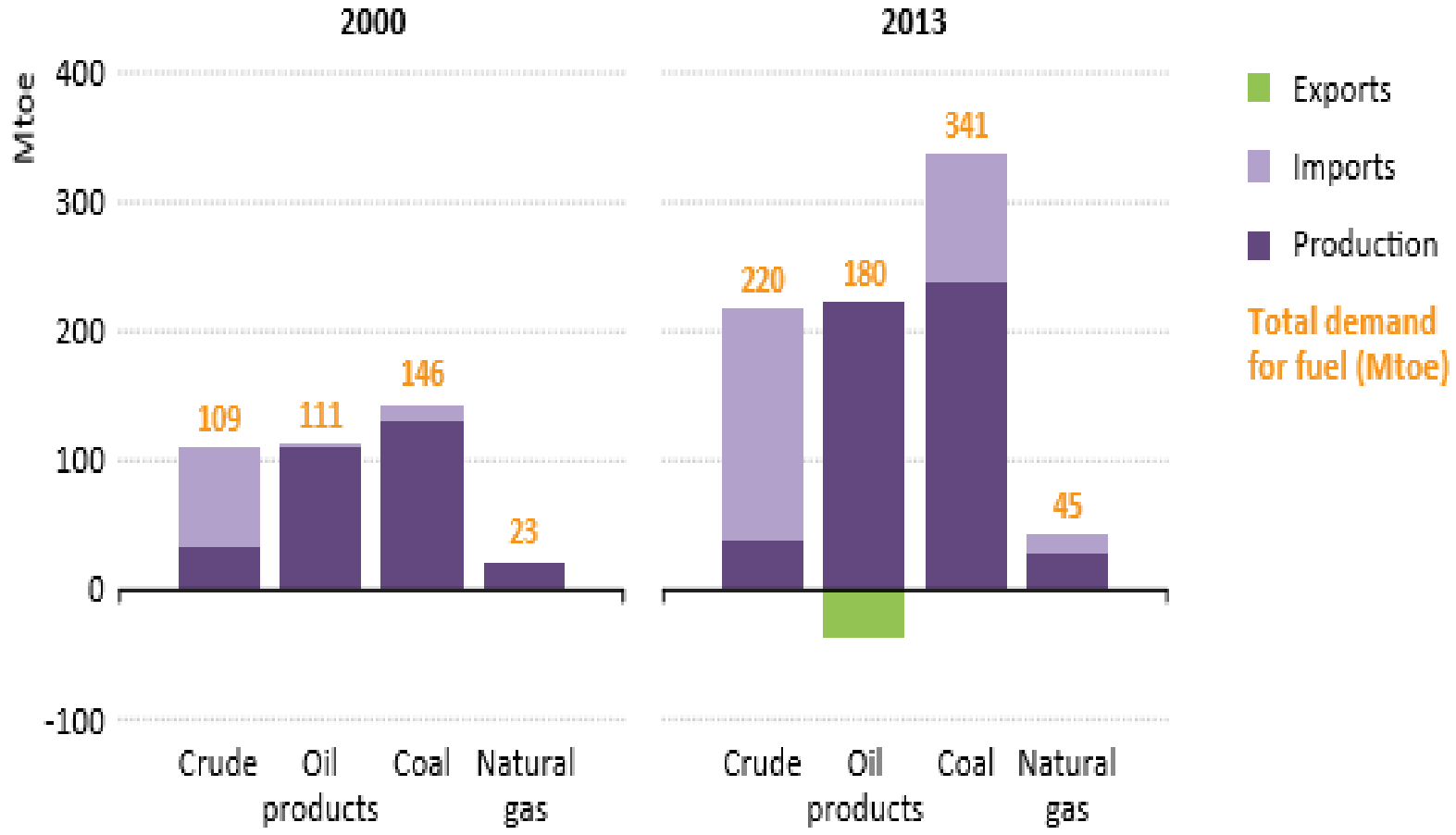
Domestic crude oil production of just over 900 thousand barrels per day (kb/d) is far from enough to satisfy the needs of 4.4 mb/d of refinery capacity. The output from the refinery sector, in turn, is more than enough to meet India's current consumption of oil products, at around 3.8 mb/d (with the exception of LPG, for which India imports about half of domestic consumption).

India has relatively modest oil resources and most of the proven reserves (around 5.7 billion barrels) are located in the western part of the country, notably in Rajasthan and in offshore areas near Gujarat and Maharashtra.

India has almost doubled its refining capacity in the last ten years and has added more than 2 mb/d of new capacity since 2005, with strong private sector participation from companies such as Reliance and Essar (India is now fourth in the world in terms of total refining capacity, behind only the United States, China and Russia).

India's refinery assets include the largest refinery in the world, Reliance's Jamnagar complex, with over 1.2 mb/d of throughput capacity (more than India's domestic crude production). These capacity additions have given India a surplus of refined products, as the growth in oil product demand growth, even at an impressive 4.2% average annual rate, has been slower than the capacity boom.

Figure 1.9 ▷ Fossil-fuel balance in India



Note: Demand for crude oil shows refinery intake.

Natural gas

Natural gas has a relatively small share (6%) of the domestic energy mix. Optimism about the pace of expansion, fuelled by some large discoveries in the early 2000s, has been dashed by lower than expected output from offshore domestic fields. The main onshore producing fields are in the states of Assam in the northeast, Gujarat in the west and Tamil Nadu and Andhra Pradesh in the south. Some of the most promising areas are offshore, including the Krishna Godavari basin off the east coast.

Production of conventional gas reached 34 bcm (billion cubic meters) in 2013 and was supplemented by NG imports via four regasification terminals. The majority state-owned gas company, GAIL, is the largest player in the midstream and downstream gas market.

Hydropower

India has significant scope to expand its use of hydropower: its current 45 GW of installed capacity (of which over 90% is large hydro) represents a little under a third of the assessed resource. Much of the remaining potential is in the north and northeast. A further 14 GW are under construction, although some of these plants have been delayed by technical or environmental problems and public opposition.

If developed prudently, hydropower can bring multiple benefits as a flexible source of clean electricity, and also as a means of water management for flood control, irrigation and domestic uses.

Bioenergy

Bioenergy accounts for roughly a quarter of India's energy consumption, by far the largest share of which is the traditional use of biomass for cooking in households. This reliance gives rise to a number of problems, notably the adverse health effects of indoor air pollution. India is also deploying a range of more modern bioenergy applications, relying mainly on residues from its large agricultural sector.

Biofuels are another area of bioenergy development in India, supported by an ambitious blending mandate, dating back to 2009, that anticipates a progressive increase to a 20% share for bioethanol and biodiesel by 2017. Implementation has thus far been slower than planned: the present share of bioethanol – mostly derived from sugarcane – remains well under 5% and progress with biodiesel has been even more constrained.

Wind and solar

India has the fifth-largest amount of installed wind power capacity in the world, with 23 GW in 2014, although investment has fluctuated with changes in subsidy policies at national and state level. Key supporting measures have included a generation-based financial incentive (a payment per unit of output, up to certain limits) and an accelerated depreciation provision.

Solar power has played only a limited role in power generation thus far, with installed capacity reaching 3.7 GW in 2014, much of this added in the last five years. However, India began to put a much stronger emphasis on solar development with the launch in 2010 of the Jawaharlal Nehru National Solar Mission, the target of which was dramatically upgraded in 2014 to 100 GW of solar installations by 2022, 40 GW of rooftop solar photovoltaics (PV) and 60 GW of large- and medium-scale grid-connected PV projects (as part of a broader 175 GW target of installed renewable power capacity by 2022, excluding large hydropower).

Nuclear power

India has twenty-one operating nuclear reactors at seven sites, with a total installed capacity close to 6 GW. Another six nuclear power plants are under construction, which will add around 4 GW to the total. The operation of the existing nuclear fleet has been constrained in the past by chronic fuel shortages, in 2008 the average load factor was as low as 40%. This constraint was eased after India became a party to the Nuclear Suppliers' Group agreement in 2008, allowing access not only to technology and expertise but also reactor parts and uranium. The average plant load factor rose to over 80% in 2013.

Though the current share of nuclear power in the generation mix is relatively small at 3%, India has ambitious plans to expand its future role, including a long-term plan to develop more complex reactors that utilise thorium – a potential alternative source of fuel for nuclear reactors. India has limited low-grade uranium reserves, but it has the world's largest reserves of thorium: developing a thorium fuel cycle will though require a range of tough economic, technical and regulatory challenges to be overcome.

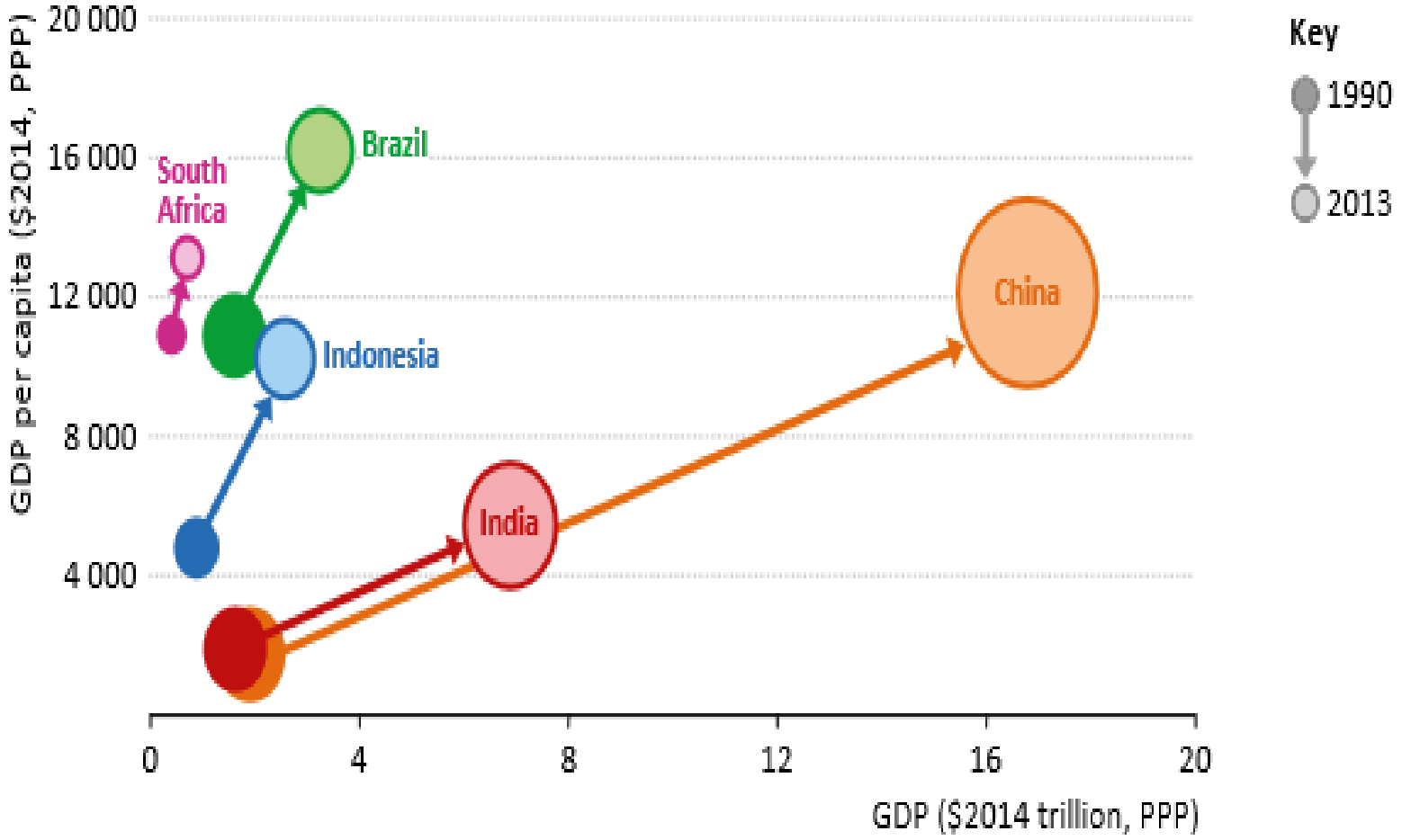
Factors affecting India's energy development

Economy and demographics

The pace of economic and demographic change is a vitally important driver of India's energy sector. Since 1990, India's economy has grown at an average rate of 6.5% a year, second only to China among the large emerging economies, and two-and-a-half-times the global average (if both these countries are excluded). This propelled India beyond Japan in 2008, to become the third-largest economy in the world, measured on a PPP basis. India alone has accounted for over 9% of the increase in global economic output since 1990.

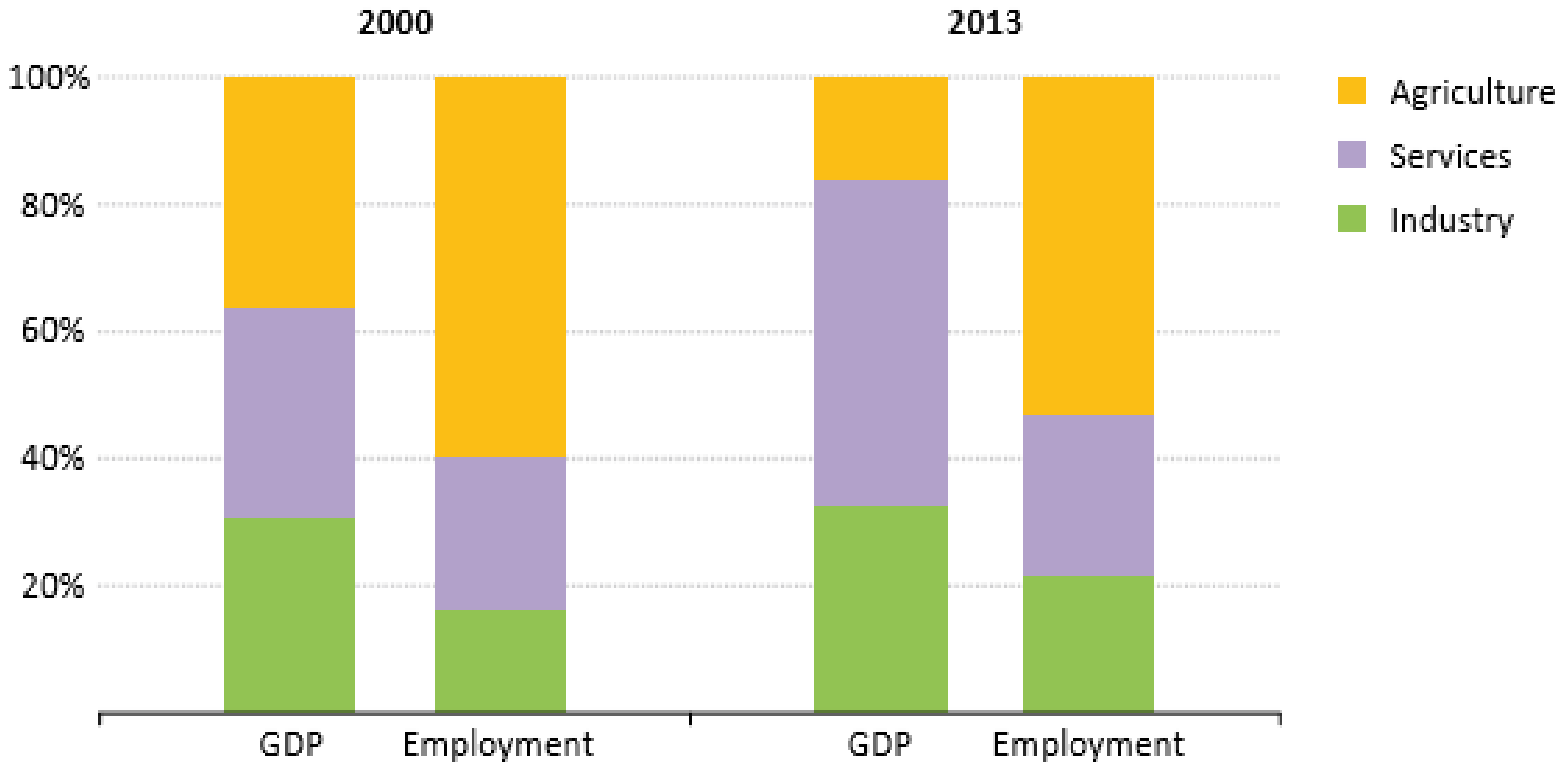
PPP = Purchasing power parity
IEA = International Energy Agency
GDP = Gross Domestic Product

Figure 1.10 ▷ GDP per capita and total GDP for selected countries, 1990 and 2013



to re-balance the economy in 2014 Indian government announced the "Make in India" initiative, with the intention of increasing the share of manufacturing in GDP to 25% by 2022 creating 100 million jobs in the process.

Figure 1.11 ▷ Composition of GDP and employment structure in India



Policy and institutional framework

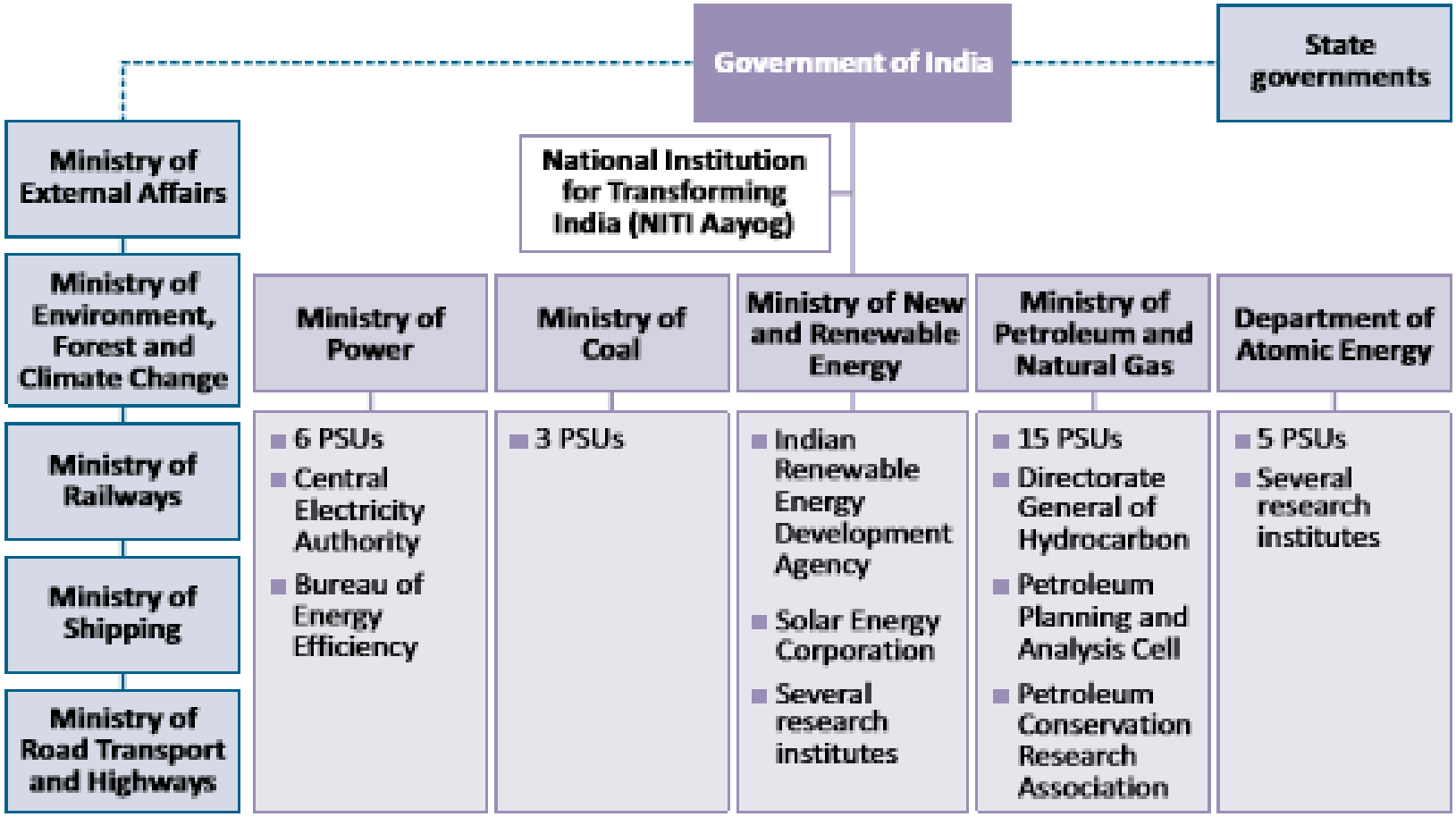
Some key aspects of the emerging energy vision are:

- A commitment to the efficient use of all types of energy in order to meet rapidly growing demand.
- a volumetric target for India to produce 1.5 billion tonnes of coal by 2020
- objective of reducing reliance on fossil-fuel imports by 10%.
- including the objective of supplying round-the-clock electricity to all of India's population

- increased private investment (including foreign investment) in energy

- Effective co-ordination has been improved by the appointment of a single Minister for Power, Coal, New and Renewable Energy, although the individual ministries themselves continue to exist as separate entities.

