

BLOCK**2****RESOURCE BASE**

UNIT 6**LAND RESOURCES**

UNIT 7**WATER RESOURCES**

UNIT 8**FOREST RESOURCES**

UNIT 9**MINERAL RESOURCES**

UNIT 10**ENERGY RESOURCES**

GLOSSARY

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BLOCK 2: RESOURCE BASE

The sustainable use of natural resources is essential for the growth and development of any country or region. Land is a limited resource and we utilize it for growing crops, constructing buildings and structures, and so many other economic and cultural activities. Land and water resources are very closely related to each other. Water is vital for human survival. Surface and near-surface water include rivers, reservoirs, lakes, ponds, oceans, etc., are together recognized as water resources. Forest resources help in increasing the health of planet Earth through the continuous supply of energy and matter to all living organisms. Studying the importance of mineral and energy resources is essential in understanding the economic growth of a society or a country as a whole. There is a close relationship between the availability of resources and economy of a region as it helps in assessing and managing the sustainable use of natural resources.

This block introduces you to the resource base dealing with the land, water, forest, mineral, and energy resources spread across five units.

Unit 6: Land Resources

Land resources are the main topic of this unit. Land is economically valuable and essential to a nation's development efforts. In this unit, you will learn about distribution and use of land resources as well as the classification of land use in India. Understanding the land-man ratio and land use capacity is necessary to comprehend the Indian economy. One must have the knowledge about the quality and productivity of land in a specific area, for which the concept of land degradation and the key processes involved in it are explained in this unit.

Unit 7: Water Resources

On the planet Earth, the survival of living creatures mainly depends on water. Three-fourths of the Earth's surface is occupied by water in different forms, like solid, liquid, and gaseous. In this unit, we have introduced the types and characteristics of water resources and the importance of multipurpose river valley projects in India. The first multipurpose project in India, i.e., the Damodar River Valley Project, is explained in detail to understand the importance of multipurpose river valley projects in India.

Unit 8: Forest Resources

This unit explains the forest resources as they are considered a storehouse of biodiversity, which is extremely vital for the functioning of the ecosystem and its services in the biosphere. The types, characteristics, and distribution of forest resources in India are explained. We have also discussed the crucial issues related to Indian forests, such as deforestation, afforestation, conservation and management practices, etc., in this unit.

Unit 9: Mineral Resources

This unit introduces you to mineral resources. We use minerals for many purposes that are available in nature with a definite chemical composition and recognizable physical properties. In this unit, we have explained the classification of mineral resources along with the distribution and utilization of mineral resources in India. The potential wealth of the region depends upon the natural endowment of mineral resources. It is also

important to know the conservation measures for mineral resources, which are explained at the end of this unit.

Unit 10: Energy Resources

In this unit, we have explained energy resources. It is essential to understand the role of energy in socio-economic development because it is one of the important factors in promoting industrial growth in the economy of a country. From this unit, you will learn the classification of energy resources and the distribution and utilization of major renewable and non-renewable energy resources in India. We have also explained various energy conservation methods in this unit.

We hope that after studying this block, you will better understand the various resources of land, water, forest, minerals, and energy along with their importance, mainly with special reference to India.

Our best wishes are with you in this endeavor.

We suggest for any assistance regarding this course, you can contact at:
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LAND RESOURCES |

Structure

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6.2	Landuse Classification	6.8	Terminal Questions
6.3	Land Resource Distribution and Utilization	6.9	Answers
6.4	Land-Man Ratio	6.10	References and Suggested Further Reading
6.5	Landuse Capability		

6.1 INTRODUCTION

You have studied the physiographic setting of India in Block 1. You will now study various resources including land, water, forest, minerals and energy from Unit 6 to 10 of Block 2 of this course. The present Unit 6 explains you about land resources. Land resource is an important part of resource studies because of its economic value. Landuse classification is developed for valuing land resources in country's developmental activities, for which you will study Section 6.2. The distribution of land resources and their utilization across the country are discussed in Section 6.3.

Sections 6.4 and 6.5 will explain you about land-man ratio and land use capability. Various natural and/or human activities can affect the land that leads to the deterioration of quality and productivity of land. This loss of potential may be called land degradation. We have explained land degradation and different types of processes involved in it and also the important remedial measures to arrest the land degradation discussed in Section 6.6.

Expected Learning Outcomes

After studying this unit, you should be able to:

- define landuse and explain landuse classification;
- describe land distribution and its utilization;
- highlight the land-man ratio; and
- explain landuse capability and land degradation problems.