Figure 1.12 ▻ Main institutions in India with influence on energy policy

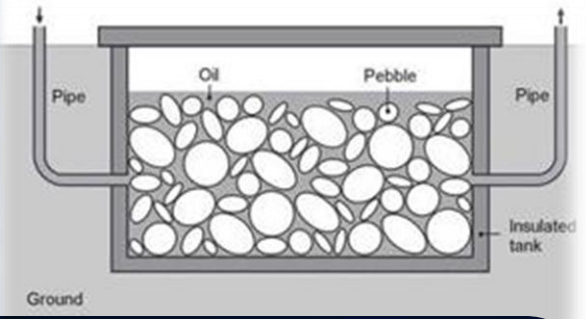


Notes: PSU = Public sector undertaking (state-owned enterprise). Other ministries with responsibilities relevant to the energy sector include the Ministry of Urban Development, Ministry of Water Resources, Ministry of Agriculture, Ministry of Finance and the Department of Science and Technology.

Source: Adapted from (IEA, 2012).

Energy prices and affordability

Module II



Energy storage system

Energy Management

Energy Audit

Energy Analysis

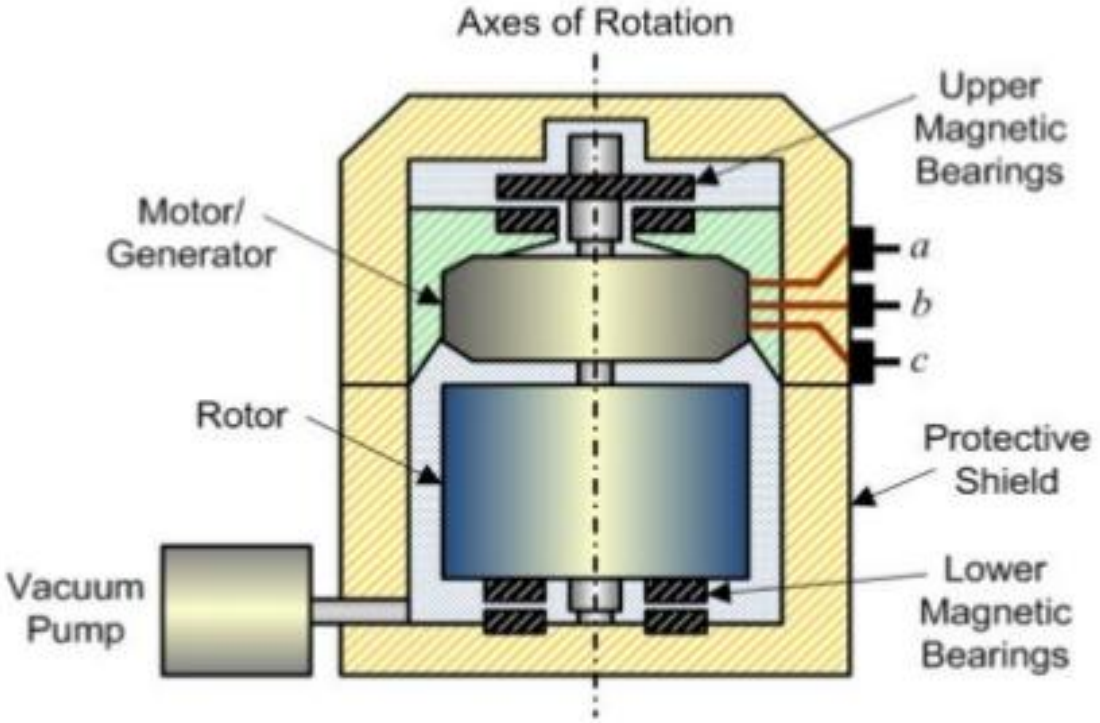
Thermal Energy storage

- Sensible heat storage
- Latent heat storage
- Thermal chemical storage

- Low temperature below 100 degree Celsius
- Medium temperature 100-500
- High temperature above 500

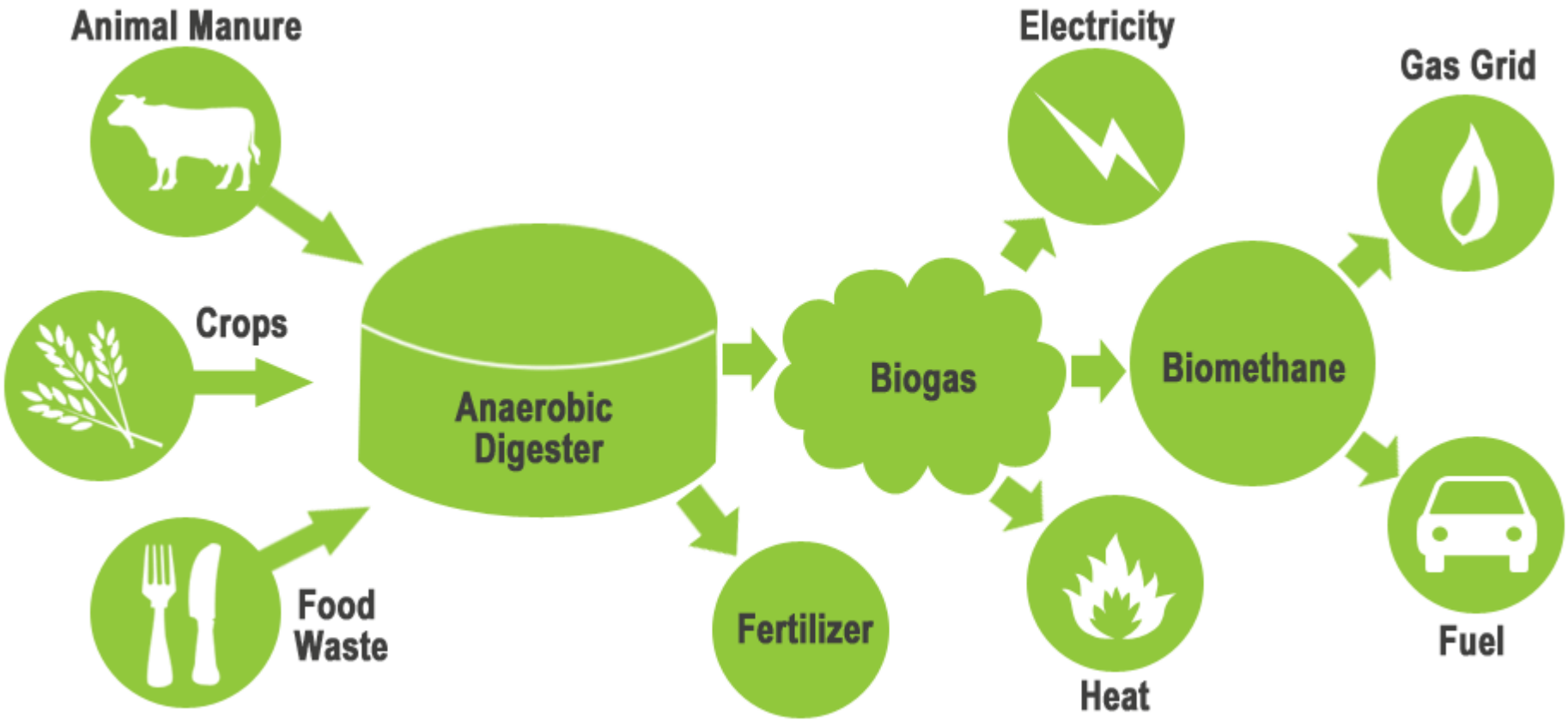
- Liquid as storage medium
- Solid as storage medium

FLY WHEEL ENERGY STORAGE

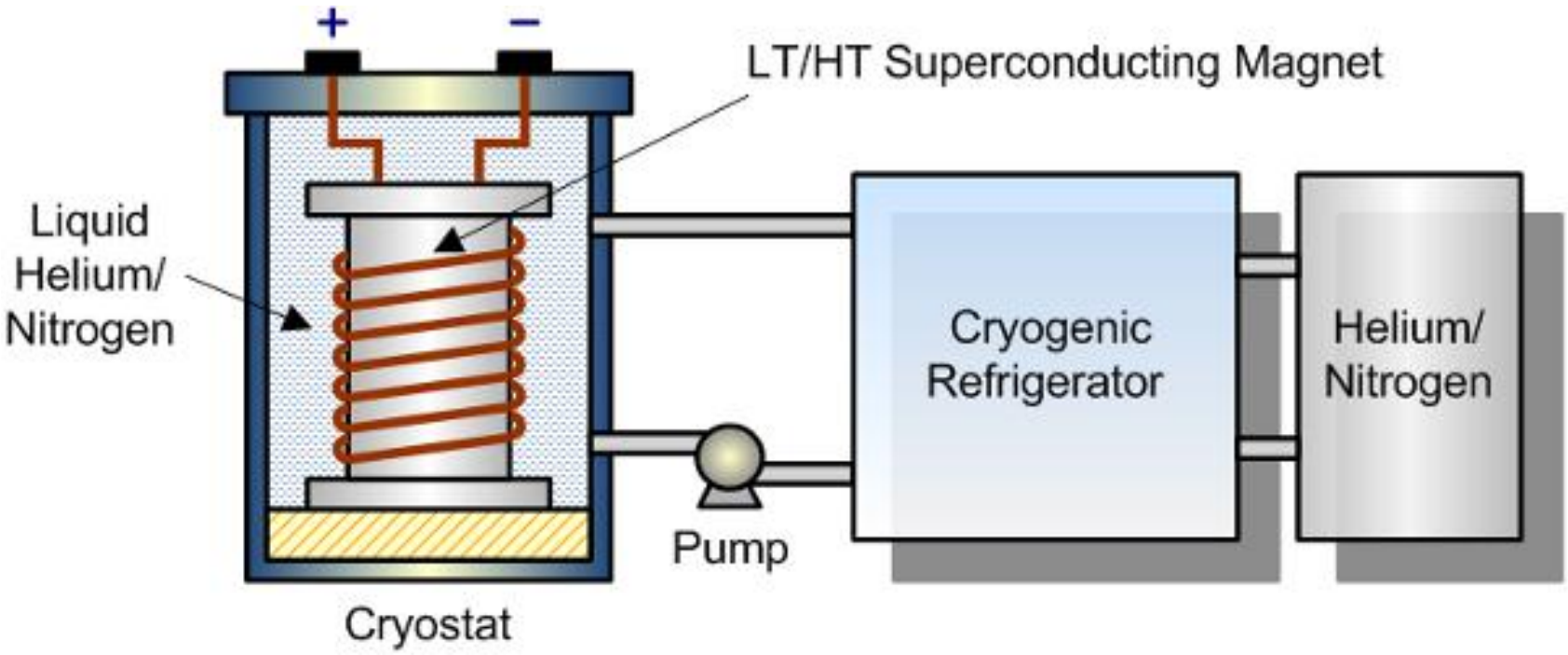


Chemical energy Storage

Biological Storage



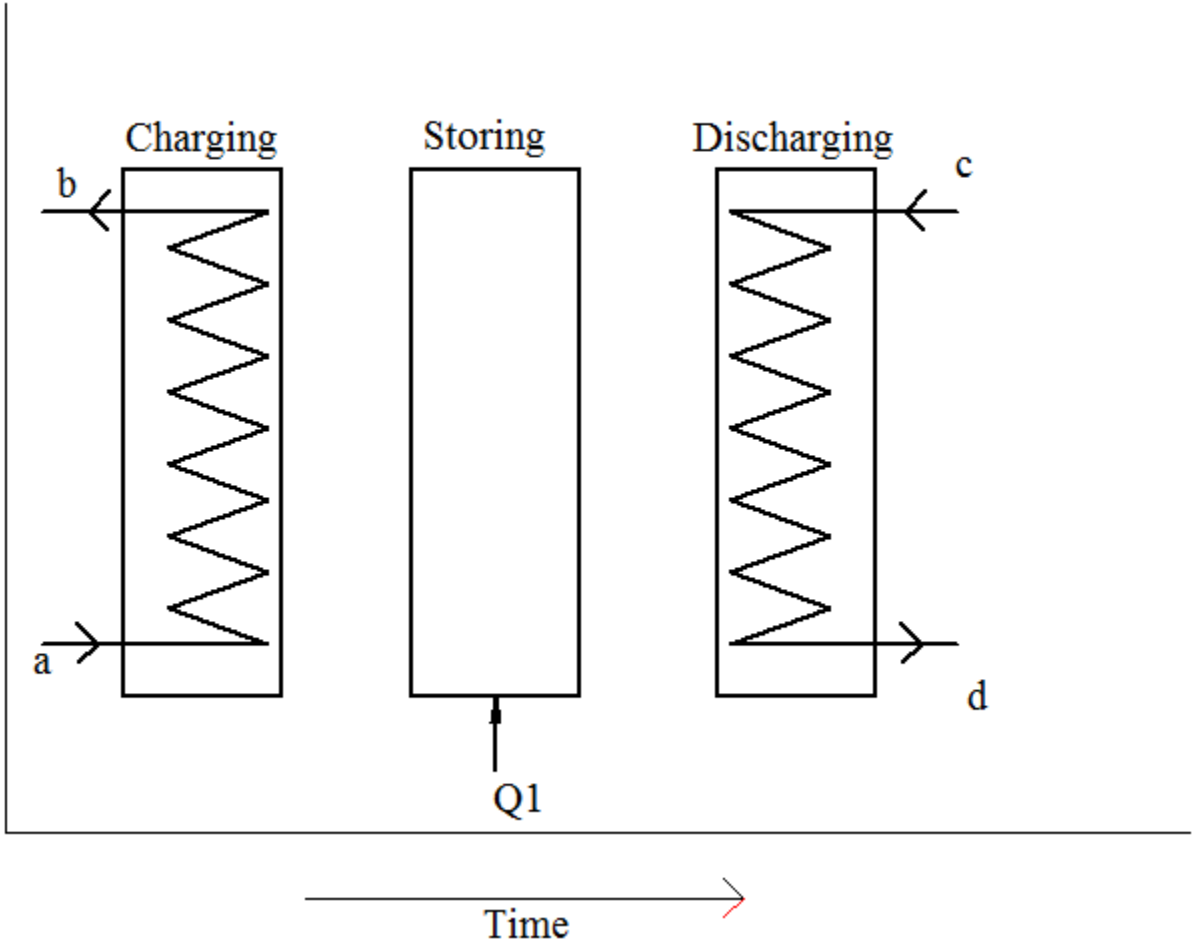
Magnetic Storage (SMES)



Thermal Energy Storage (TES)

- Why Thermal Energy Storage?
  - Primary energy sources are conventional Energy sources.
  - Electricity generation has to be balanced to satisfy fluctuation.
  - Seasonal fluctuation is out of control.
  - Utility companies generate electricity using primary energy sources to offset peak.
  - Almost every modern society has mid day and early evening electricity demand.
  - Demand leads to build additional peak demand power station leads to 3-4 times higher energy bill than standard base load electricity production cost.