6.2 LANDUSE CLASSIFICATION

You all are aware that the human beings live on the Earth's surface cover, which is called the land. Land is the solid surface of the Earth that is not permanently submerged in water. Have you ever thought if the water flooded the entire globe and there is no place to stand? Yes, it is almost impossible for living creatures able to sustain without land. Every day, we see the land and use it for agriculture and other productive activities. The land is a resource. It includes *"the physical, biotic, environmental, infrastructural and socio-economic components of a natural land unit, including surface and near-surface freshwater resources"*. The term landuse refers to the economic and cultural activities like residential, agricultural, industrial, mining, recreation, etc., that are done on a piece of land for human use. Landuse differs from landcover, which explains the surface cover on the ground, for example, vegetation, buildings, infrastructure, bare soil, etc. Landcover does not describe the use of cover type. For example, the forest cover may be used for timber production and the ponds or lakes may be found in interior lands used for recreational purposes. Now you can explain landuse, which means how people are utilizing the land. Here, we must understand both the land and water which are very close to each other. The major reservoirs and river water can be considered as a separate resource called "water resources" which you will learn in the next Unit 7.

Let us think, is it really need a land classification for any country's geographical area? Yes, it is crucial because it helps to determine the total value of land. The classification can also vary from one country to the other based on its value, price and different subtypes of land, and ultimately, all economically relevant land. For example, the cost of land in the built up or housing area may differ from that in the open/agricultural land area. Therefore, the location, size (square yards/square meters) and use of land are important to know for the country's developmental activities. In India, we use a "nine-fold" classification of landuse for managing the land resource. These classes are explained below (MOSPI 2021):

1. **Forests:** Forest lands are designated legally as forests or administered as forests, whether state-owned or private, and whether wooded or maintained as potential forest land. The area of crops raised in the forest and grazing lands or areas open for grazing within the forests are also included under the forest area.
2. **Area under Non-agricultural Use:** Land occupied by buildings, roads and railways or water bodies, e.g. rivers and canals and other lands are used other than agriculture.
3. **Barren and Un-culturable Land:** Land which cannot be brought under cultivation except at an exorbitant cost is called unculturable land. For example, mountains, deserts, etc. These land parcels can be isolated blocks or within cultivated holdings.
4. **Permanent Pastures and other Grazing Lands:** All grazing lands such as permanent pastures, meadows, village common grazing lands, etc. are included under this category.

5. **Land under Miscellaneous Tree Crops:** It includes all cultivable land which is not included in 'Net Area Sown' but is put to some agricultural uses. Lands other than "orchards", including casuarina trees, thatching grasses, bamboo bushes, and other groves for fuel, etc., fall under this category.
6. **Culturable Waste Land:** It includes lands available for cultivation, whether not taken up for cultivation or taken up for cultivation once but not cultivated during the current year and the last five years or more in succession for one reason or other. Such lands may be either fallow or covered with shrubs and jungles, which are not put to any use. They may be assessed or unassessed and may lie in isolated blocks or within cultivated holdings. Land once cultivated but not cultivated for five years in succession should also be included in this category at the end of five years.
7. **Fallow Land other than Current Fallow:** The land was taken up for cultivation but is temporarily out of cultivation for a period of not less than one year and not more than five years.
8. **Current Fallows:** It represents cropped areas that are kept fallow during the current year. For example, if any seeding area is not cropped in the same year, it may be treated as current fallow.
9. **Net Area Sown:** It represents the total area sown with crops and orchards. Area sown more than once in the same year are counted only once.

As we know that population is growing very rapidly all over the globe. We all essentially need food for life. It is required not only for human beings but also for animals and other living creatures. The changes in land use patterns are now very significant. If you observe carefully in your surrounding areas, you will find a lot of changes in them over a period of time. The optimum utilization of land resources is very important. It must be maintained and used cautiously to produce better productivity to meet the future needs of the growing population. We ought to monitor the changes in resources for prosperity. Let us study the scenario of this vital resource at national level.

6.3 LAND RESOURCE DISTRIBUTION AND UTILIZATION

6.3.1 Distribution of Land Resource

You have understood the various land use categories and their importance. You might be knowing that those categories of land are distributed everywhere but not the same across the country. Yes, in our country, the distribution of land under different uses varies from one region to the other. The first Agriculture Census was launched in 1970-71, which described the number and area of operational land holdings in India. A total of five groups of operational holdings are proposed by **size of land holdings** in hectares (ha). These include (i) marginal land holdings of less than one hectare, (ii) small holdings of between one and two hectares, (iii) semi-medium (2-4 ha), (iv) medium (4-10 ha), and (v) large holdings of ten hectares or more.

Table 6.1 explains the five categories of land holdings in the country, both in number and area, during different time periods. The provisional data available for the year 2015-16 is provided by the 10th Agricultural Census. Overall, the number of landholdings in all categories increased from 71 million (M) in 1970-71 to 146.4 M in 2015-16. While, operational area decreased to 157.8 M ha from 162.2 Mha. The majority of land holdings are identified as marginal groups, which occupy nearly 68.5% of all holdings while small groups occupy 17.6%. These two groups, both marginal and small, cumulatively occupy about 86% of total number of holdings in the country. The marginal and small sizes of landholdings account for almost 50% (24% and 22.9%, respectively) of the total cultivated area.

Large landholdings (10 hectares and above) on the other hand, account for only 0.6% of total holdings and 9.1% of the total cultivated area (2015-16). The highest operated area in hectares by marginal farmers was 24% in 2015-16, a substantial increase from 9%, whereas large size holdings drastically decreased to 9.1% from 30.9% in 1970-71. Small and semi-medium size groups had positively increased and medium groups had decreased in handling the operated area (Fig. 6.1). This characteristic of landholdings is directly related to physical, economic and social factors. Many of these factors are not suitable for modern methods of agriculture.

The distribution of operational landholdings amongst the states is given in Table 6.2. On the whole, nearly 146 M of landholdings were operated during 2015-16. The states like Uttar Pradesh, Bihar, Maharashtra, and Madhya Pradesh operate more than 10 million landholdings in all groups, while Chandigarh (748), Daman & Diu (8,016) and Lakshadweep (10,017) operate the lowest landholdings.

Table 6.1: Number and Area of Operational Holdings by Size Group.

Size Groups	Number of Holdings (in '000)			Operated Area (in '000 ha)			Average (in '000 ha)		
	1970-71	2005-06*	2015-16	1970-71	2005-06*	2015-16	1970-71	2005-06*	2015-16 (P)
Marginal (Less than 1 hectare)	36200 (51)	83694 (64.8)	100251 (68.5)	14599 (9.0)	32026 (20.2)	37923 (24.0)	0.40	0.38	0.38
Small (1 to 2 hectares)	13432 (18.9)	23930 (18.5)	25809 (17.6)	19282 (11.9)	33101 (20.9)	36151 (22.9)	1.44	1.38	1.40
Semi-Medium (2 to 4 hectares)	10681 (15)	14127 (10.9)	13993 (9.6)	29999 (18.5)	37898 (23.9)	37619 (23.8)	2.81	2.68	2.69
Medium (4 to 10 hectares)	7932 (11.2)	6375 (4.9)	5561 (3.8)	48234 (29.7)	36583 (23.1)	31810 (20.2)	6.08	5.74	5.72
Large (10 hectares and above)	2766 (3.9)	1096 (0.8)	838 (0.6)	50064 (30.9)	18715 (11.8)	14314 (9.1)	18.1	17.08	17.08
All Holdings	71011 (100)	129222 (100)	146454 (100)	162178 (100)	158323 (100)	157817 (100)	2.28	1.23	1.08

(Source: Department of Agriculture, Cooperation & Farmers Welfare (Agriculture Census 2015-16, Phase-I); *-Excluding Jharkhand; and Figures in parentheses indicate percentage share out of total holdings/area)

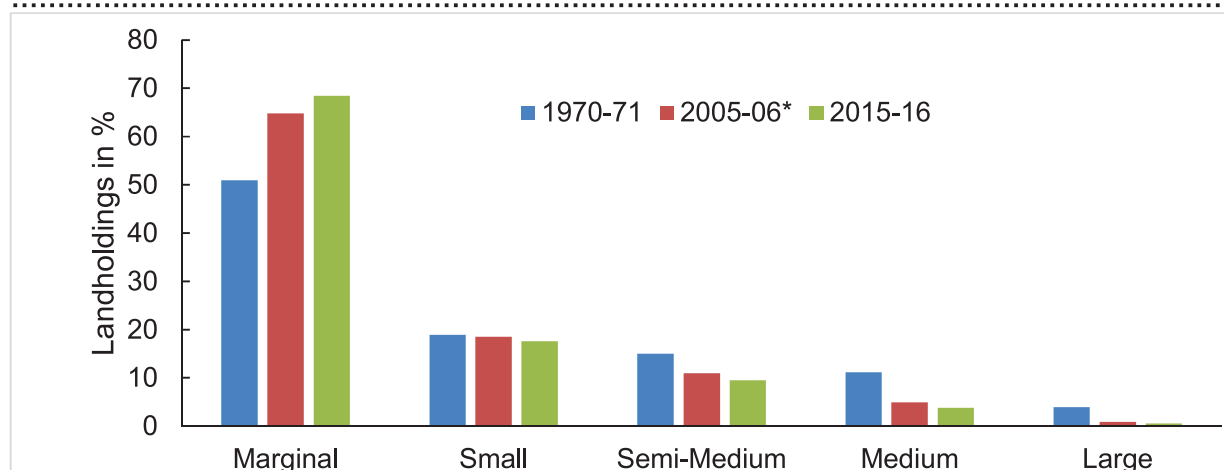


Fig. 6.1: Type of Land Holdings Occupied During 1970-2016.

Rajasthan is the only state having large-sized (> 10 ha) holdings, accounting for 3.58 lakhs, followed by Maharashtra (69,715), Madhya Pradesh (62,885), Punjab (57,707), and Karnataka (55,706). The marginal operational holdings are found the highest in Uttar Pradesh (nearly 20 M) and Bihar (about 15 M), followed by Maharashtra (7.8 M), Kerala (7.3 M), Tamil Nadu (6.2 M), West Bengal (5.99 M), and Andhra Pradesh (5.9 M).