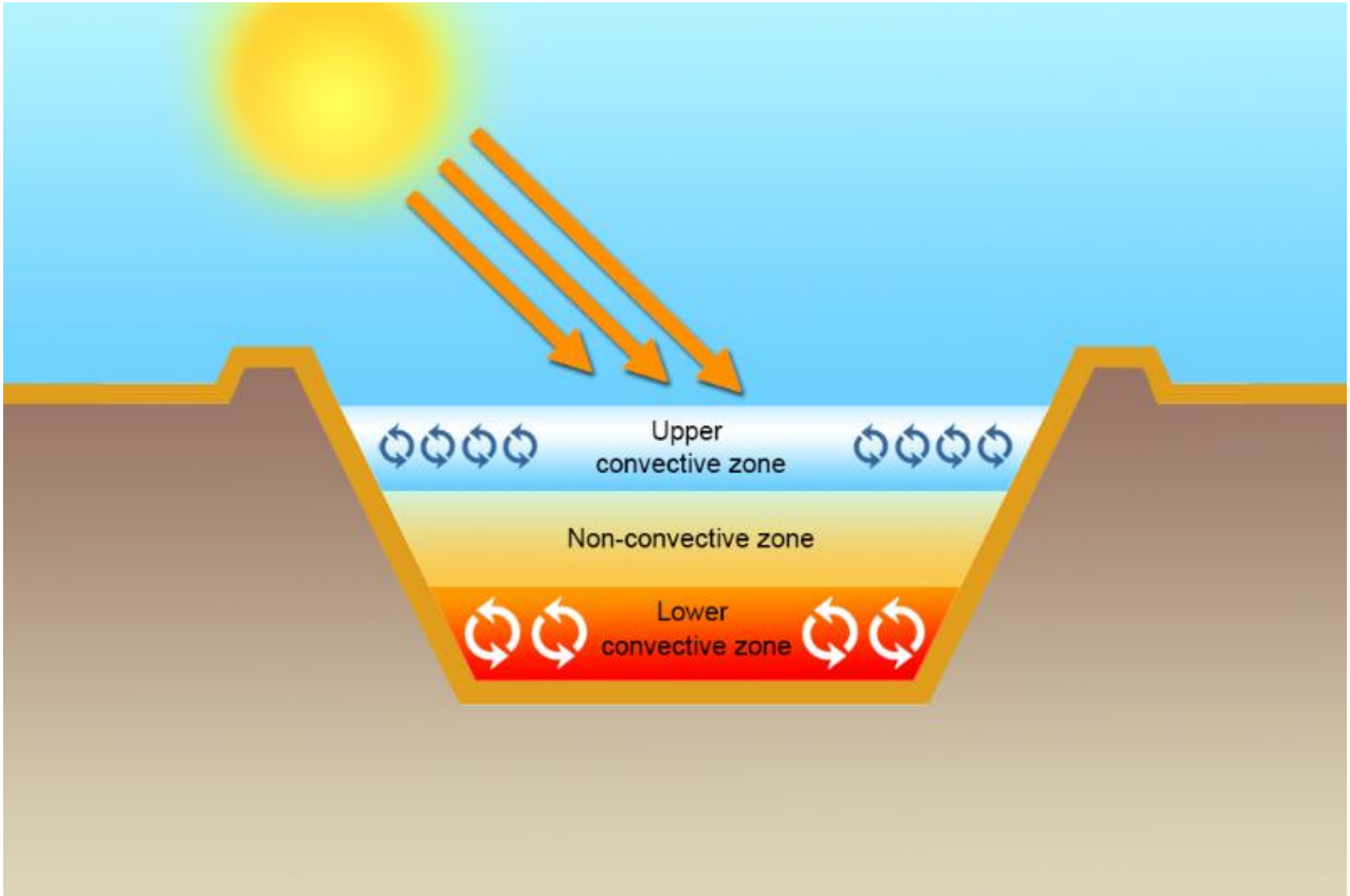
Definition of thermal storage



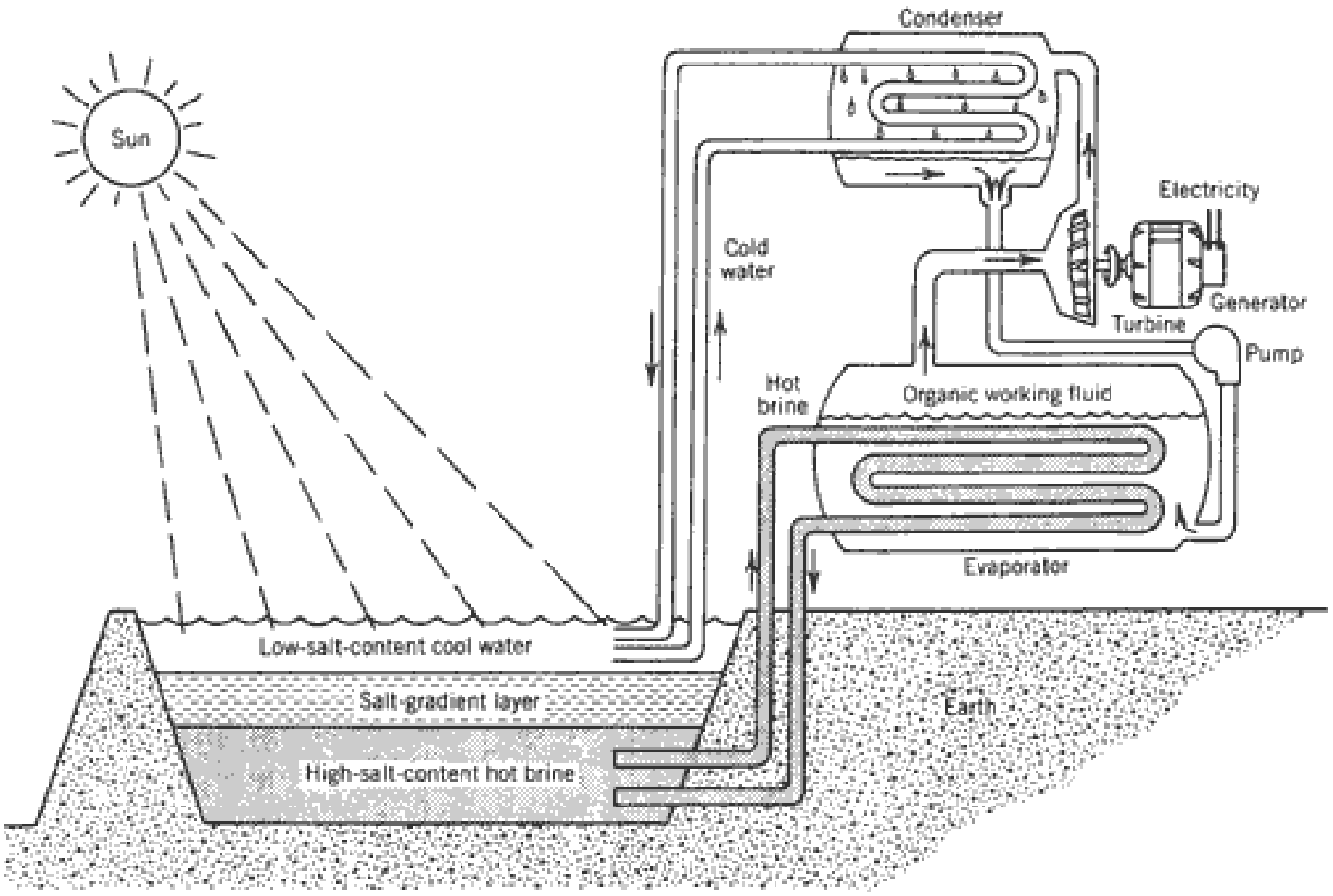
Types of thermal storage system

- Cold storage
- Fabric and slab energy storage
- Solar storage
- Packed Rock beds
- Low temperature CO2 Storage
- Thermo chemical energy storage
- Sensible heat
- Latent heat

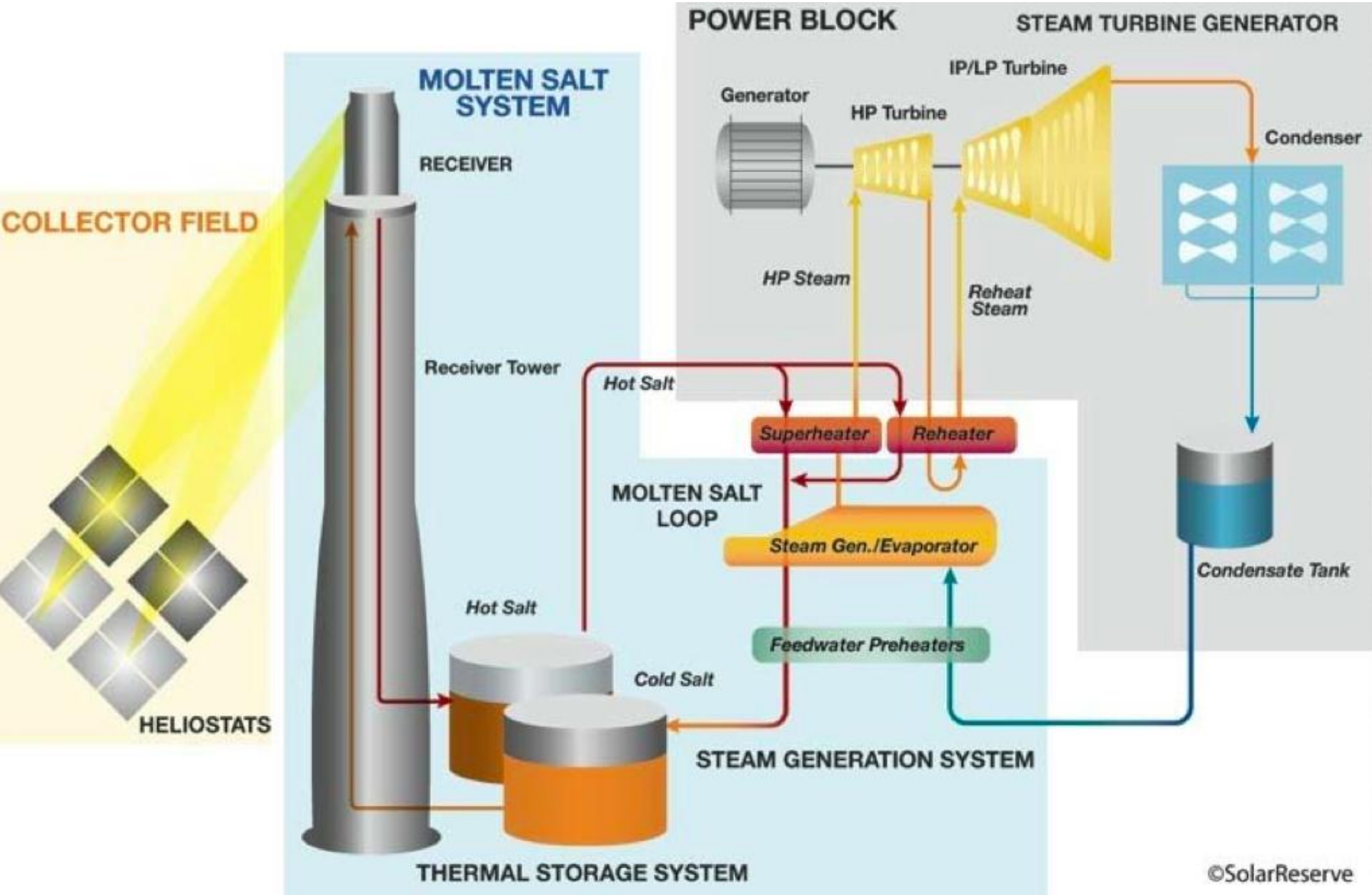
Sensible heat storage : Solar Pond



Sensible heat storage : Solar Pond



Latent heat storage



Energy Audit

As per the Energy Conservation Act, 2001, Energy Audit is defined as "the verification, monitoring and analysis of use of energy including submission of technical report containing recommendations for improving energy efficiency with cost benefit analysis and an action plan to reduce energy consumption".

Need for Energy Audit

- Energy Audit will help to understand more about the ways energy and fuel are used in any industry, and help in identifying the areas where waste can occur and where scope for improvement exists.

Type of Energy Audit

- The type of Energy Audit to be performed depends on:

  - Function and type of industry

  - Depth to which final audit is needed

  - Potential and magnitude of cost reduction desired

- Thus Energy Audit can be classified into the following two types.

  i) Preliminary Audit

  ii) Detailed Audit

Preliminary Energy Audit Methodology

- Establish energy consumption in the organization
- Estimate the scope for saving
- Identify the most likely (and the easiest areas for attention)
- Identify immediate (especially no-/low-cost) improvements/ savings
- Set a 'reference point'
- Identify areas for more detailed study/measurement
- Preliminary energy audit uses existing, or easily obtained data

Detailed energy auditing

- Detailed energy auditing is carried out in three phases: Phase I, II and III.
- **Phase I - Pre Audit Phase**
- **Phase II - Audit Phase**
- **Phase III - Post Audit Phase**

Ten Steps Methodology for Detailed Energy Audit

Step No	PLAN OF ACTION	PURPOSE / RESULTS
	Phase I –Pre Audit Phase	
Step 1	• Plan and organise • Walk through Audit • Informal Interview with Energy Manager, Production / Plant Manager	• Resource planning, Establish/organize a Energy audit team • Organize Instruments & time frame • Macro Data collection (suitable to type of industry.) • Familiarization of process/plant activities • First hand observation & Assessment of current level operation and practices
Step 2	• Conduct of brief meeting / awareness programme with all divisional heads and persons concerned (2-3 hrs.)	• Building up cooperation • Issue questionnaire for each department • Orientation, awareness creation

Step 3	Phase II –Audit Phase • Primary data gathering, Process Flow Diagram, & Energy Utility Diagram	• Historic data analysis, Baseline data collection • Prepare process flow charts • All service utilities system diagram (Example: Single line power distribution diagram, water, compressed air & steam distribution. • Design, operating data and schedule of operation • Annual Energy Bill and energy consumption pattern (Refer manual, log sheet, name plate, interview)
Step 4	• Conduct survey and monitoring	• Measurements : Motor survey, Insulation, and Lighting survey with portable instruments for collection of more and accurate data. Confirm and compare operating data with design data.
Step 5	• Conduct of detailed trials /experiments for selected energy guzzlers	• Trials/Experiments: - 24 hours power monitoring (MD, PF, kWh etc.). - Load variations trends in pumps, fan compressors etc.

		- Boiler/Efficiency trials for (4 – 8 hours) - Furnace Efficiency trials Equipments Performance experiments etc
Step6	• Analysis of energy use	• Energy and Material balance & energy loss/waste analysis
Step 7	• Identification and development of Energy Conservation (ENCON) opportunities	• Identification & Consolidation ENCON measures • Conceive, develop, and refine ideas • Review the previous ideas suggested by unit personal • Review the previous ideas suggested by energy audit if any • Use brainstorming and value analysis techniques • Contact vendors for new/efficient technology

Step 8	• Cost benefit analysis	• Assess technical feasibility, economic viability and prioritization of ENCON options for implementation • Select the most promising projects • Prioritise by low, medium, long term measures
Step9	• Reporting & Presentation to the Top Management	• Documentation, Report Presentation to the top Management.
	Phase III –Post Audit phase	
Step10	• Implementation and Follow-up	Assist and Implement ENCON recommendation measures and Monitor the performance • Action plan, Schedule for implementation • Follow-up and periodic review

Sample format for Energy Audit

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Energy and Environment

Module 3
Environment

Environmental studies deals with every issue that affects an organism. It is essentially a multidisciplinary approach that brings about an appreciation of our natural world and human impacts on its integrity.

Its components include biology, geology, chemistry, physics, engineering, sociology, health, anthropology, economics, statistics, computers and philosophy.

Scope

As we look around at the area in which we live, we see that our surroundings were originally a natural landscape such as a forest, a river, a mountain, a desert, or a combination of these elements.

Everything around us forms our environment and our lives depend on keeping its vital systems as intact as possible.

Natural forest acts like a sponge which holds water and releases it slowly. Deforestation leads to floods in the monsoon and dry rivers once the rains are over.

Our natural resources can be compared with money in a bank. If we use it rapidly, the capital will be reduced to zero. On the other hand, if we use only the interest, it can sustain us over the longer term. This is called sustainable utilisation or development.

Activity 1:

Take any article that you use in daily life – a bucket full of water, or an item of food, a table, or a book. Trace its components journey backwards from your home to their origins as natural resources in our environment. How many of these components are renewable resources and how many non-renewable?

For every resource we use we must ask ourselves the following questions:

- What is the rarity of the resource and where does it originate?

- Who uses it most intensively and how?

- How is it being overused or misused?

- Who is responsible for its improper use – the resource collector, the middleman, the end user?

- How can we help to conserve it and prevent its unsustainable use?

Activity 2:

Try to answer the questions above for one of the components in the article you chose in Activity 1. Then answer the following questions:

- Are you using that resource unsustainably?

- In what ways could you reduce, reuse and recycle that resource?

- Is there an unequal distribution of this resource so that you are more fortunate than many others who have less access to it?

Importance

We live in a world in which natural resources are limited. Water, air, soil, minerals, oil, the products we get from forests, grasslands, oceans and from agriculture and livestock, are all a part of our life support systems. Without them, life itself would be impossible.

We waste or pollute large amounts of nature's clean water; we create more and more material like plastic that we discard after a single use; and we waste colossal amounts of food, which is discarded as garbage.

Manufacturing processes create solid waste by products that are discarded, as well as chemicals that flow out as liquid waste and pollute water, and gases that pollute the air.

Air pollution leads to respiratory diseases, water pollution to gastro-intestinal diseases, and many pollutants are known to cause cancer.

We cannot expect Governments alone to manage the safeguarding of the environment, nor can we expect other people to prevent environmental damage.

Activity 3:

- Think of all the things that you do in a day. List these activities and identify the main resources used during these activities. What can you do to prevent waste, reuse articles that you normally throw away, what recycled materials can you use?

- Think of the various energy sources you use everyday. How could you reduce their use?

Activity 4:

Exercises in self learning about the environment

Attempt to assess the level of damage to the environment due to your actions that have occurred during your last working day, the last week, the last year. Then estimate the damage you are likely to do in your lifetime if you continue in your present ways.

Use the following examples for the above exercise:

Example – Plastic: Plastic bags, plastic ball pens

Think about all the articles you use daily that are made from plastic. Plastic plays an important part in our modern lives.

Make a list of the plastic articles you usually use.

- How can you reduce the amount of plastic you use?
- What effects does plastic have on our environment?
- Where did the plastic come from/ how is it made?
- What happens to it when you throw it away/ where does it go?

Example – Water:

- How much do you really need to use, as against how much you waste when you:

(a) Brush your teeth? (b) Have a bath? (c) Wash clothes? (d) Wash the scooter or car?

- Where did the water come from? What is its actual source? How has it reached you?
- Where will the waste water go?
- Do you feel you should change the way you use water?
- How can you change this so that it is more sustainable?

Productive value of nature:

As scientists make new advances in fields such as biotechnology we begin to understand that the world's species contain an incredible and uncountable number of complex chemicals. These are the raw materials that are used for developing new medicines and industrial products and are a storehouse from which to develop thousands of new products in the future.

While individually, we perhaps cannot directly prevent the extinction of a species, creating a strong public opinion to protect the National Parks and Wildlife Sanctuaries in which wild species live is an importance aspect of sustainable living.

There is a close link between agriculture and the forest, which illustrates its productive value. For crops to be successful, the flowers of fruit trees and vegetables must be pollinated by insects, bats and birds. Their life cycles however frequently require intact forests.

Aesthetic/Recreational value of nature:

This is created by developing National Parks and Wildlife Sanctuaries in relatively undisturbed areas. A true wilderness experience has not only recreational value but is an incredible learning experience.

The beauty of nature encompasses every aspect of the living and non-living part of our earth. One can appreciate the magnificence of a mountain, the power of the sea, the beauty of a forest, and the vast expanse of the desert.

A wilderness experience has exceptional recreational value. This has been described as nature tourism, or wildlife tourism, and is also one aspect of adventure tourism. These recreational facilities not only provide a pleasurable experience but are intended to create a deep respect and love for nature.

A botanical garden or a zoo, one concept that can be developed is to create small nature awareness areas with interpretation facilities at district and taluka levels. These areas can be developed to mimic natural ecosystems even though they could be relatively small in size.

Such nature trails are invaluable assets for creating conservation education and awareness. They can be developed in a small woodlot, a patch of grassland, a pond ecosystem, or be situated along an undisturbed river or coastal area. This would bring home to the visitor the importance of protecting our dwindling wilderness areas.

The option values of nature:

Thus if we use up all our resources, kill off and let species of plants and animals become extinct on earth, pollute our air and water, degrade land, and create enormous quantities of waste, we as a generation will leave nothing for future generations. Our present generation has developed its economies and lifestyles on unsustainable patterns of life. however, nature provides us with various options on how we utilize its goods and services.

This is its option value. We can use up goods and services greedily and destroy its integrity and long term values, or we can use its resources sustainably and reduce our impacts on the environment. The option value allows us to use its resources sustainably and preserve its goods and services for the future.