There are a lot of variations in the distribution of land between the states of India (Table 6.2). Medium holdings are occupied by the states of Rajasthan, Maharashtra, Madhya Pradesh, Gujarat, and Karnataka, which is quite significant. As per the data, we can observe that the holdings have become scattered and are not economically viable for mechanization and large scale irrigation activities. Suitable land reform measures may need to be taken for better farm production and productivity to achieve international levels.

Table 6.2: Number of Operational Holdings by Size Group (Year 2015-2016).

State/UT	Marginal	Small	Semi-Medium	Medium	Large	All Holdings
Andaman & Nicobar Islands	5154	2533	2875	1364	28	11954
Andhra Pradesh	5904039	1646246	769843	189034	14748	8523910
Arunachal Pradesh	27161	24056	29018	26328	6690	113253
Assam	1868020	495313	295286	79262	3830	2741711
Bihar	14970585	943796	414015	81408	3089	16412893
Chandigarh	480	139	81	46	2	748
Chhattisgarh	2434321	879477	493056	180823	23095	4010772
Dadra & Nagar Haveli	8511	3829	1887	746	99	15072
Daman & Diu	7422	423	131	34	6	8016
Delhi	11489	5436	2587	1209	121	20842
Goa	59472	8083	4309	2092	607	74563
Gujarat	2018827	1615788	1150254	495869	39888	5320626
Haryana	802396	313937	277972	192327	41383	1628015
Himachal Pradesh	712204	173456	82265	25920	2964	996809

Jammu & Kashmir	1186887	159988	58102	10998	534	1416509
Jharkhand	1961615	418684	277306	125514	19827	2802946
Karnataka	4767132	2213732	1192724	451445	55706	8680739
Kerala	7333248	181372	55744	11274	1858	7583496
Lakshadweep	9562	281	135	31	8	10017
Madhya Pradesh	4834531	2724684	1674301	706734	62885	10003135
Maharashtra	7815823	4339259	2327023	733619	69715	15285439
Manipur	76705	48737	22269	2734	39	150484
Meghalaya	122748	60268	39863	9256	262	232397
Mizoram	44963	27483	13834	3209	285	89774
Nagaland	8211	29790	63332	73769	21430	196532
Odisha	3636658	887272	286735	51210	3975	4865850
Puducherry	28361	3385	1568	481	45	33840
Punjab	154412	207436	367938	305220	57707	1092713
Rajasthan	3070873	1677372	1416174	1131440	358757	7654616
Sikkim	44294	12767	10591	3513	367	71532
Tamil Nadu	6224319	1119229	452236	127650	14513	7937947
Telangana	3840131	1408979	563530	125630	9465	5947735
Tripura	504105	47987	18538	2491	73	573194
Uttar Pradesh	19099828	3008403	1313695	376790	22909	23821625
Uttarakhand	659064	148817	58040	14496	888	881305
West Bengal	5997758	970895	255957	17514	608	7242732
All India	100251309	25809332	13993214	5561480	838406	146453741

(Source: Department of Agriculture, Cooperation & Farmers Welfare, Agriculture Census 2015-16, Phase-I)

6.3.2 Utilization of Land

Let us study some interesting statistics about land resource utilization. You have studied in Section 6.2, the distribution of the total geographical area of the country into its different uses. The area under nine landuse categories adds up to the total reported area, which is generally less than the total geographical area. While the total geographical area is measured by Survey of India and remains fixed, the reported area is derived from revenue records of local bodies.

Land utilization statistics provide the information where a piece of land is used for various purposes under different classes. It explains whether the land is cultivated, under grazing, or forested, but it does not explain the potential utilization of a land parcel. You will understand the landuse statistics of India during 1970-2016 by studying Table 6.3. Furthermore, Table 6.4 provides you the information related to the area under different crops.

Cereal and pulses are food grains grown largely in India. India ranks third in the production of cereals and first in the production of pulses. The cereals include rice, jowar, bajra, maize, ragi, wheat, barley and others are cultivated in our country. These food grains occupy around 50 percent of the gross cropped area (GCA). Rice is the largest crop grown in India which accounts 22% of India's GCA. The second highest percentage of crop producer noted

is wheat contributing around 16%. The states of West Bengal, Punjab and Uttar Pradesh are the leading rice producing states in the country whereas the wheat growing states are including Punjab, Haryana, Rajasthan, Uttar Pradesh and Madhya Pradesh, etc. The oilseeds namely groundnut, sesame, rapeseed and mustard, linseed and other oil seeds grown in the country occupying about 15% of gross cropped area.

Table 6.3: Landuse Statistics of India (in Million Hectares).

S. No	Classification	1970-71	2000-01	2015-16(P)
I.	Geographical Area	328.73	328.73	328.73
II.	Reporting Area for Land Utilization Statistics	303.75	305.19	307.75
1.	Forest	63.83 (21.01%)	69.84 (22.88%)	71.87 (23.35%)
2.	Not Available for Cultivation (A+B)	44.61	41.23	44.02
	(A) Area Under Non-agricultural Uses	16.48 (5.42%)	23.75 (7.78%)	27.08 (8.80%)
	(B) Barren & Un-culturable Land	28.13 (9.26%)	17.48 (5.73%)	16.94 (5.51%)
3.	Other Uncultivated land excluding Fallow Land (A+B+C)	35.13	27.74	25.64
	(A) Permanent Pasture & other Grazing Land	13.26 (4.37%)	10.66 (3.49%)	10.26 (3.33%)
	(B) Land under Miscellaneous Tree Crops & Groves not included in Net Area Sown	4.37 (1.44%)	3.44 (1.13%)	3.09 (1.01%)
	(C) Culturable Waste Land	17.50 (5.76%)	13.63 (4.47%)	12.29 (3.99%)
4.	Fallow Lands(A+B)	19.33	25.04	26.72
	(A) Fallow Lands other than Current Fallows	8.73 (2.87%)	10.27 (3.36%)	11.31 (3.67%)
	(B) Current Fallows	10.60 (3.49%)	14.78 (4.84%)	15.41 (5.01%)
5.	Net Area Sown(6-7)	140.86 (46.37%)	141.34 (46.31%)	139.51 (45.33%)
6.	Total Cropped Area (Gross Cropped Area)	165.79	185.34	197.05
7.	Area Sown more than once	24.93	44.00	57.55
8.	Cropping Intensity*	117.70	131.13	141.25
III.	Net Irrigated Area	31.10	55.20	67.30
IV.	Gross Irrigated Area	38.20	76.19	96.62

(Source: Directorate of Economics & Statistics, DAC&FW; and Percentages worked out over Reported Area; P: Provisional; *Cropping Intensity is percentage of the gross cropped area to the net area sown)

Table 6.4: The Percentage Distribution of Gross Cropped Area.

Crops	Percentage Share of Area to Gross Cropped Area (GCA)		
	2013-14 (P)	2014-15 (P)	2015-16 (P)
Rice	22.13	22.30	22.01
Jowar	2.86	3.15	3.09
Bajra	4.03	3.96	3.61
Maize	4.49	4.43	4.30
Ragi	0.60	0.60	0.58
Wheat	15.61	16.18	15.72
Barley	0.34	0.37	0.28
Other Cereals & Millets	0.36	0.35	0.37
Coarse Cereals	12.69	12.85	12.24
Total Cereals	50.43	51.33	49.97
Gram	4.68	3.86	3.78
Tur	1.76	1.71	1.77
Other Pulses	5.40	5.37	6.04
Total Pulses	11.83	10.94	11.59
Total Food-grains	62.26	62.26	61.56
Sugarcane	2.75	2.81	2.66
Condiments & Spices	1.64	1.74	1.96
Total Fruits	2.07	2.12	2.36
Potatoes	0.84	0.89	0.98
Onions	0.30	0.33	0.57
Total Vegetables	2.80	2.91	3.46
Groundnut	2.70	2.57	2.27
Sesame	0.84	0.93	1.01
Rapeseed & Mustard	3.01	2.72	2.84
Linseed	0.11	0.11	0.09
Other Oil Seeds	8.31	7.99	8.15
Total Oil Seeds	14.98	14.33	14.36
Cotton	5.93	6.38	6.14
Jute	0.38	0.38	0.37
Mesta	0.03	0.04	0.04
Total Fibers	6.37	6.82	6.56
Tobacco	0.23	0.24	0.22
Other Crops	6.89	6.76	6.85
Gross Cropped Area	100.00	100.00	100.00

(Source: Directorate of Economics & Statistics, DAC & FWP; P: Provisional)

You will further study about the distribution and production of various crops in details in Unit 11 on Agriculture of Block-3.

SAQ I

Describe the term landuse?

6.4 LAND-MAN RATIO

Do you know why the land-man ratio is so important to study? Yes, because humans use natural resources such as land, water, minerals, and others, for different purposes. We play a key role in developmental activities. You can see that the prosperity of any habitation or region depends on the ability of people to utilize land resources judiciously. The land-man ratio provides clues with regard to the spatial distribution of population that mostly correlates with the capabilities of land resources. The **land-man ratio** refers to the population density of any particular region. It refers to "*a method of calculating the number of people living in a certain location per unit of area or volume*". Each portion of land has a certain number of people who can live on it. As a result, it is essential to understand the population-to-land-area ratio. It is generally expressed in terms of people per square kilometer of area as:

Land-Man ratio or Density of Population = Total population of the region/Total area of the region.

Let us understand by studying a simple example which is explained below:

Example: The region 'A' has 100 sq. km of area and the total population of that region (A) is 3,00,000. Calculate the land-to-man ratio of the region A.

In this case, the density of population or land man ratio can be calculated as:
 $3,00,000 \text{ (total population)} / 100 \text{ (area)} = 3,000 \text{ people/sq. km.}$

Let us study some of the factors that influence population distribution and density of a region.

6.4.1 Factors Influencing Population Distribution and Density

The spatial distribution of the population for any region is not uniformly distributed over time and space. There are some factors that impact on population distribution and density may be divided into two main groups: 1) physical factors and 2) socio-economic factors.