NEED FOR PUBLIC AWARENESS

Just as for any disease, prevention is better than cure. To prevent ill-effects on our environment by our actions, is economically more viable than cleaning up the environment once it is damaged. Individually we can play a major role in environment management. We can reduce wasting natural resources and we can act as watchdogs that inform the Government about sources that lead to pollution and degradation of our environment.

This can only be made possible through mass public awareness. Mass media such as newspapers, radio, television, strongly influence public opinion. However, someone has to bring this about. If each of us feels strongly about the environment, the press and media will add to our efforts. Politicians in a democracy always respond positively to a strong publicly supported movement

Suggested further activities for concerned students:

- Join a group to study nature, such as WWFI or BNHS, or another environmental group.
- Begin reading newspaper articles and periodicals such as 'Down to Earth', WWF-I newsletter, BNHS Hornbill, Sanctuary magazine, etc. that will tell you more about our environment. There are also several environmental websites.
- Lobby for conserving resources by taking up the cause of environmental issues during discussions with friends and relatives.

Practice and promote issues such as saving paper, saving water, reducing use of plastics, practicing the 3Rs principle of reduce, reuse, recycle, and proper waste disposal.

- Join local movements that support activities such as saving trees in your area, go on nature treks, recycle waste, buy environmentally friendly products.

- Practice and promote good civic sense such as no spitting or tobacco chewing, no throwing garbage on the road, no smoking in public places, no urinating or defecating in public places.

- Take part in events organised on World Environment Day, Wildlife Week, etc.

- Visit a National Park or Sanctuary, or spend time in whatever nature you have near your home.

Institutions in Environment

Bombay Natural History Society (BNHS), Mumbai: BNHS began as a small society of six members in 1883. publishes a popular magazine called Hornbill and also an internationally well-known Journal on Natural History. publications include

Salim Ali ------Handbook on birds,

JC Daniel's ----Indian Reptiles,

SH Prater's ----Indian Mammals and

PV Bole's -------Indian Trees.

One of its greatest scientists was Dr. Salim Ali whose ornithological work on the birds of the Indian subcontinent is world famous.

World Wide Fund for Nature (WWF-I), New Delhi: The WWF-I was initiated in 1969 in Mumbai after which the headquarters were shifted to Delhi with several branch offices all over India. The early years focused attention on wildlife education and awareness. It runs several programs including the Nature Clubs of India program for school children and works as a think tank and lobby force for environment and development issues.

Center for Science and Environment (CSE), New Delhi: Activities of this Center include organising campaigns, holding workshops and conferences, and producing environment related publications. It published a major document on the 'State of India's Environment', the first of its kind to be produced as a Citizen's Report on the Environment. The CSE also publishes a popular magazine, 'Down to Earth',

CPR Environmental Education Centre, Madras: The CPR EEC was set up in 1988. It conducts a variety of programs to spread environmental awareness and creates an interest in conservation among the general public. It focussed attention on NGOs, teachers, women, youth and children to generally promote conservation of nature and natural resources. Its programs include components on wildlife and biodiversity issues. CPR EEC also produces a large number of publications.

Centre for Environment Education (CEE), Ahmedabad: The Centre for Environment Education, Ahmedabad was initiated in 1989. It has a wide range of programs on the environment and produces a variety of educational material. CEE's Training in Environment Education {TEE} program has trained many environment educators.

- Salim Ali Center for Ornithology and Natural History (SACON), Coimbatore:
- Bharati Vidyapeeth Institute of Environment Education and Research (BVIEER), Pune
- Botanical Survey of India (BSI):
- Kalpavriksh, Pune:
- Wildlife Institute of India (WII), Dehradun:
- Uttarkhand Seva Nidhi (UKSN), Almora:
- Zoological Survey of India (ZSI):

People in Environment

Charles Darwin ----'Origin of Species'

Ralph Emerson spoke of the dangers of commerce to our environment way back in the 1840s

Henry Thoreau in the 1860s wrote that the wilderness

John Muir is remembered as having saved the great ancient sequoia trees in California' forests

Rachel Carson published several articles that caused immediate worldwide concern on the effects of pesticides on nature and mankind

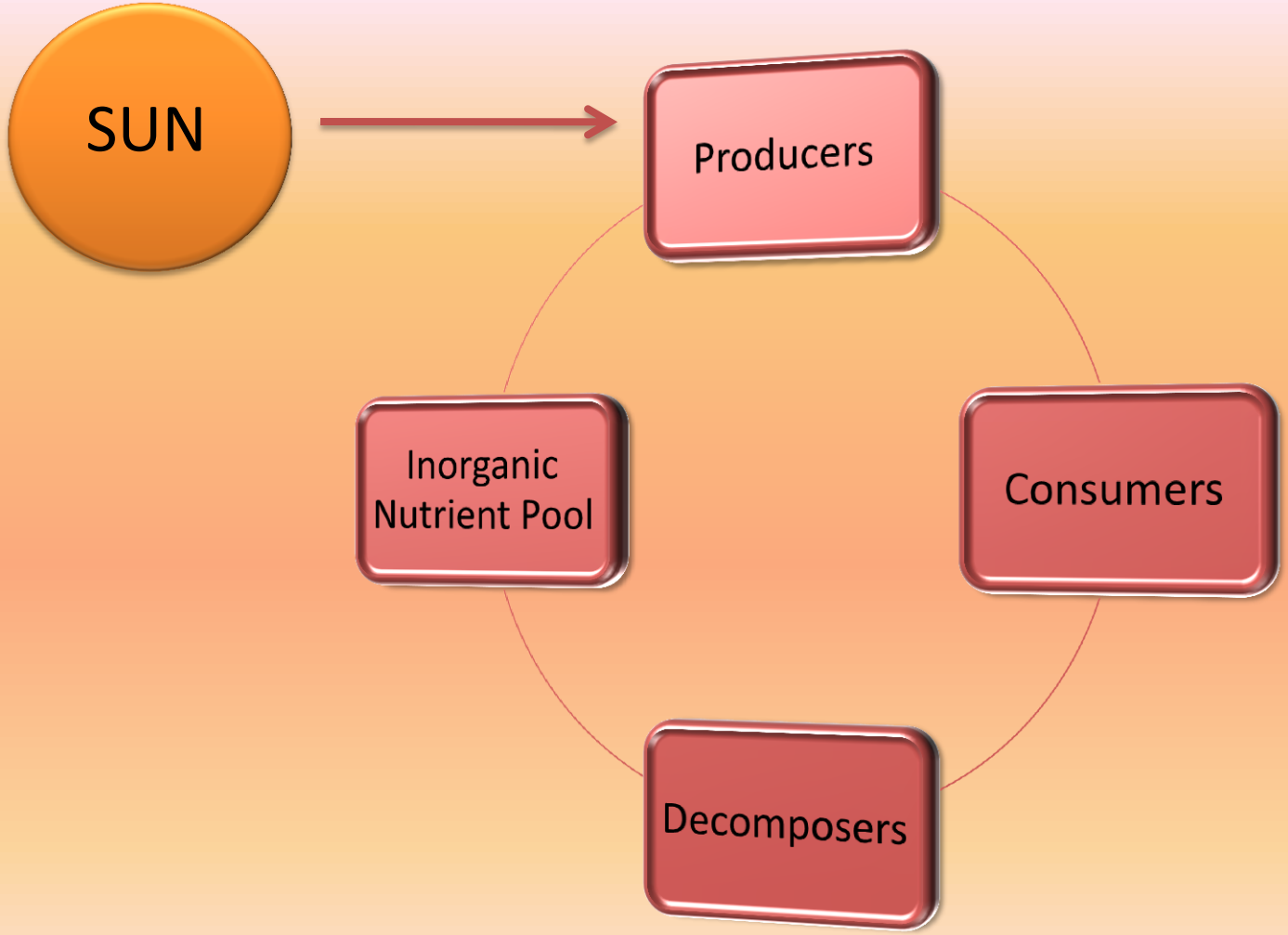
EO Wilson is an entomologist who envisioned that biological diversity was a key to human survival on earth. He wrote ‘Diversity of Life’ in 1993

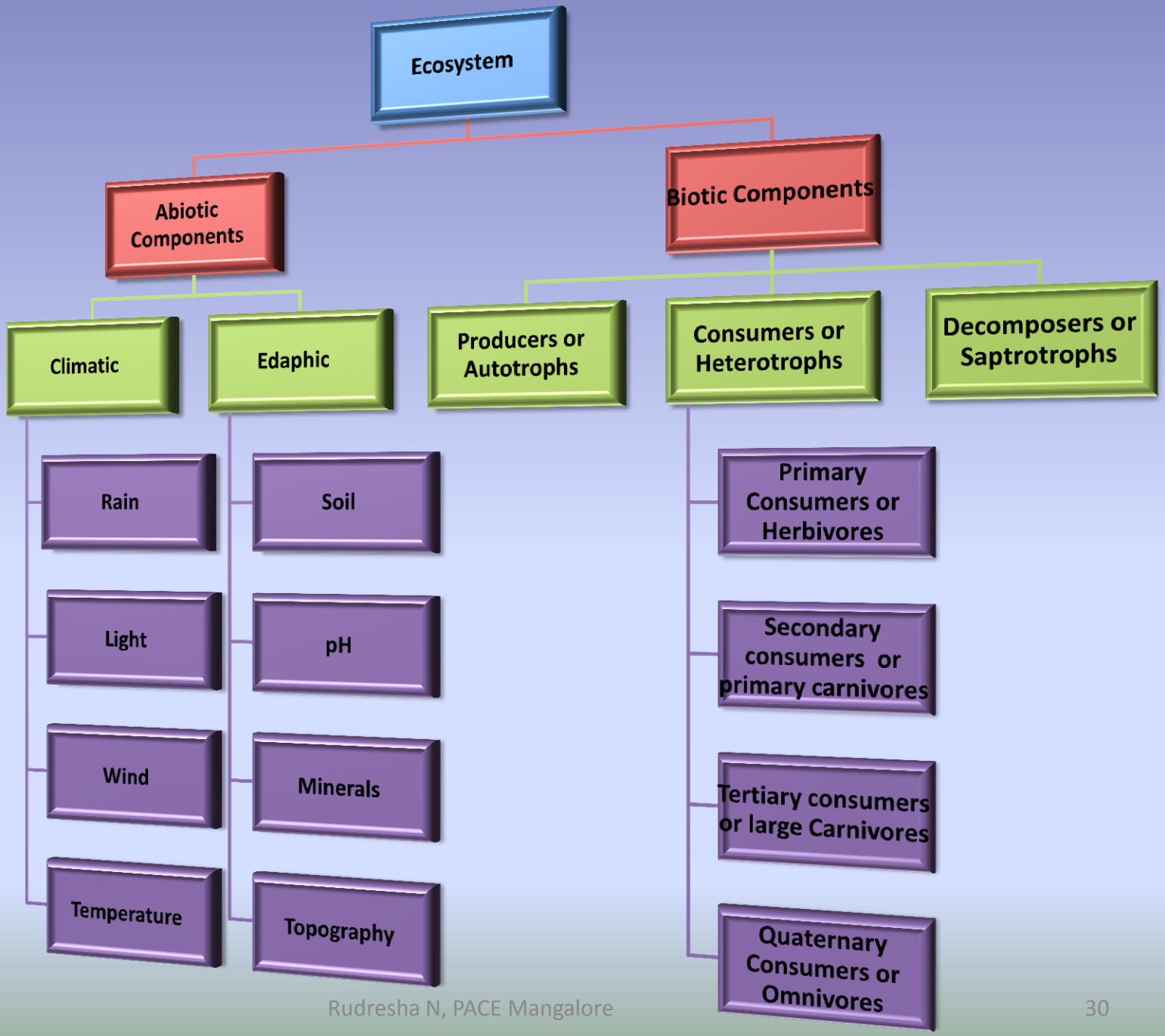
Salim Ali’s name is synonymous with ornithology in India and with the Bombay Natural History Society (BNHS)

Ecosystem

- Forests,
- Grasslands
- Deserts
- Mountains
- Rivers
- Lakes
- Marine Environment

Energy flow in Ecosystem




Ecosystem
Abiotic Components
Biotic Components
Climatic
Edaphic
Producers or Autotrophs
Consumers or Heterotrophs
Decomposers or Saptrotrophs
Rain
Light
Wind
Temperature
Soil
pH
Minerals
Topography
Primary Consumers or Herbivores
Secondary consumers or primary carnivores
Tertiary consumers or large Carnivores
Quaternary Consumers or Omnivores

FOOD CHAINS, FOOD WEBS AND ECOLOGICAL PYRAMIDS

- The transfer of energy from the source in plants through a series of organisms by eating and being eaten constitutes food chains.

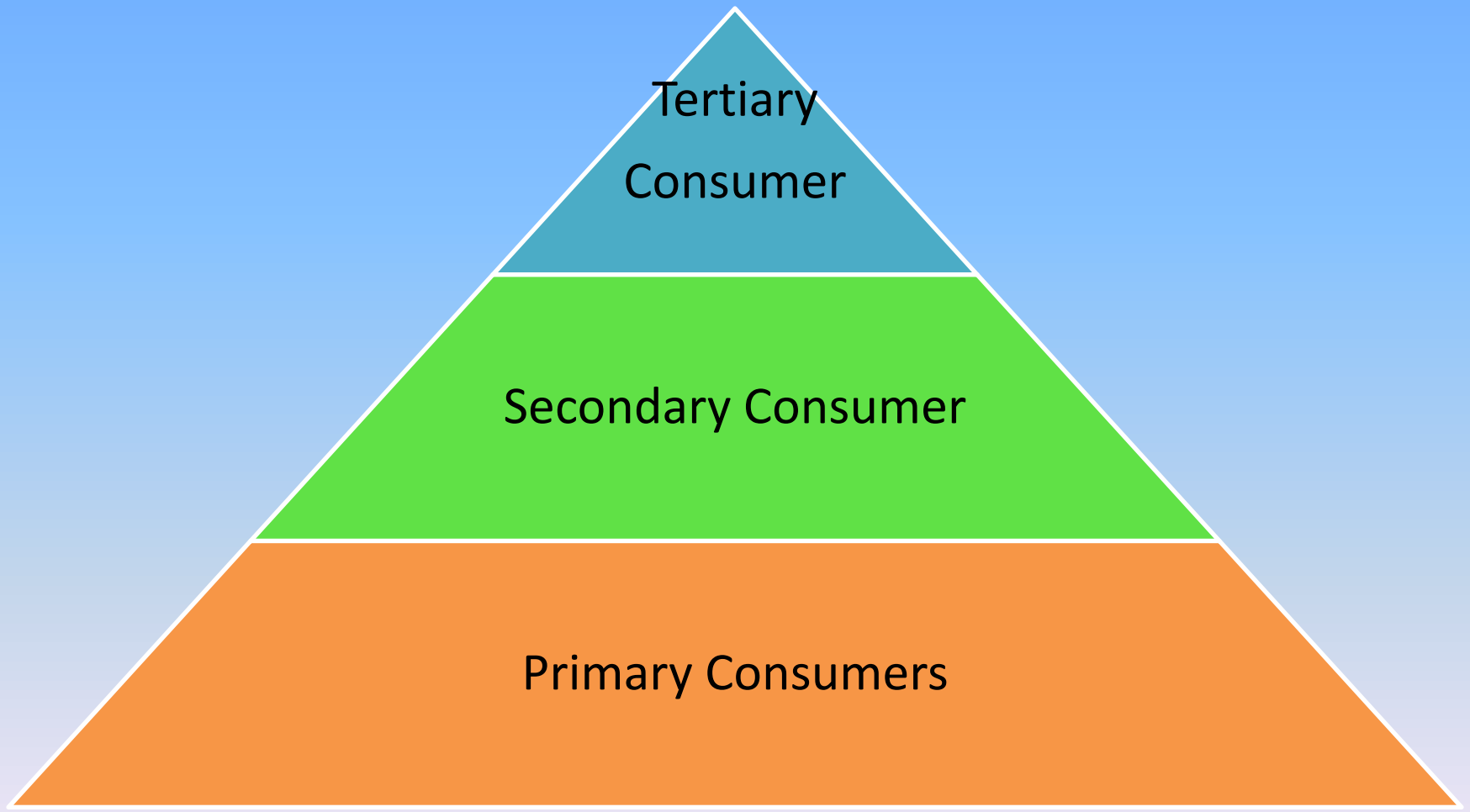
- The most obvious aspect of nature is that energy must pass from one living organism to another.

Food Webs

- In an ecosystem there are a very large number of interlinked chains. This forms a food web.

- If the linkages in the chains that make up the web of life are disrupted due to human activities that lead to the loss or extinction of species, the web breaks down.

Ecological Pyramids



What you should see are its different characteristics. A forest has layers from the ground to the canopy. A pond has different types of vegetation from the periphery to its centre. The vegetation on a mountain changes from its base to its summit.

Ecosystem:

The living community of plants and animals in any area together with the Non-living components of the environment such as Soil, Air and water constitute the ecosystem.

Ecosystems are divided into

1. Terrestrial or land based ecosystem
2. Aquatic ecosystem

STRUCTURE AND FUNCTIONS OF AN ECOSYSTEM.