1. **Physical Factors:** These factors have an important impact on population density and distribution. Topography, landforms, climate, and soils are examples of physical factors. Despite technological advancements, the patterns of population distribution throughout the world continue to reflect the effect of many physical causes.
2. **Socio-Economic Factors:** Socio-economic factors also have a significant impact on population density and distribution, much like physical factors. It is well acknowledged that socioeconomic (non-physical) factors are becoming more important, like socio-cultural and political factors, and natural resource exploitation, are some of the socioeconomic elements that have an influence on people. However, the relative relevance of these two factors may not be completely agreed upon. Physical elements are important in certain locations, whereas socioeconomic ones are more important in others.

Depending upon the purpose, population data can be plotted, described, or analyzed in a variety of ways. Population data is collected and mapped on the basis of big units such as states or smaller divisions like districts, and even at the Mandal/Taluk and Village levels. These data sets are utilized when more precise information is required to link population with the type of land and other related factors.

6.5 LANDUSE CAPABILITY

Till now, you have understood about the nine-fold landuse classification system of India, and the distribution and utilization of land resources in the country. You have also read about the land-man ratio and the factors like physical and social, which are affecting the population distribution and density. You now know the landuse capability.

Landuse capability or land capability is the capacity of land to support a specific landuse without incurring damage. The ability of the land surface to sustain natural plant growth/animal habitat or artificial crop growth/human habitat can be characterized as land capability. It can be understood that some kind of landuse which is suited for a specific type of land viz. human habitation, agriculture, grasslands, forests, animal habitat, etc. Depending on terrain features such as slope, soil type, soil depth, and erosion conditions, etc., different types of land have varying capacities. If some land features are incompatible with agriculture, it is preferable to use or maintain the continuation of such an area for other landuses. Land capability evaluations are the initial step in determining the land suitability for a certain use. Land suitability reflects other variables such as economics, infrastructural needs, water and energy needs, challenging and accompanying landuses are all taken into account. Let us study the classification for land capability.

6.5.1 Land Capability Classification

Land capability classification is a technique of classifying land based on the inherent constraints imposed on long-term usage by soil characteristics, terrain, drainage, and climate. It is a guiding concept that uses the land in accordance with its capabilities and treats it in accordance with its requirements. The capacity classes are divided into two groups: Group 1 includes those that are suitable for cultivation and Group 2 includes those that are not suitable for cultivation. Group 1 contains land classes I to IV and Group 2 contains V to VIII. The characteristics of each group have been discussed below in terms of landuse capability.

Group 1: Suitable for Cultivation

- i) **Class I:** These lands have low slopes (0-1%) and high cultivable capacity. These are excellent lands that can be safely cultivated and used for any crop using any agricultural method.
- ii) **Class II:** These lands are having gentle slopes (1-3%) and are good for cultivation, however some conservation techniques like contour farming and terracing need to be adopted. These lands have some constraints like limiting crop choice, being moderately deep and vulnerable to wind and water erosion, etc.

- iii) **Class III:** These lands often have moderate slopes (3-5%), posing significant constraints that limit crop choice or necessitate specific conservation methods like strip cropping, bund construction, etc. Soils are moderately fertile and are prone to more severe erosion and degradation. However, they may be utilized for agriculture if enough plant cover is maintained.
- iv) **Class IV:** These lands are usually on steep slopes (5-8%) with shallow soil depth and low fertility. These are prone to erosion and have a high risk of damage, but they may be farmed on occasionally if treated carefully.

Group 2: Unsuitable for Cultivation

- i) **Class V:** These lands have steep slopes (8-12%) and are either wet or stony for cultivation. They typically have little to no erosion risk. If well managed, these can be used for pastures or forestry, and it is possible to control grazing.
- ii) **Class VI:** These lands have steep slopes (12-18%) and shallow soils used for grazing and forestry. Grazing should be controlled to protect plant cover, and usage should be restricted until cover is restored.
- iii) **Class VII:** These lands are characterized by degraded, rugged terrain, thin soil depth, and steeper slopes of up to 25%. The soils may be marshy or drought-prone, with all of the restrictions that apply to greater extent. They are utilized for forestry with complete green cover, gully control structures, and severely restricted grazing if there is enough rainfall.
- iv) **Class VIII:** These lands are in difficult terrain, with some of the poorest soil types and possibly in excess of 25% of the steepest slopes. These may be considered as wastelands also. They can only be utilized in woods with extremely solid gully management methods, if the conditions are favorable for tree development and wildlife habitat. Not suitable for use in a forest or for grazing.

6.5.2 Land Capability at Sub-class Level

The second category in the land capability categorization is subclass capability. Land capability subclasses are designated by the class codes namely e, w, s, and c. These are sub-categories of capability classes based on four major constraints: i) Erosion risk (e) (ii) Wetness, drainage, or overflow (w), (iii) Rooting zone limits (s), and (iv) Climate constraints (c). The sub-classes are identified by appending the limitation symbol to the capability class number.

- i) **Subclass-e:** soils are those whose vulnerability to erosion is the most significant problem or hazard limiting their usage. The main soil variables that impact soils in this category are erosion susceptibility and previous erosion damage.
- ii) **Subclass-w:** soils are those for which excess water is the primary danger or constraint to their usage. Soils in this category are affected by poor soil drainage, dampness, a high water table, and overflow.

- iii) **Subclass–s:** soils having constraints inside the rooting zone, such as root zone shallowness, stones, limited moisture-holding capacity, low fertility that is difficult to improve, and salt or sodium concentration.
- iv) **Subclass–c:** soils are those for which the climate (temperature or absence of moisture) is the most significant danger or constraint to their usage.

The capability class is determined by the prevailing limitation, which is represented by the subclass. Within a capability class with basically equal types of limits, the sub-classes e, w, s, and c have the following priority: e, w, s, and c. In capability classes I and VIII, subclasses are not allocated to soils or miscellaneous regions.

SAQ 2

- a) Write about any two physical and socio-economic factors influencing population density.
 - b) In land-capability classification, which of the lands are represented by Class-I?
-

6.6 LAND DEGRADATION

Do you think without food any biological organisms can sustain on the globe? The haphazard growth of population and their intervention in the natural environment for the sole purpose of economic growth leading to degradation of land and alteration of biological environment.

Land degradation is defined as the loss of current or potential productivity of the land as a result of natural or anthropogenic activities. It is essentially a deterioration in the quality and productivity of land. Degradation occurs due to several interconnected causes that can lead to a downward sequence, resulting in land that is no longer suitable for economically viable use. An ever-increasing global population and the ongoing degradation of vast tracks of land are threatening the fundamental processes of the natural and agricultural ecosystems on the Earth, as well as the quality of human living. Because of its negative effects on agronomic productivity, the environment, food security, and quality of life, land degradation will continue to be a major distress in the twenty-first century. Land degradation has a negative influence on productivity since the condition of the land on site has deteriorated. The influence of land degradation on universal food security and environmental quality has elevated the prominence of land degradation among global concerns. The extent of deterioration is determined by the people's activity towards the land, and they can play a critical role in amending a downward trend. Land and environmental deterioration can be exacerbated by unsustainable agricultural practices, poverty, and illiteracy as well as global warming and climate change of the 21st century. In this scenario, we need to understand the major land degradation processes occurring in the current world environment.

Land degradation is made up of a number of different components and processes, each of which is inseparably related to each other. Although there are many different types of land degradation processes, you will mainly focus on three key components of land degradation, i.e. soil, water, and forest.

1. Soil and Land Degradation

As we all are aware that **soil erosion** is one of the most serious and universal types of land degradation. Soil erosion is the process of a soil cover getting depleted and then being washed away. Soil development and erosion occur at the same time and there is typically a balance between the two. Human activities like deforestation, overgrazing, mining operations, etc., can disrupt this equilibrium. Natural factors such as wind and water can also cause soil erosion. These factors can cause damage to farmland production, eventually rendering the ground unfit for farming.

Running water cuts the clayey soils into massive channels and these are called "gullies" or "badlands", which may become unsuitable for agriculture. Sometimes water may flow down as a sheet over vast areas and the top soil will be washed away. This process is called "**sheet erosion**". On the other hand, wind erosion is a natural phenomenon in which wind forcibly transfers soil from one area to another. It has the potential to create enormous economic and environmental harm. While wind erosion is more frequent in deserts, along the sand dunes and beaches of the coastal areas. It can also occur due to specific terrain characteristics in certain areas.

Changes in the physical, chemical, and biological properties of the soil can reduce land productivity. The alteration of physical properties of soils like structure and water holding capacity, leads to physical degradation, while chemical degradation can be identified through acidification and loss of plant nutrient. Due to a decrease in soil organic matter, the activity of the fauna may also reduce which is referred to as biological degradation.

Salinization, another major threat that refers to all types of soil degradation caused by a rise in salt levels in the soils and extreme accumulation of free salts. It occurs as a result of poor canal-based irrigation project planning and management. Depending on the composition, salt-affected lands are classified as saline, sodic, or saline-sodic. The main effect of soil salinity on plant development is a reduction in water uptake. In these soils, crops easily die owing to a lack of water absorption, even with adequate soil moisture. Salinized soils appear as white encrustations and are enclosed by a belt of restricted crop growth, which leads to water logging in the long run.

2. Water and Land Degradation

We are now experiencing acute water shortages across the length and breadth of the country, particularly in arid areas for drinking and agriculture. Due to industrial, construction, and changing patterns of agricultural activities, both the surface water and groundwater resources are affected in terms of quantity as well as quality. The discernable changes include the lowering of the water table, contamination by pollutants, changes in the flow regime in rivers and sedimentation, etc. The natural water cycle includes groundwater where the precipitation that falls on the ground surface infiltrates into the

subsurface to some extent. Groundwater recharge is the portion that goes downhill through the soil until it reaches the saturated rock material. Saturated groundwater flows slowly and may ultimately discharge into streams, lakes, and seas.