Structural aspects

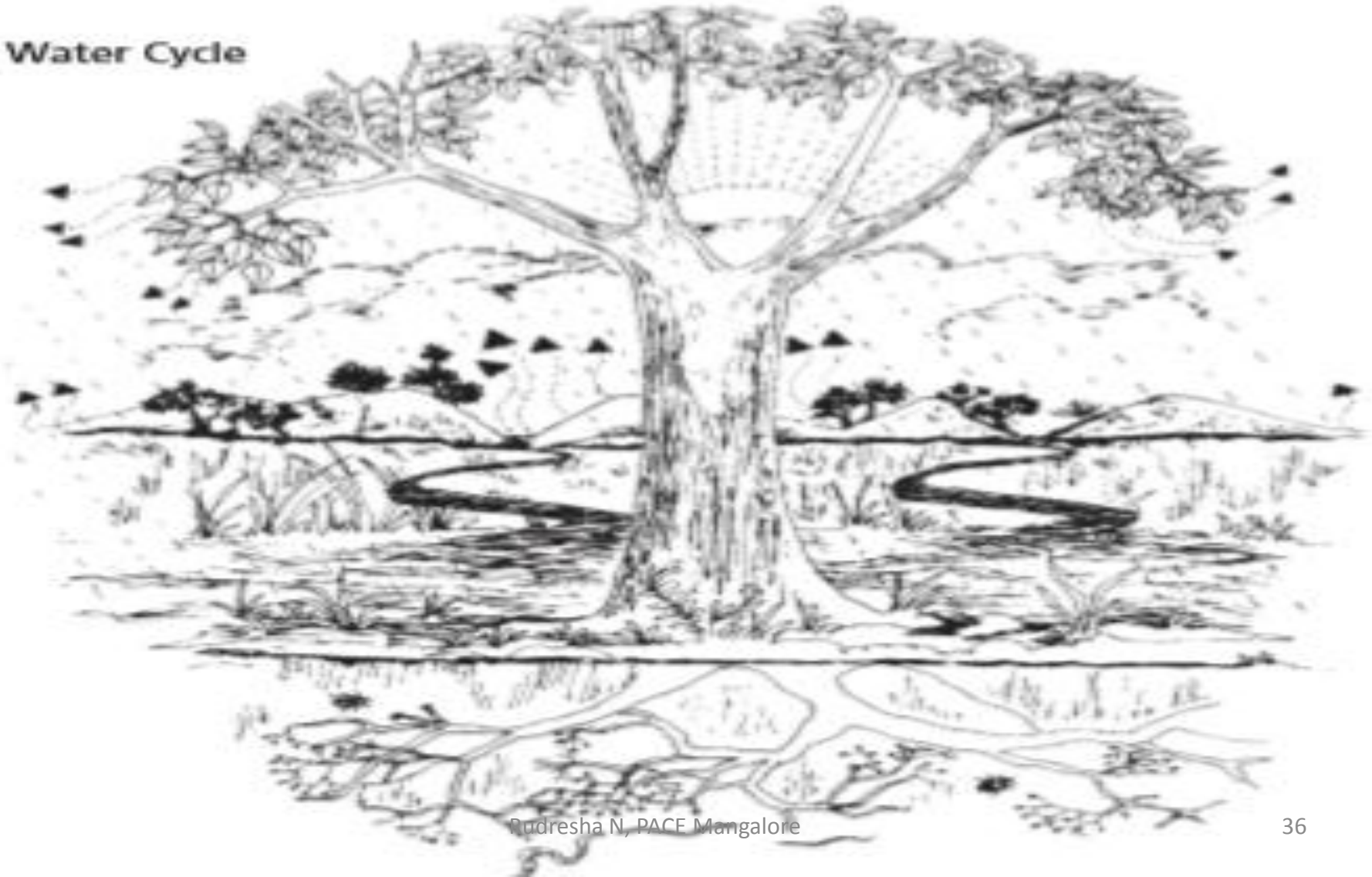
Components that make up the structural aspects of an ecosystem include:

1) Inorganic aspects – C, N, CO_2, H_2O.
2) Organic compounds – Protein, Carbohydrates, Lipids – link abiotic to biotic aspects.
3) Climatic regimes – Temperature, Moisture, Light & Topography.
4) Producers – Plants.
5) Macro consumers – Phagotrophs – Large animals.
6) Micro consumers – Saprotrophs, absorbers – fungi.

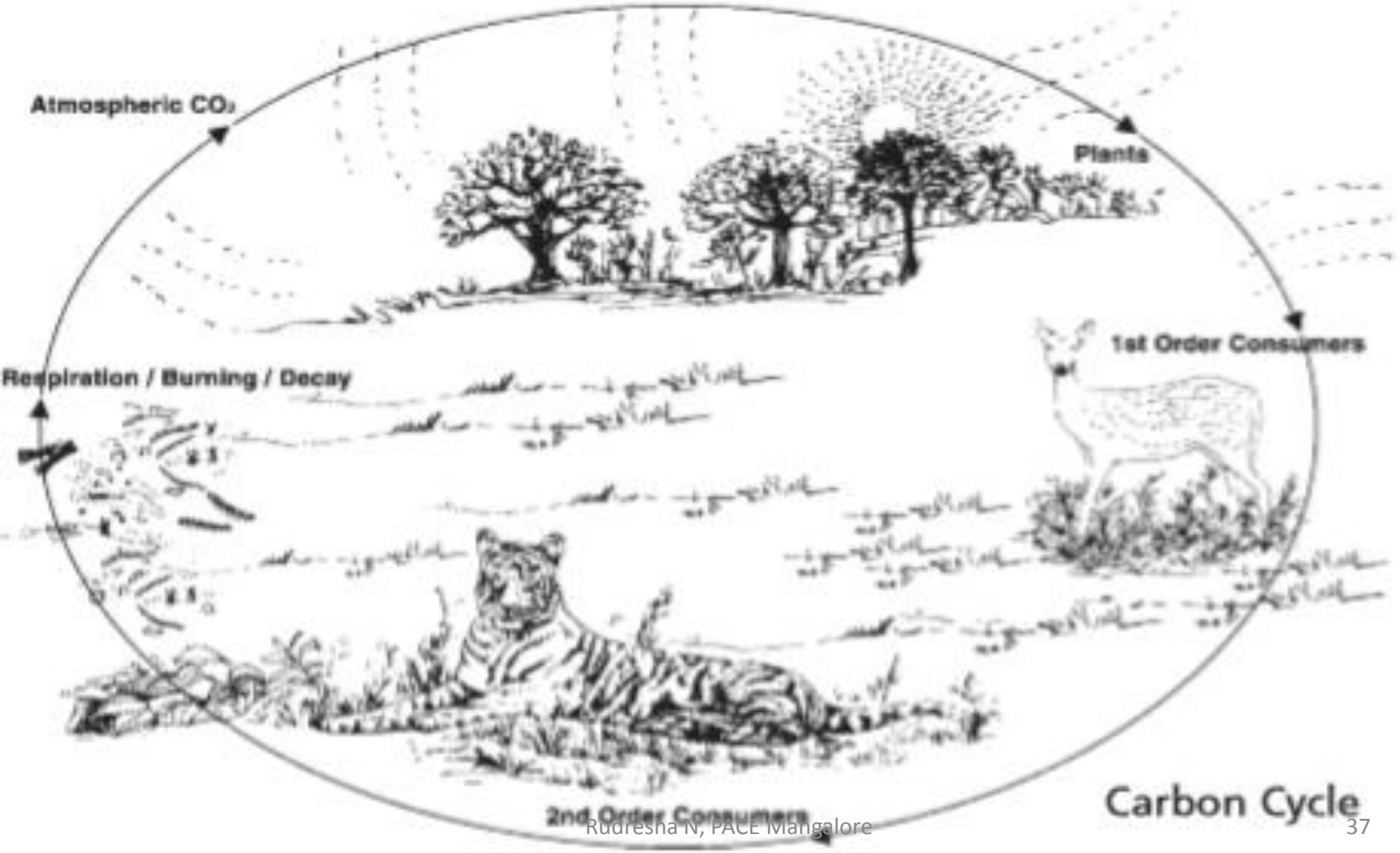
Functional aspects

1) Energy cycles.
2) Food chains.
3) Diversity-interlinkages between organisms.
4) Nutrient cycles-biogeochemical cycles.
5) Evolution.

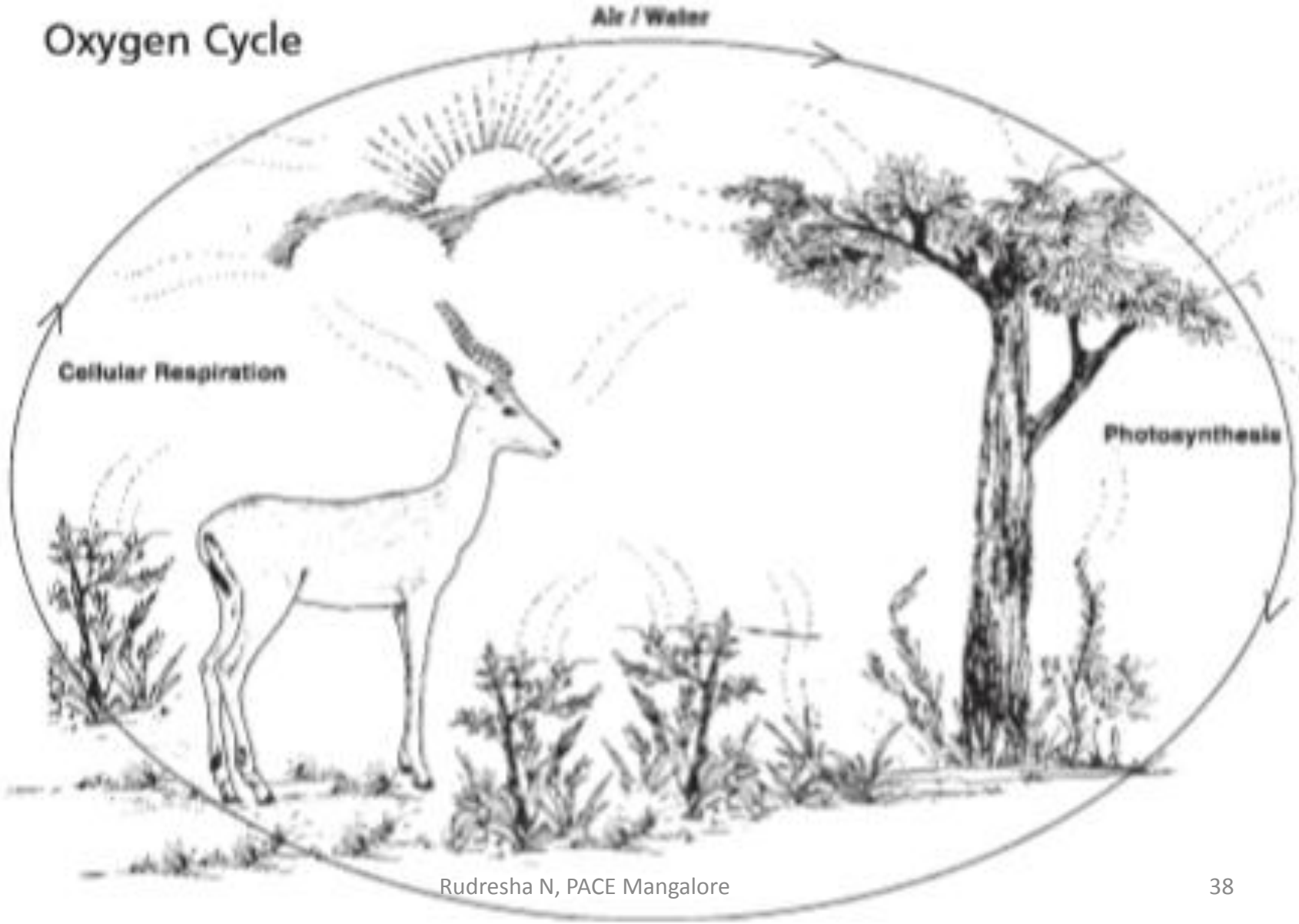
The Water Cycle



The Carbon cycle



The Oxygen Cycle



The Nitrogen Cycle

Energy Cycle

Forest ecosystem

Forests are formed by a community of plants which is predominantly structurally defined by its trees, shrubs, climbers and ground cover. Natural vegetation looks vastly different from a group of planted trees, which are in orderly rows. The most 'natural' undisturbed forests are located mainly in our National Parks and Wildlife Sanctuaries.

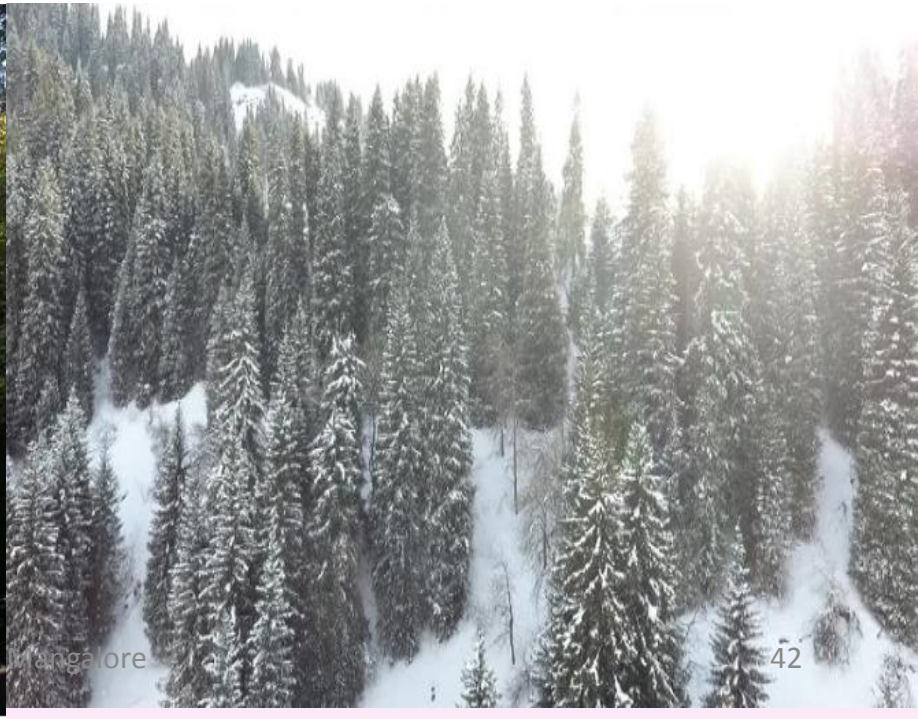
Forest types in India

1. Coniferous forests
2. Broadleaved forests

Coniferous forests

Grow in the Himalayan mountain region, where the temperatures are low. These forests have tall stately trees with needlelike leaves and downward sloping branches so that the snow can slip off the branches. They have cones instead of seeds and are called gymnosperms.

Coniferous forest



Broadleaved forests

Broadleaved forests have large leaves of various shapes. It is Classified as

1. Evergreen forests
2. Deciduous forests
3. Thorn forests
4. Mangrove forests

Evergreen forests grow in the high rainfall areas of the Western Ghats, North Eastern India and the Andaman and Nicobar Islands. These forests grow in areas where the monsoon lasts for several months. Some even get two monsoons, such as in Southern India.

Evergreen plants shed a few of their leaves throughout the year. There is no dry leafless phase as in a deciduous forest. An evergreen forest thus looks green throughout the year. The trees overlap with each other to form a continuous canopy. Thus very little light penetrates down to the forest floor.

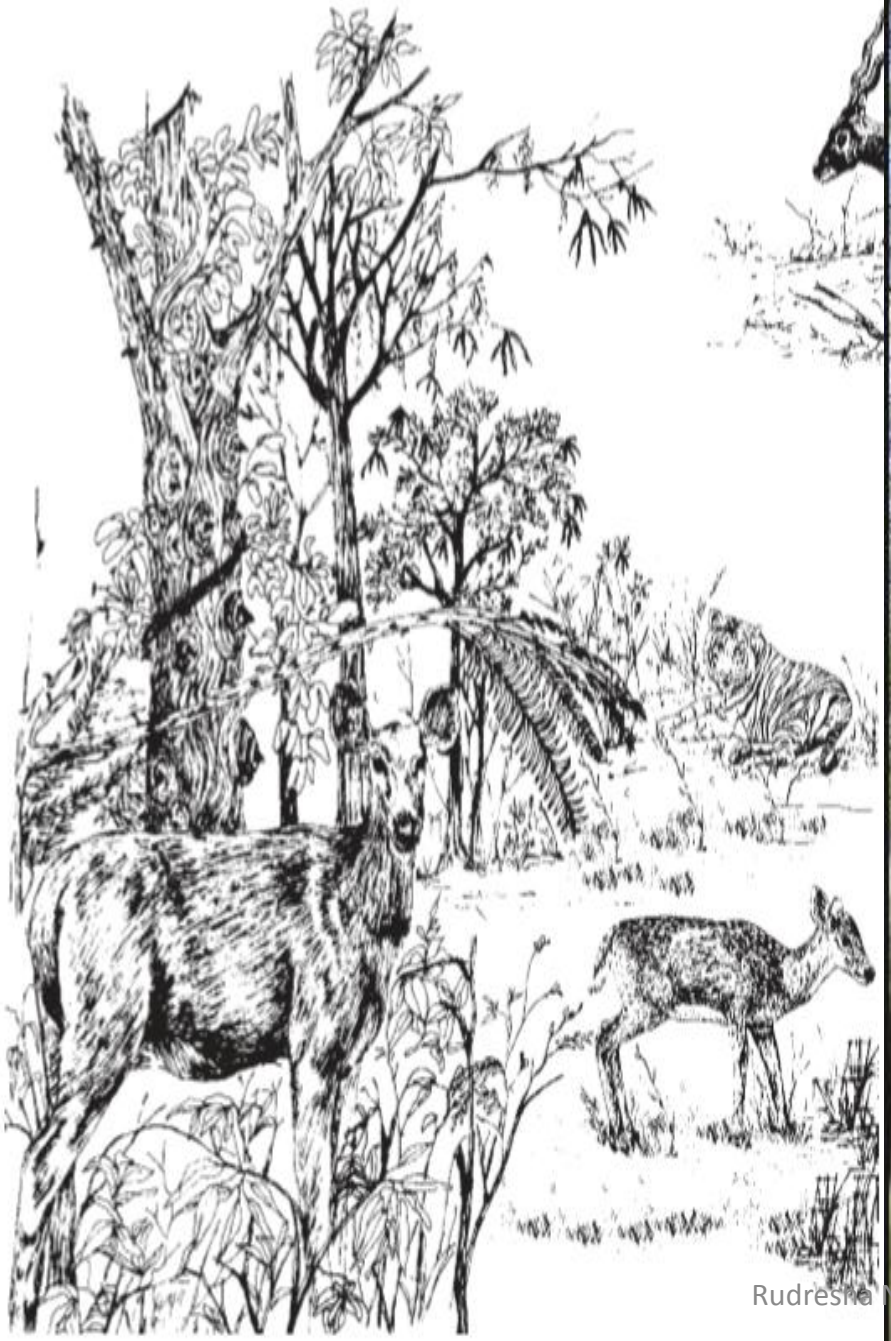
The forest is rich in orchids and ferns. The barks of the trees are covered in moss. The forest abounds in animal life and is most rich in insect life.

Deciduous forests

These are found in regions with a moderate amount of seasonal rainfall that lasts for only a few months. Most of the forests in which Teak trees grow are of this type. The deciduous trees shed their leaves during the winter and hot summer months. In March or April they regain their fresh leaves just before the monsoon, when they grow vigorously in response to the rains. Thus there are periods of leaf fall and canopy regrowth.

The forest frequently has a thick undergrowth as light can penetrate easily onto the forest floor.

Deciduous forest



Thorn forests

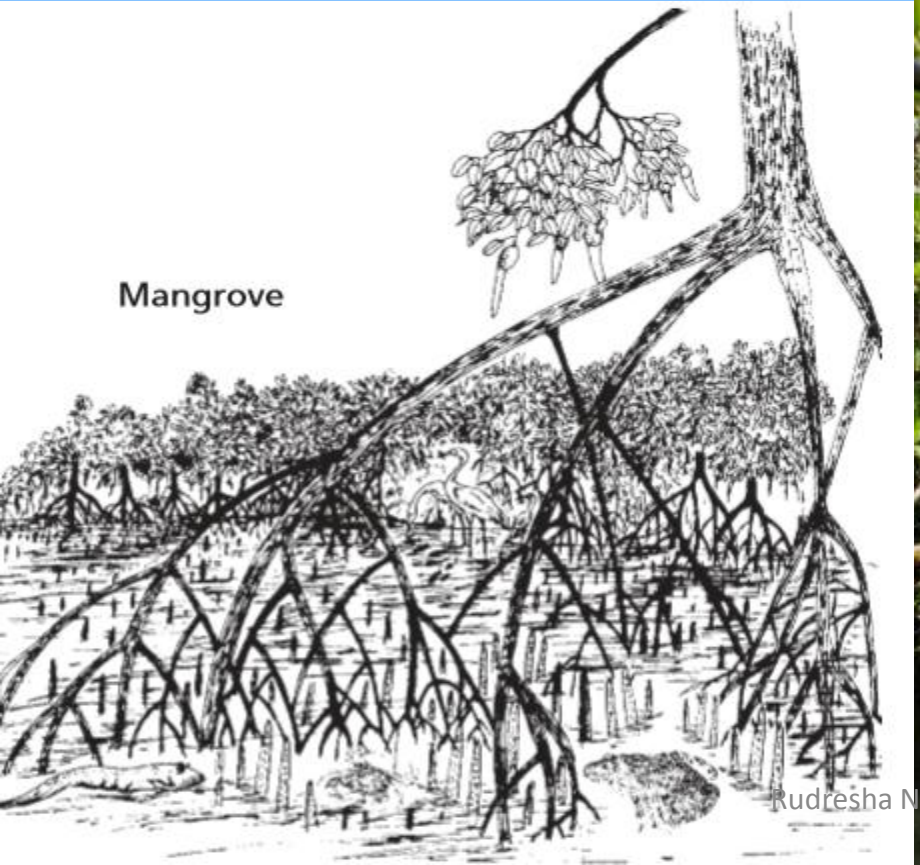
These are found in the semi- arid regions of India. The trees, which are sparsely distributed, are surrounded by open grassy areas. Thorny plants are called xerophytic species and are able to conserve water. Some of these trees have small leaves, while other species have thick, waxy leaves to reduce water losses during transpiration.

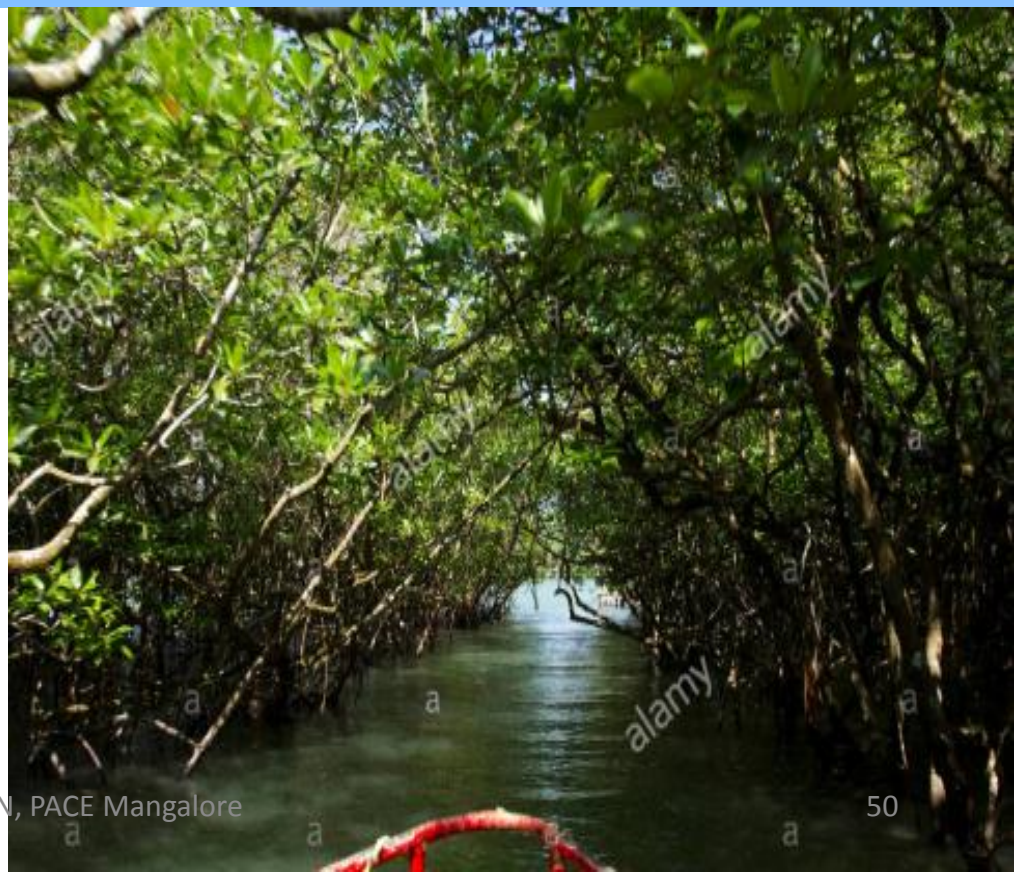
Thorn forest trees have long or fibrous roots to reach water at great depths. Many of these plants have thorns, which reduce water loss and protect them from herbivores.


Thorn forest

Mangrove forests

These forests grow along the coast especially in the river deltas. These plants are able to growin a mix of saline and fresh water. They grow luxuriantly in muddy areas covered with silt that the rivers have brought down. The mangrove trees have breathing roots that emerge from the mud-banks.





Forest communities:

Forest type	Plants Examples	Common Animal Examples	Rare Animal Examples
Himalayan Coniferous	Pine, deodar	Wild goats and sheep, Himalayan black bear.	Snow leopard, Hangul, Himalayan brown bear, Musk deer, Himalayan Wolf.
Himalayan Broadleaved	Maple, oak		
Evergreen North-east, Western Ghats, Andaman & Nicobar	Jamun, Ficus, Dipterocarpus	Tiger, Leopard, Sambar, Malabar whistling thrush, Malabar Pied hornbill, tree frogs.	Pigmy Hog, Rhino, Liontailed macaque
Deciduous – Dry	Teak, Ain, Terminalia	Tiger, Chital, Barking deer, Babblers, Flycatchers, Hornbills.	
Moist	Sal		
Thorn and scrub, Semiarid forests	Babul, Ber, Neem	Blackbuck, Chinkara, Fourhorned antelope, Partridge, Monitor lizard.	Wolf, Bustard, Florican, Bustards,
Mangrove Delta Forests	Avicenia	Crocodile, shorebirds – sandpipers, plovers, fish, crustacea.	Water monitor lizard.

Hungul

Musk deer

Pigmy Hog

lion tailed macaque



Bustard


Florican

Water monitor lizard

Grassland ecosystems

A wide range of landscapes in which the vegetation is mainly formed by grasses and small annual plants are adapted to India's various climatic conditions. These form a variety of grassland ecosystems with their specific plants and animals.

Grasslands cover areas where rainfall is usually low and/or the soil depth and quality is poor. The low rainfall prevents the growth of a large number of trees and shrubs, but is sufficient to support the growth of grass cover during the monsoon.

Many of the grasses and other small herbs become dry and the part above the ground dies during the summer months. In the next monsoon the grass cover grows back from the root stock and the seeds of the previous year.

Animals are able to live in conditions where food is plentiful after the rains, so that they can store this as fat that they use during the dry period when there is very little to eat.

Grassland Types in India:
variety of ecosystems that are located in different climatic conditions ranging from near desert conditions, to patches of shola grasslands that occur on hillslopes alongside the extremely moist evergreen forests in South India.

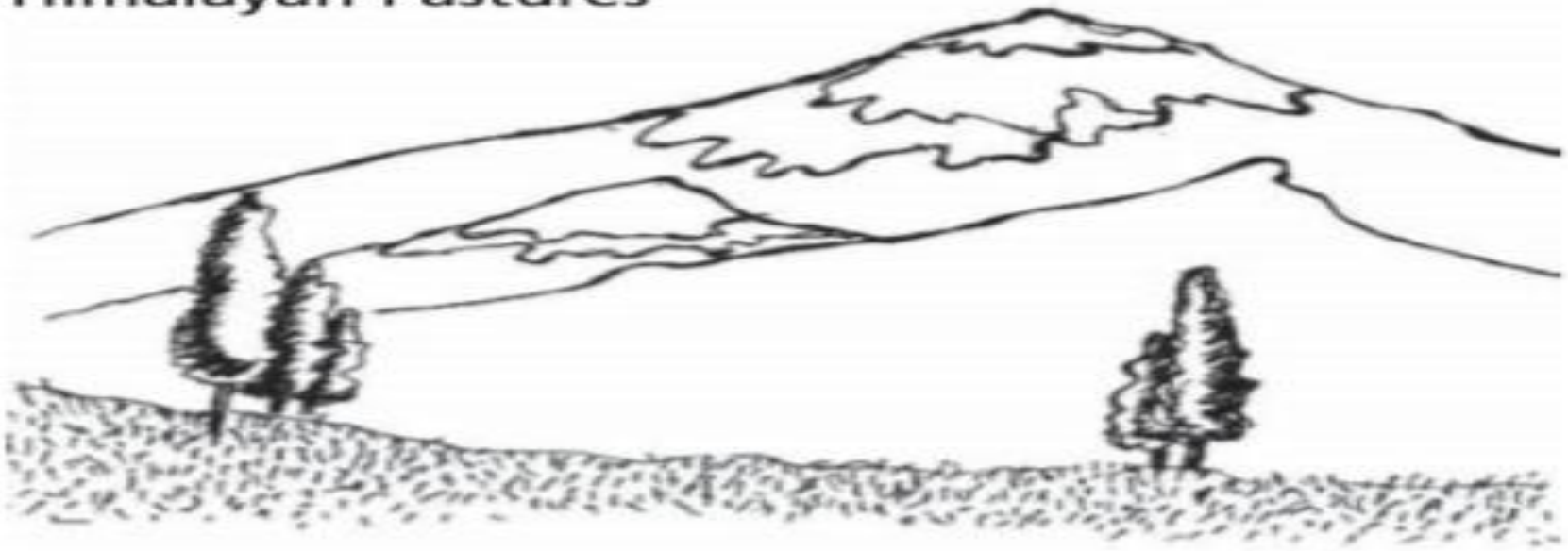
1. Himalayan pasture belt.
2. Terai Grasslands.
3. Semiarid Grasslands.
4. Shola Grasslands

Himalayan pasture belt

Himalayan pasture belt extends up to the snowline. The grasslands at a lower level form patches along with coniferous or broadleaved forests. Himalayan wildlife require both the forest and the grassland ecosystem as important parts of their habitat. The animals migrate up into the high altitude grasslands in summer and move down into the forest in winter when the snow covers the grassland.

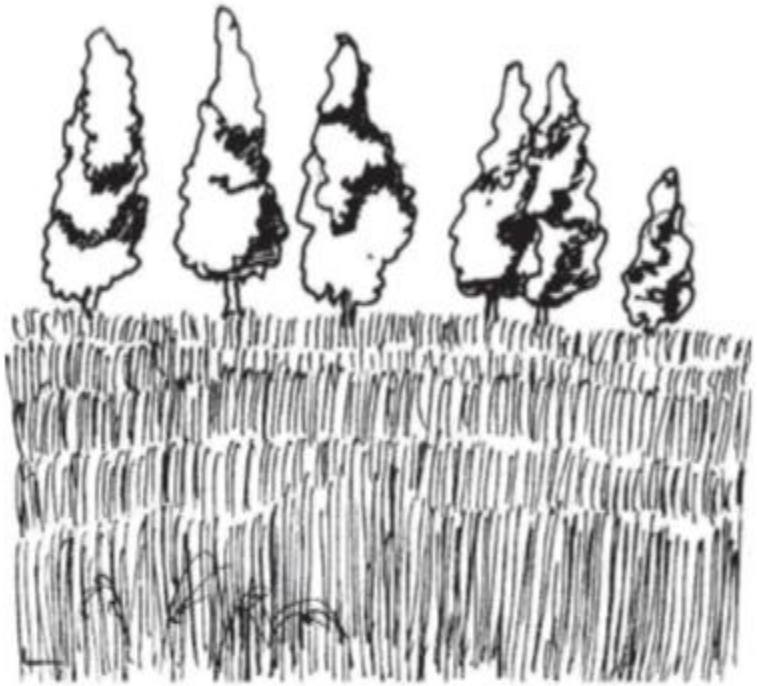
Himalayan hill slopes are covered with thousands of colourful flowering plants. There are also a large number of medicinal plants. Like rennet, Aconitum ferox.

Himalayan Pastures



Terai Grasslands

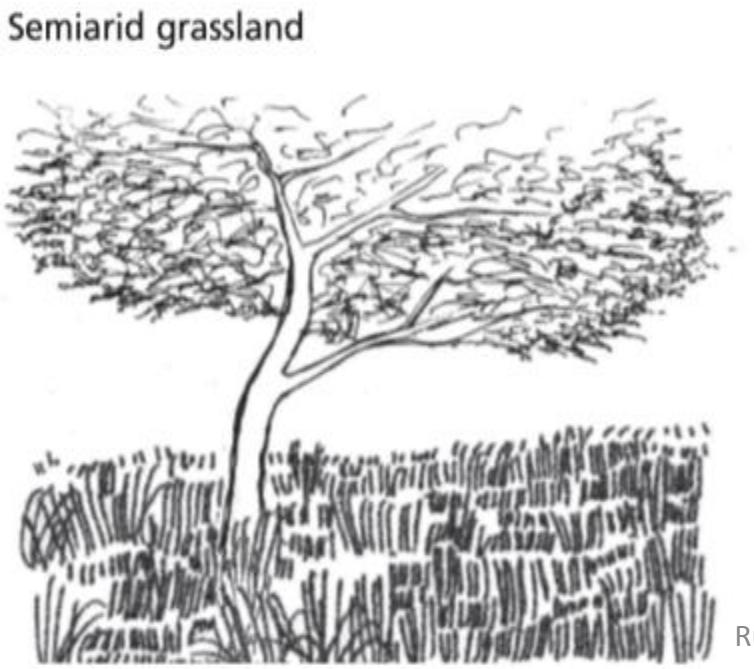
The patches of tall elephant grass, which grows to a height of about five meters, are located in the low-lying waterlogged areas. The Sal forest patches cover the elevated regions and the Himalayan foothills.



Terai grassland

Semi-arid plains of Western India, Central India and the Deccan

These are covered by grassland tracts with patches of thorn forest. Several mammals such as the wolf, the blackbuck, the chinkara, and birds such as the bustards and floricans are adapted to these arid conditions. The Scrublands of the Deccan Plateau are covered with seasonal grasses and herbs on which its fauna is dependent. It is teaming with insect life on which the insectivorous birds feed.



Shola grasslands

Shola grasslands consist of patches on hillslopes along with the Shola forests on the Western Ghats, Nilgiri and Annamalai ranges. This forms a patchwork of grassland on the slopes and forest habitats along the streams and lowlying areas.

Grasslands are not restricted only to low rainfall areas. Certain grassland types form when clearings are made in different forest types. Some are located on the higher steep hill slopes with patches of forest that occur along the streams and in depressions. The grasslands are related to repeated fires that do not permit the forest to grow.

The grasses are the major producers of biomass in these regions. Each grassland ecosystem has a wide variety of species of grasses and herbs. Some grass and herb species are more sensitive to excessive grazing and are suppressed if the area is over grazed. Others are destroyed by repeated fires and cannot regenerate. Thus overused or frequently burnt grasslands are degraded and are poor in plant species diversity.

Desert ecosystem

Desert and semi arid lands are highly specialized and sensitive ecosystems that are easily destroyed by human activities. The species of these dry areas can live only in this specialized habitat.

Deserts and semi arid areas are located in Western India and the Deccan Plateau. The climate in these vast tracts is extremely dry. There are also cold deserts such as in Ladakh, which are located in the high plateaus of the Himalayas. The most typical desert landscape that is seen in Rajasthan is in the Thar Desert. This has sand dunes. There are also areas covered with sparse grasses and a few shrubs, which grow if it rains

In an area it may rain only once every few years. In the adjoining semi arid tract the vegetation consists of a few shrubs and thorny trees such as kher and babul.

Kher
Plant

Babul

The Great and Little Rann of Kutch are highly specialised arid ecosystems. In the summers they are similar to a desert landscape. These are low-lying areas near the sea, they get converted to salt marshes during the monsoons. During this period they attract an enormous number of aquatic birds such as ducks, geese, cranes, storks, etc.

The Great Rann is famous, as it is the only known breeding colony of the Greater and Lesser Flamingos in our country. The Little Rann of Kutch is the only home of the wild ass in India.

Wild Ass

Geese

Storks

Flamingos

The rare animals include the Indian wolf, desert cat, desert fox and birds such as the Great Indian Bustard and the Florican. Some of the commoner birds include partridges, quails and sandgrouse.

Aquatic ecosystems

The aquatic ecosystems constitute the marine environments of the seas and the fresh water systems in lakes, rivers, ponds and wetlands.

Types of Aquatic ecosystems

Fresh water ecosystems				Marine ecosystems	
Flowing water		Still water	Brackish water	Saline water	
Streams	Rivers	Ponds, wetlands, lakes	Deltas	Coastal shallows, Coral reefs	Deep ocean

If aquatic ecosystems are misused or over utilized, their ability to provide resources suffers in the long term. Over-fishing leads to a fall in the fish catch. River courses that are changed by dams to provide electricity affect thousands of people who do not get a continuous supply of water downstream for their daily use. When wetlands are drained, their connected rivers tend to cause floods. These are all examples of unsustainable changes in the use of natural resources and nature's ecosystems that are dependent on hydrological regimes.

Brackish water

ecosystems in river deltas are covered by mangrove forests and are among the world's most productive ecosystems in terms of biomass production. The largest mangrove swamps are in the Sunderbans in the delta of the Ganges

Pond ecosystem

There are differences in a pond that is temporary and has water only in the monsoon, and a larger tank or lake that is an aquatic ecosystem throughout the year. Most ponds become dry after the rains are over and are covered by terrestrial plants for the rest of the year.

When a pond begins to fill during the rains, its life forms such as the algae and microscopic animals, aquatic insects, snails, and worms come out of the floor of the pond where they have remained dormant in the dry phase. Gradually more complex animals such as crabs frogs and fish return to the pond.

Lake ecosystem

There are fish that are herbivorous and are dependent on algae and aquatic weeds. The small animals such as snails are used as food by small carnivorous fish, which in turn are eaten by larger carnivorous fish.

Animals excrete waste products, which settle on the bottom of the lake. This is broken down by small animals that live in the mud in the floor of the lake. This acts as the nutrient material that is used by aquatic plants for their growth. During this process plants use Carbon from CO2 for their growth and in the process release Oxygen. This Oxygen is then used by aquatic animals, which filter water through their respiratory system.

Stream and River ecosystems

Streams and rivers are flowing water ecosystems in which all the living forms are specially adapted to different rates of flow. Some plants and animals such as snails and other burrowing animals can withstand the rapid flow of the hill streams. Other species of plants and animals such as water beetles and skaters can live only in slower moving water.

Common Burrowing Animals

European Rabbit

Ant

River Otter

Chipmunk

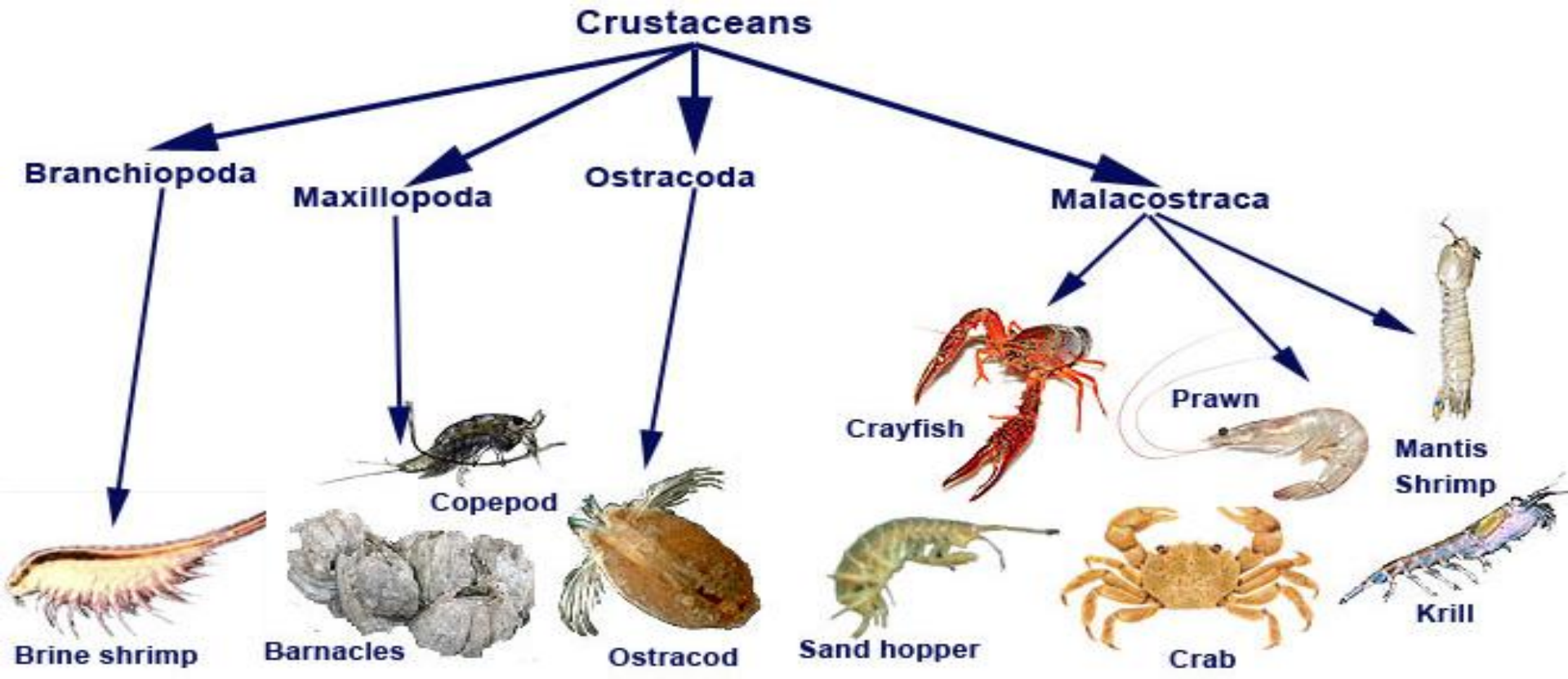
Some species of fish, such as Mahseer, go upstream from rivers to hill streams for breeding. They need crystal clear water to be able to breed. They lay eggs only in clear water so that their young can grow successfully.

The community of flora and fauna of streams and rivers depends on the clarity, flow and oxygen content as well as the nature of their beds. The stream or river can have a sandy, rocky or muddy bed, each type having its own species of plants and animals.

Marine ecosystems

The Indian Ocean, the Arabian Sea and the Bay of Bengal constitute the marine ecosystems around peninsular India.

The shallow areas near Kutch and around the Andaman and Nicobar Islands are some of the most incredible coral reefs in the world. Coral reefs are only second to tropical evergreen forests in their richness of species. Fish, crustacea, starfish, jellyfish and the polyps that deposit the coral are a few of the thousands of species that form this incredible world under the shallow sea.



The marine ecosystem continued to maintain its abundant supply of fish over many generations. Now with intensive fishing by using giant nets and mechanised boats, fish catch in the Indian Ocean has dropped significantly.

Seashore ecosystems

Beaches can be sandy, rocky, shell covered or muddy. On each of these different types, there are several specific species which have evolved to occupy a separate niche. There are different crustacea such as crabs that make holes in the sand.

Various shore birds feed on their prey by probing into the sand or mud on the sea shore.


© Jaina Litwak

CASE STUDY

Threats to wetlands in Assam Threats to wetlands in Assam Almost 40% of all wetlands in Assam are under threat. A survey conducted by the Assam Remote Sensing Application Center (ARSAC), Guwahati, and the Space Research Center, Ahemadabad, has revealed that 1367 out of 3513 wetlands in Assam are under severe threat due to invasion of aquatic weeds and several developmental activities. The wetlands of Assam form the greatest potential source of income for the State in terms of fisheries and tourism. Though the wetlands of Assam have the capacity of producing 5,000 tones of fish per hectare per year, around 20,000 tones of fish have to be imported to meet local demands. This is primarily due to poor wetland management.

Module IV

Pollution

Pollution

- Pollution is the effect of undesirable changes in our surroundings that have harmful effects on plants, animals and human beings.
- No natural phenomenon has led to greater ecological changes than have been made by mankind.
- Pollutants include solid, liquid or gaseous substances present in greater than natural abundance produced due to human activity, which have a detrimental effect on our environment.
- An average human requires about 12 kg of air each day, which is nearly 12 to15 times greater than the amount of food we eat.

From an ecological perspective pollutants can be classified as follows:

- Degradable or non-persistent pollutants
- Slowly degradable or persistent pollutants
- Non-degradable pollutants

Degradable or non-persistent pollutants: These can be rapidly broken down by natural processes. Eg: domestic sewage, discarded vegetables, etc.

Slowly degradable or persistent pollutants: Pollutants that remain in the environment for many years in an unchanged condition and take decades or longer to degrade. Eg: DDT and most plastics.

Non-degradable pollutants: These cannot be degraded by natural processes. Once they are released into the environment they are difficult to eradicate and continue to accumulate. Eg: toxic elements like lead or mercury.

CAUSES, EFFECTS AND CONTROL MEASURES OF POLLUTION

Air Pollution

History of air pollution:

- The origin of air pollution on the earth can be traced from the times when man started using firewood as a means of cooking and heating. Hippocrates has mentioned air pollution in 400 BC.
- With the discovery and increasing use of coal, air pollution became more pronounced especially in urban areas. It was recognized as a problem 700 years ago.
- in London in the form of smoke pollution, which prompted King Edward I to make the first antipollution law to restrict people from using coal for domestic heating in the year 1273.
- In spite of this air pollution became a serious problem in London during the industrial revolution due to the use of coal in industries.

- The earliest recorded major disaster was the ‘London Smog’ that occurred in 1952 that resulted in more than 4000 deaths due to the accumulation of air pollutants over the city for five days.
- In Europe, around the middle of the 19th century, a black form of the Peppered moth was noticed in industrial areas.
- Air pollution began to increase in the beginning of the twentieth century with the development of the transportation systems and large-scale use of petrol and diesel.
- The Air Pollution Control Act in India was passed in 1981 and the Motor Vehicle Act for controlling the air pollution, very recently.
- The greatest industrial disaster leading to serious air pollution took place in Bhopal where extremely poisonous methyl isocyanide gas was accidentally released from the Union Carbide’s pesticide manufacturing plant on the night of December 3rd 1984. The effects of this disaster on human health and the soil are felt even today.

Sulphur oxides are produced when sulphur containing fossil fuels are burnt.

Nitrogen oxides are found in vehicular exhausts. Nitrogen oxides are significant, as they are involved in the production of secondary air pollutants such as ozone.

Hydrocarbons are a group of compounds consisting of carbon and hydrogen atoms. They either evaporate from fuel supplies or are remnants of fuel that did not burn completely. Using higher oxygen concentrations in the fuel-air mixture and using valves to prevent the escape of gases, fitting of catalytic converters in automobiles, are some of the modifications that can reduce the release of hydrocarbons into the atmosphere.

Particulates are small pieces of solid material (for example, smoke particles from fires, bits of asbestos, dust particles and ash from industries) dispersed into the atmosphere. Repeated exposure to particulates can cause them to accumulate in the lungs and interfere with the ability of the lungs to exchange gases.

Lead is a major air pollutant that remains largely unmonitored and is emitted by vehicles. High lead levels have been reported in the ambient air in metropolitan cities. Leaded petrol is the primary source of airborne lead emissions in Indian cities.

Types of particulates

Term	Meaning	Examples
Aerosol	General term for particles suspended in air	Sprays from pressurized cans
Mist	Aerosol consisting of liquid droplets	Sulfuric acid mist
Dust	Aerosol consisting of solid particles that are blown into the air or are produced from larger particles by grinding them down	Dust storm
Smoke	Aerosol consisting of solid particles or a mixture of solid and liquid particles produced by chemical reaction such as fires	Cigarette smoke, smoke from burning garbage
Fume	Generally means the same as smoke but often applies specifically to aerosols produced by condensation of hot vapors of metals.	Zinc/lead fumes
Plume	Geometrical shape or form of the smoke coming out of a chimney	
Fog	Aerosol consisting of water droplets	
Smog	Term used to describe a mixture of smoke and fog.	

Effects of air pollution

1. **Effects of air pollution on living organisms**
2. **Effects on plants**
3. **Effects of air pollution on materials**
4. **Effects of air pollution on the stratosphere**

Effects of air pollution on living organisms

Prolonged smoking or exposure to air pollutants can overload or breakdown these natural defenses causing or contributing to diseases such as lung cancer, asthma, chronic bronchitis (Coughing & difficulty breathing) and emphysema (lungs that primarily causes shortness of breath).

- Cigarette smoking is responsible for the greatest exposure to carbon monoxide.
- Exposure to air containing even 0.001 percent of carbon monoxide for several hours can cause collapse, coma and even death.
- As carbon monoxide remains attached to haemoglobin in blood for a long time, it accumulates and reduces the oxygen carrying capacity of blood.
- This impairs perception and thinking, slows reflexes and causes headaches, drowsiness(Excess sleeping), dizziness(spinning) and nausea(motion).
- Carbon monoxide in heavy traffic causes headaches, drowsiness and blurred vision.

Sulphur dioxide irritates respiratory tissues. It also reacts with water, oxygen and other material in the air to form sulfur-containing acids. The acids can become attached to particles which when inhaled are very corrosive to the lung.

Nitrogen oxides especially NO2 can irritate the lungs, aggravate asthma or chronic bronchitis and also increase susceptibility to respiratory infections such as influenza or common colds.

Suspended particles aggravate bronchitis and asthma. Exposure to these particles over a long period of time damages lung tissue and contributes to the development of chronic respiratory disease and cancer.

Many volatile organic compounds such as (benzene and formaldehyde) and toxic particulates (such as lead, cadmium) can cause mutations, reproductive problems or cancer. Inhaling ozone, a component of photochemical smog causes coughing, chest pain, breathlessness and irritation of the eye, nose and the throat.

Effects on plants

- When some gaseous pollutants enter leaf pores they damage the leaves of crop plants.
- Chronic exposure of the leaves to air pollutants can break down the waxy coating that helps prevent excessive water loss and leads to damage from diseases, pests, drought and frost.
- Such exposure interferes with photosynthesis and plant growth, reduces nutrient uptake and causes leaves to turn yellow, brown or drop off altogether. At a higher concentration of Sulphur dioxide majority of the flower buds become stiff and hard. They eventually fall from the plants, as they are unable to flower.

Effects of air pollution on materials

Every year air pollutants cause damage worth billions of rupees. Air pollutants break down exterior paint on cars and houses. All around the world air pollutants have discoloured irreplaceable monuments, historic buildings, marble statues, etc.

Water Pollution

Although 71% of the earth's surface is covered by water only a tiny fraction of this water is available to us as fresh water.

About 97% of the total water available on earth is found in oceans and is too salty for drinking or irrigation.

The remaining 3% is fresh water.

Of this 2.997% is locked in ice caps or glaciers.

Thus only 0.003% of the earth' total volume of water is easily available to us as soil moisture, groundwater, water vapor and water in lakes, streams, rivers and wetlands.

In short if the world's water supply were only 100 litres our usable supply of fresh water would be only about 0.003 litres (one-half teaspoon).

The future wars in our world may well be fought over water.

Water availability on the planet: Water that is found in streams, rivers, lakes, wetlands and artificial reservoirs is called surface water.

Water that percolates into the ground and fills the pores in soil and rock is called groundwater.

Porous water-saturated layers of sand, gravel or bedrock through which ground water flows are called aquifers.

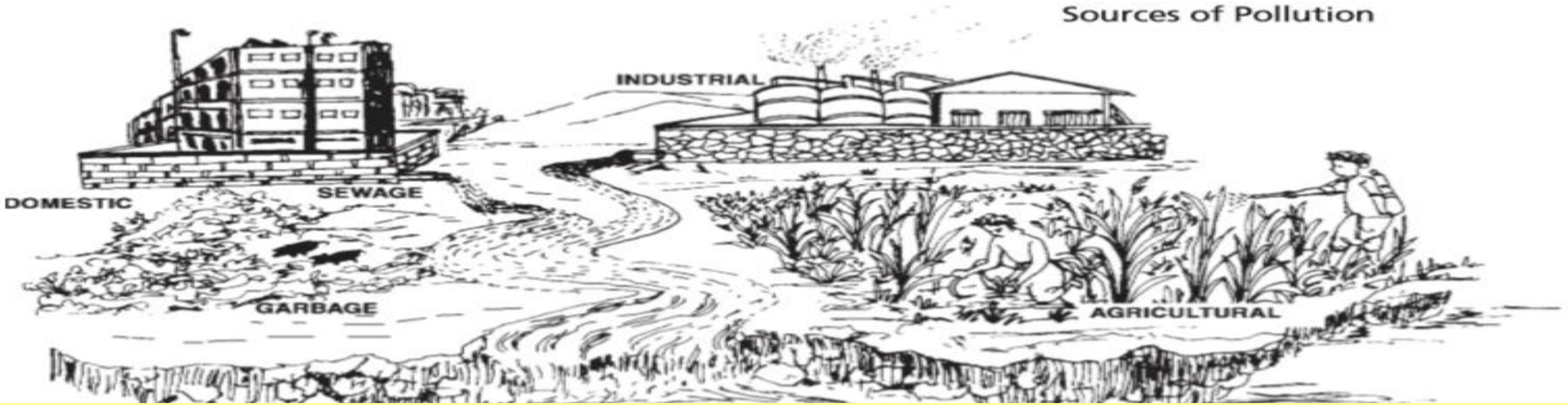
Most aquifers are replenished naturally by rainfall that percolates downward through the soil and rock. This process is called natural recharge.

However in India even areas that receive adequate rainfall during the monsoon suffer from water shortages in the post monsoon period due to lack of storage facilities.

When the quality or composition of water changes directly or indirectly as a result of man's activities such that it becomes unfit for any purpose it is said to be polluted.

Point sources of pollution: When a source of pollution can be readily identified because it has a definite source and place where it enters the water it is said to come from a point source. Eg. Municipal and Industrial Discharge Pipes.

When a source of pollution cannot be readily identified, such as agricultural runoff, acid rain, etc, they are said to be **non-point sources of pollution.**


Sources of Pollution
INDUSTRIAL
DOMESTIC
SEWAGE
GARBAGE
AGRICULTURAL

Causes of water pollution

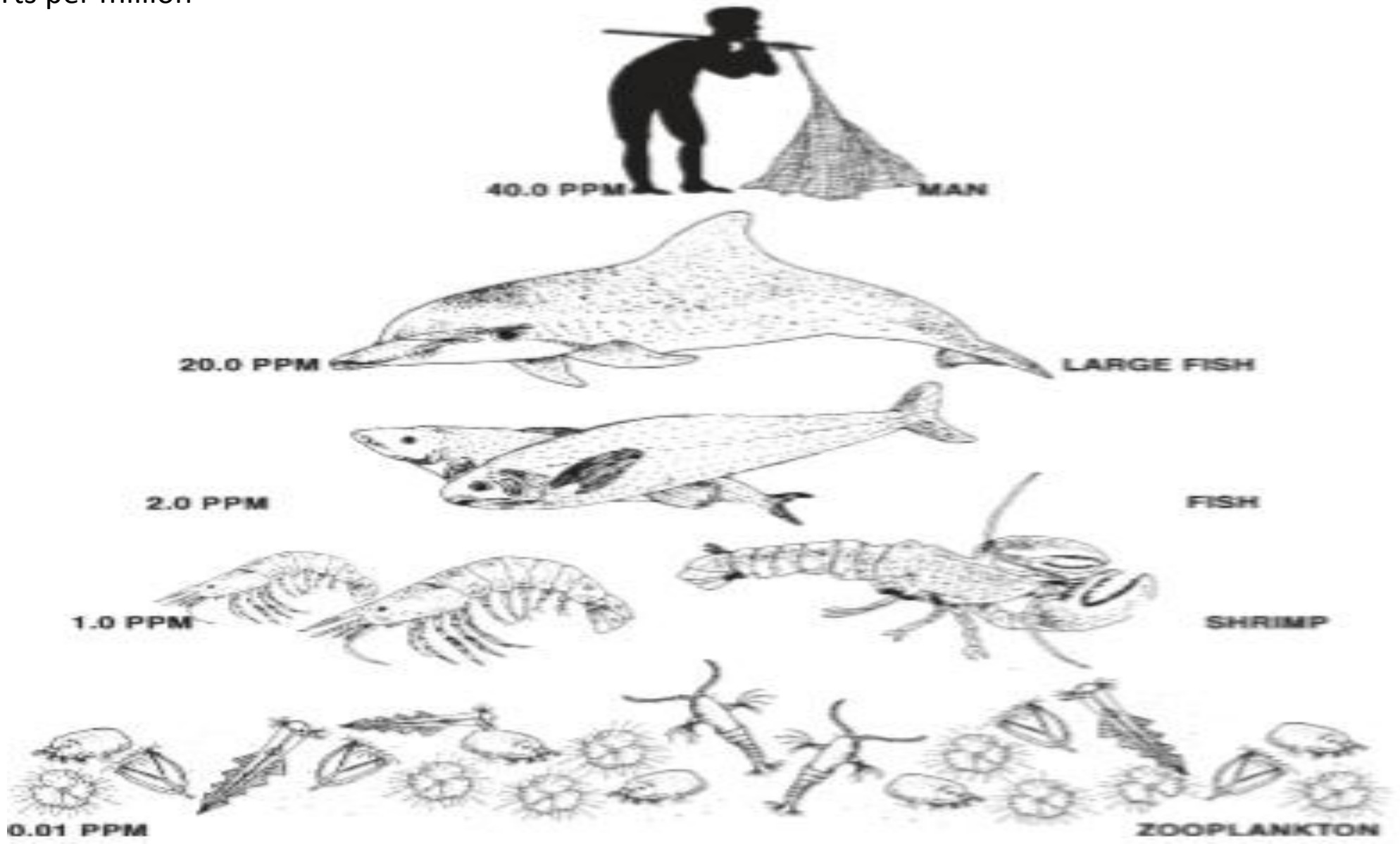
Disease-causing agents (pathogens) which include bacteria, viruses, protozoa and parasitic worms that enter water from domestic sewage and untreated human and animal wastes.

Eg. Escherichia coli & streptococcus faecalis. These bacteria normally grow in the large intestine of humans where they are responsible for some food digestion and for the production of vitamin K.

Another category of water pollutants is **oxygen depleting wastes**. These are organic wastes that can be decomposed by aerobic (oxygen requiring) bacteria. Large populations of bacteria use up the oxygen present in water to degrade these wastes. In the process this degrades water quality. The amount of oxygen required to break down a certain amount of organic matter is called the biological oxygen demand (BOD).

Inorganic plant nutrients. These are water soluble nitrates and phosphates that cause excessive growth of algae and other aquatic plants. The excessive growth of algae and aquatic plants due to added nutrients is called eutrophication.

Ppm – parts per million



The quantity of fertilizers applied in a field is often many times more than is actually required by the plants. The chemicals in fertilizers and pesticides pollute soil and water.

While excess fertilizers cause eutrophication, pesticides cause bioaccumulation and biomagnification.

Pesticides which enter water bodies are introduced into the aquatic food chain. They are then absorbed by the phytoplanktons and aquatic plants. These plants are eaten by the herbivorous fish which are in turn eaten by the carnivorous fish which are in turn eaten by the water birds. At each link in the food chain these chemicals which do not pass out of the body are accumulated and increasingly concentrated resulting in biomagnification of these harmful substances.

One of the effects of accumulation of high levels of pesticides such as DDT is that birds lay eggs with shells that are much thinner than normal. This results in the premature breaking of these eggs, killing the chicks inside.

water soluble inorganic chemicals which are acids, salts and compounds of toxic metals such as mercury and lead.

Sediment of suspended matter is another class of water pollutants. These are insoluble particles of soil and other solids that become suspended in water.

Water soluble radioactive isotopes are yet another source of water pollution. These can be concentrated in various tissues and organs as they pass through food chains and food webs. Ionizing radiation emitted by such isotopes can cause birth defects, cancer and genetic damage.

Hot water let out by power plants and industries that use large volumes of water to cool the plant result in rise in temperature of the local water bodies.

Oil is washed into surface water in runoff from roads and parking lots which also pollutes groundwater. Accidental oil spills from large transport tankers at sea have been causing significant environmental damage.

CASE STUDY

One of the worst oil spill disasters that have occurred is that of the Exxon Valdez. On 24th march 1989 the Exxon Valdez, a tanker more than three football fields wide went off course in a 16 kilometer wide channel in Prince William Sound near Valdez in Alaska.

It hit submerged rocks, creating an environmental disaster.

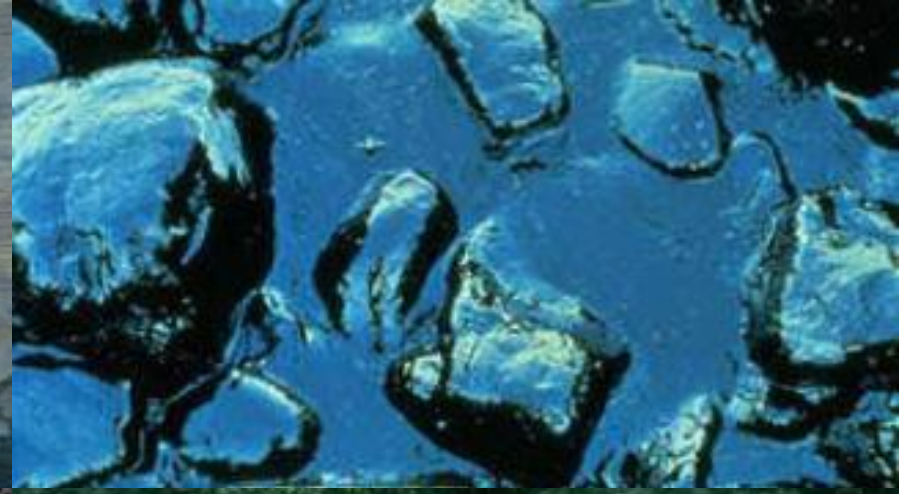
The rapidly spreading oil slick coated more than 1600 kilometers of shoreline killing between 300,000 and 645,000 water birds and a large number of sea otters, harbor seals, whales and fishes.

Exxon spent $ 2.2. billion directly on the clean-up operations. However some results of the cleanup effort showed that where high pressure jets of hot water were used to clean beaches coastal plants and animals that had survived the spill were killed.

Thus it did more harm than good. Exxon pleaded guilty in 1991 and agreed to pay the Federal Government and the state of Alaska $ 1 billion in fines and civil damages.

This $8.5 billion accident might have been prevented if Exxon had spent only $22.5 million to fit the tanker with a double hull-one inside the other. Such double hulled vessels would be less likely to rupture and spill their contents. The spill highlighted the need for marine pollution prevention.









EXXON VALDEZ

Groundwater pollution:

While oil spills are highly visible and often get a lot of media attention, a much greater threat to human life comes from our groundwater being polluted which is used for drinking and irrigation. While groundwater is easy to deplete and pollute it gets renewed very slowly and hence must be used judiciously.

Groundwater flows are slow and not turbulent hence the contaminants are not effectively diluted and dispersed as compared to surface water. Moreover pumping groundwater and treating it is very slow and costly. Hence it is extremely essential to prevent the pollution of groundwater in the first place.

arsenic problem in West Bengal for the last fourteen years.

Arsenic is a naturally occurring element that is widely distributed in the earths crust. It is found in water, air, food and soil.

Ground water is polluted due to:

- Urban run-off of untreated or poorly treated waste water and garbage
- Industrial waste storage located above or near aquifers
- Agricultural practices such as the application of large amounts of fertilizers and pesticides, animal feeding operations, etc. in the rural sector
- Leakage from underground storage tanks containing gasoline and other hazardous substances
- Leachate from landfills
- Poorly designed and inadequately maintained septic tanks
- Mining wastes

The state of India’s rivers

India has always had a tradition of worshipping rivers. Most of the rivers in India are named after gods, goddesses or saints. However a large majority of the Indian population including those who worship the rivers do not think twice before polluting a river.

Urbanization, industrialization, excess withdrawal of water, agricultural run-off, improper agricultural practices and various religious and social practices all contribute to river pollution in India.

Every single river in India be it the Ganga, Yamuna, Cauvery or the Krishna have their own share of problems due to pollution.

Waters from the Ganga and the Yamuna are drawn for irrigation through the network of canals as soon as these rivers reach the plains reducing the amount of water that flows downstream. What flows in the river is water from small nalas, and streams that carry with them sewage and industrial effluents.

Central Pollution Control Board (CPCB), the Government has not been able to tackle this issue. Sewage and municipal effluents account for 75% of the pollution load in rivers while the remaining 25% is from industrial effluents and non-point pollution sources.

In 1985, India launched the Ganga Action plan (GAP) the largest ever river clean-up operation in the country. The plan has been criticized for, overspending and slow progress.

The GAP Phase II in 1991 included cleaning operations for the tributaries of the Ganga, ie; the Yamuna, Gomti and the Damodar. Thus the Yamuna Action Plan (YAP), Gomti Action Plan and the Damodar Action plan were added.

In 1995 the National River Conservation plan was launched. Under this all the rivers in India were taken up for clean-up operations. In most of these plans, attempts have been made to tap drains, divert sewage to sewage treatment plants before letting out the sewage into the rivers.

The biggest drawback of these river cleaning programs was that they failed to pin responsibilities as to who would pay for running the treatment facilities in the long run.

With the power supply being erratic and these plants being heavily dependent on power, most of these facilities lie underutilized. Moreover the problem of river pollution due to agricultural runoff has not been addressed in these programs.

NRCP is scheduled to be completed by March 2005. The approved cost for the plan is Rs. 772.08 crores covering 18 rivers in 10 states including 46 towns.

The cost is borne entirely by the Central Government and the Ministry of Environment and Forests is the nodal agency that co-ordinates and monitors the plan.

Control measures for preventing water pollution

While the foremost necessity is prevention, setting up effluent treatment plants and treating waste through these can reduce the pollution load in the recipient water. The treated effluent can be reused for either gardening or cooling purposes wherever possible. A few years ago a new technology called the Root Zone Process has been developed by Thermax.

This system involves running contaminated water through the root zones of specially designed reed beds. The reeds, which are essentially wetland plants have the capacity to absorb oxygen from the surrounding air through their stomatal openings.

The oxygen is pushed through the porous stem of the reeds into the hollow roots where it enters the root zone and creates conditions suitable for the growth of numerous bacteria and fungi. These micro-organisms oxidize impurities in the wastewaters, so that the water which finally comes out is clean.

Module V

Social Issues and the Environment

THE WILDLIFE PROTECTION ACT

This Act passed in 1972, deals with the declaration of National Parks and Wildlife Sanctuaries and their notification.

It provides for setting up Wildlife Advisory Boards. It prohibits hunting of all animals specified in Schedules I to IV of the Act. These are notified in order of their endangeredness. Plants that are protected are included in schedule VI.

The Amendment to the Wildlife Protection Act in 2002 is more stringent and prevents the commercial use of resources by local people. It has brought in new concepts such as the creation of Community Reserves. It has also altered several definitions. For instance in animals, fish are now included. Forest produce has been redefined to ensure protection of ecosystems.

One cannot expect to use the Act to reduce this without increasing Forest Staff, providing weapons, jeeps, radio equipment, etc. for establishing a strong deterrent force.

Penalties: A person who breaks any of the conditions of any license or permit granted under this Act shall be guilty of an offence against this Act.

The offence is punishable with imprisonment for a term which may extend to three years or with a fine of Rs 25,000 or with both.

An offence committed in relation to any animal specified in Schedule I, or Part II of Schedule II, like the use of meat of any such animal, or animal articles like a trophy, shall be punishable with imprisonment for a term not less than one year and may extend to six years and a fine of Rs 25,000.

In the case of a second or subsequent offence of the same nature mentioned in this sub-section, the term of imprisonment may extend to six years and not less than two years with a penalty of Rs.10,000.

What can an individual do?

1) If you observe an act of poaching, or see a poached animal, inform the local Forest Department Official at the highest possible level. One can also report the event through the press. Follow up to check that action is taken by the concerned authority. If no action is taken, one must take it up to the Chief Wildlife Warden of the State.

2) Say ‘no’ to the use of wildlife products and also try to convince other people not to buy them.

3) Reduce the use of wood and wood products wherever possible.

4) Avoid misuse of paper because it is made from bamboo and wood, which destroys wildlife habitat. Paper and envelopes can always be reused.

5) Create a pressure group and ask Government to ensure that the biodiversity of our country is conserved.

6) Do not harm animals. Stop others from inflicting cruelty to animals.
7) Do not disturb birds nests and fledglings.

8) When you visit the Zoo do not tease the animals by throwing stones or feeding them, and prevent others from doing so.

9) If you come across an injured animal do what you can to help it.

10) If the animal needs medical care and expert attention contact the Society for the Prevention of Cruelty to Animals in your city.

11) Create awareness about biodiversity conservation in your own way to family and friends.

12) Join organizations, which are concerned with protection of biodiversity, such as Worldwide Fund For Nature –India (WWFI), Bombay Natural History Society (BNHS), or a local conservation NGO.

FOREST CONSERVATION ACT

To appreciate the importance of the Forest Conservation Act of 1980, which was amended in 1988, it is essential to understand its historical background. The Indian Forest Act of 1927 consolidated all the previous laws regarding forests that were passed before the 1920's.

The Act gave the Government and Forest Department the power to create Reserved Forests, and the right to use Reserved Forests for Government use alone.

Some forests were also to be controlled by a village community, and these were called Village Forests.

India's first Forest Policy was enunciated in 1952. Between 1952 and 1988, the extent of deforestation was so great that it became evident that there was a need to formulate a new policy on forests and their utilisation.

Penalties for offences in Reserved Forests: No person is allowed to make clearings or set fire to a Reserved Forest. Cattle are not permitted to trespass into the Reserved Forest. Felling, collecting of timber, bark or leaves, quarries or collecting any forest product is punishable with imprisonment for a term of six months, or with a fine which may extend to Rs.500, or both.

What can an individual do to support the Act?

1) Be alert to destructive activities in your local green areas such as Reserved Forests and Protected Forests, and in Protected Areas (National Parks and Wildlife Sanctuaries). Report any such act to the Forest Department as well as the Press. Report of violations can be made to the Conservator of Forest, District Forest Officer, Range Forest Officer, Forest Guard or the District Commissioner, or local civic body.

2) Acquaint yourself with the laws, detailed rules and orders issued by the Government.

3) Be in touch with concerned local NGOs and associations. Organize one with other like minded people if none exist in your area.

4) Create awareness about the existence and value of National Parks and Sanctuaries and build up a public opinion against illegal activities in the forest or disturbance to wildlife.

5) Pressurize the authorities to implement the forest and wildlife laws and rules to protect green areas.

6) Take legal action if necessary and if possible through a Public Interest Litigation (PIL) against the offending party. Use the help of NGOs who can undertake legal action.

7) Help to create public pressure to change rules laws and procedures when necessary.

8) Use better, ecologically sensitive public transport and bicycle tracks. Do not litter in a forest area.

9) Participate in preservation of greenery, by planting, watering and caring for plants.

Whom should forest offences be reported to?

If you as a citizen come across anyone felling trees, encroaching on forest land, dumping garbage, cutting green wood, lighting a fire, or creating a clearing in Reserved Forests, Protected Forests, National Park, Sanctuary or other forest areas, you must report it to the forest / wildlife officers concerned. For urgent action one can contact the police. In fact you should file an FIR in any case because it serves as an important proof that you have made the report.

ISSUES INVOLVED IN ENFORCEMENT OF ENVIRONMENTAL LEGISLATION

Environment Impact Assessment (EIA):

Citizens actions and action groups:

CASE STUDY

The Narmada Issue

The controversy over the plan to build several dams on the Narmada River and its tributaries symbolizes the struggle for a just and equitable society in India. The construction of these dams displaces many poor and underprivileged communities, destroying their relatively self-sufficient environmentally sound economy and culture and reducing a proud people to the status of refugees or slum dwellers.

The Narmada Bachao Andolan (Save the Narmada Movement) is one of the most dynamic people's movements fighting for the rights of these underprivileged people who are being robbed of their homes, livelihoods and way of living in the name of 'national interest'.

One such dam, the Sardar Sarovar Dam, when completed will drown 37,000 hectares of fertile land and displace 200,000 adivasis and cause incomprehensible loss to the ecology.

CASE STUDY

Silent Valley

The proposed Hydel project at Silent valley, a unique pocket of tropical biodiversity in South India, in the 1970s was stopped and the area declared a National Park in 1984. This was achieved by several dedicated individuals, groups and organisations lobbying to save the area from being submerged and protect its rich biodiversity.

PUBLIC AWARENESS

Using an Environmental Calendar of Activities:

February 2: World Wetland Day

World Wetland Day is celebrated to create awareness about wetlands and their value to mankind. On February 2nd 1971, the Ramsar Convention on Wetlands of International importance was signed at Ramsar in Iran. You can initiate a campaign for proper use and maintenance of wetlands in the vicinity of the city or village.

March 21: World Forestry Day

can be used to initiate a public awareness campaign about the extremely rapid disappearance of our forests. The program must be action oriented and become an ongoing process with activities such as tree plantation.

April 7: World Health Day –

The World Health Organisation (WHO) came into existence on this day in 1948. A campaign for personal sanitation and hygiene to understanding issues of public health, occupational health, etc. can be carried out. Topics that deal with environment related diseases and their spread can be discussed and preventive measures suggested.

April 18: World Heritage Day

can be used to arrange a visit to a local fort or museum. Environment also includes our cultural monuments. Students could use this opportunity to create awareness among the local people about their very valuable heritage sites.

April 22: Earth Day

was first celebrated in 1970 by a group of people in the USA to draw attention to increasing environmental problems caused by humans on earth. This day is now celebrated all over the world with rallies, festivals, clean-ups, special shows and lectures.

June 5: World Environment Day

marks the anniversary of the Stockholm Conference on Human Environment in Sweden in 1972, where nations of the world gathered to share their concern over human progress at the expense of the environment. This day can be used to project the various environmental activities that the college has undertaken during the year. New pledges must be made to strengthen an environmental movement at the college level.

June 11: World Population Day

is a day when the vital link between population and environment could be discussed in seminars held at college and other NGOs.

August 6: Hiroshima Day
could be used to discuss our own Bhopal Gas Tragedy and the Chernobyl disaster.

September 16: World Ozone Day

was proclaimed by the United Nations as the International Day for the preservation of the ozone layer. This is a good occasion for students to find out more about the threats to this layer and initiate discussion on what they can do to help mitigate this global threat. The day marks the Montreal Protocol signed in 1987 to control production and consumption of ozone depleting substances.

September 28: Green Consumer Day

could be used to create an awareness in consumers about various products. Students could talk to shopkeepers and consumers about excess packaging and a campaign to use articles which are not heavily packaged could be carried out.

October 1-7: Wildlife Week

can consist of seminars on conserving our species and threatened ecosystems. The State forest Departments organize various activities in which every student should take part. A poster display, a street play to highlight India's rich biodiversity can be planned. Wildlife does not only mean animals, but includes plants as well.

What can I do?

Most of us are always complaining about the deteriorating environmental situation in our country. We also blame the government for inaction. However how many of us actually do anything about our own environment? You can think about the things you can do that support the environment in your daily life, in your profession and in your community. You can make others follow your environment friendly actions. A famous dictum is to 'think
globally and act locally' to improve your own environment. 'You' can make a difference to our world.

Biodiversity Conservation: A great proportion of the residual wilderness of India is now under great threat. Its unique landscapes are shrinking as the intensive forms of agriculture and industrial growth spreads through a process called 'development'. Modern science has serious doubts about the possibility of the long-term survival of the human race if man continues to degrade natural habitats, extinguishes millions of years of evolution through an extinction spasm, and looks only at short-term gains. The extinction of species cannot be reversed. Once a species is lost, it is gone forever. Future generations will hold us responsible for this great loss.

We frequently forget that we are a part of a great complex web of life and our existence depends on the integrity of 1.8 million species of plants and animals on earth that live in a large number of ecosystems.

The following are some of the things you can do to contribute towards our ecological security and biodiversity conservation.

Dos:

1. Plant more trees of local or indigenous species around your home and your workplace. Encourage your friends to do so. Plants are vital to our survival in many ways.
2. If your urban garden is too small for trees, plant local shrubs and creepers instead. These support bird and insect life that form a vital component of the food chains in nature. Urban biodiversity conservation is feasible and can support a limited but valuable diversity of life.