Excessive groundwater pumping everywhere, even in rural and urban areas has the most serious effect on changing water tables. Agricultural chemical contamination of ground water is also one of the major challenges globally. Salinization, induced by salt leaching in irrigated regions, is the most common kind of land degradation in the tropics. As salt levels rise, the water becomes unsuitable for human consumption, livestock watering and eventually too saline for use in irrigation also. Changes in river flow regimes and drying of lakes are the best examples of surface water degradation. The primary negative effect on rivers is that the flow becomes less consistent. You may observe or may read from the newspapers that perennial streams and rivers are also slowly drying up towards the end of the dry season due to various reasons.

Deforestation of headwater catchment regions of the rivers is another important factor of changing flow regime and subsequent land degradation. Rainfall flows off the surface rather than seeping into the soil, causing floods following storms and reducing groundwater flow. Soils are transported off site and deposited on land, in lakes, marshes, and streams when significant rain or wind events occur, or when soils are disturbed by human activity.

Sedimentation is also a major problem in which the process of eroded soil being deposited down slope. Sediment, the single most significant nonpoint source contaminant, contributes to the deterioration of surface water quality, endangers aquatic life, and causes stream bank erosion and often leads to floods.

3. Forest and Land Degradation

You might be aware of that the effects of **deforestation** brings problem in the natural environment. When a forest is replaced by agriculture, mining or development of an urban center or other land uses, the area is said to be deforested. Degradation, on the other hand, is a continuous process in which a forest's biomass, species composition, or soil quality deteriorates. Deforestation is frequently accompanied by degradation. Forest deterioration and depletion of resources create a substantial impact on forest-dependent population indigenous species in particular, and the global climate in general.

Deforestation and forest degradation are driven by a variety of factors that vary by location and country. The desire for land to cultivate crops or raise animals is the major driver of deforestation in the tropics. Mining, infrastructural development, urban growth, and logging are all major contributors to deforestation. Agriculture is the primary cause of deforestation due to increased demand for food, fodder and fuel. Overgrazing, demand for fuel wood, excessive logging, and human-caused fires are also some of the important factors that contribute towards degradation of the forests. Prevention of deforestation and degradation of forests can enhance carbon sequestration and contribute towards conservation of biodiversity and limiting the climate change.

6.6.1 Remedial Measures to Mitigate Land Degradation

Through the application of sustainable agricultural techniques and better land management practices, the consequences of land degradation can be reduced, prevented, and even reversed. There are a number of techniques to limit the erosion caused by wind and water which in turn can prevent land degradation. Some of the important remedial measures for the prevention of land degradation are given below.

- i) **Afforestation:** Afforestation is the establishment of a forest or stand of trees in an area where there was no previous tree cover or loss of tree cover due to land degradation. Areas prone to soil erosion can be planted with trees, especially trees that have a high soil binding capacity. Degraded lands can be improved by planting small plants and trees as well which are locally adaptable.
- ii) **Slope terracing:** Slope terracing decreases the impacts of surface water runoff and helps in the conservation of rainwater.
- iii) **Shelter belts:** A shelter belt is often a row of trees planted along fence lines. Field shelter belts minimize wind erosion, soil moisture conservation, and damage of crops by wind. To preserve the soil, they should be used in conjunction with proper agricultural residue management and other conservation techniques.
- iv) **Stabilization of sand dunes by dune plantation:** Thorny shrubs assist to prevent land degradation by holding the soil in place or by stabilizing sand dunes in the desert areas. Similarly sand dunes along the coastal zone can be stabilized through dune plantations. These are some of the effective checks on land degradation.
- v) **Strip cropping:** Strip cropping helps to prevent soil erosion by building natural barriers, which helps to retain the soil strength. Plants in some strata absorb nutrients and water from the soil more efficiently than others.
- vi) **Rotation of crops:** Crop rotation is the practice of cultivating a variety of crops in the same location over the course of several growing seasons. Crop rotations improve soil structure and organic matter in soil, reduces deterioration of soil quality and strengthens agricultural output. This process indirectly becomes a cause of prevention of land degradation.
- vii) **Wastelands reclamation:** The process of converting barren, infertile wasteland into some kind of productive land is known as wasteland reclamation. It prevents soil erosion and conserves moisture preventing further degradation of land.

In conclusion, land degradation has a direct influence on the environment. We must think and act timely how to prevent land degradation at local level. Keeping in mind the present trend of expanding population, we must adopt the sustainable development practices for conservation of land resources. Land degradation endangers land productivity and in the long term it can lead

towards desertification. Sustainable development of land resources can be achieved by increasing public knowledge and awareness of the problem and promoting suitable land management practices.

SAQ 3

- a) What is land degradation?
 - b) Write two important remedial measures to arrest land degradation.
-

6.7 SUMMARY

In this unit, you have studied so far:

- The nine-fold classification of landuse in India.
- The categorization of land holdings into five size groups such as, marginal (< 1 ha), small (1-2 ha), semi-medium (2-4 ha), medium (4-10 ha), and large (10 ha and above).
- The distribution and utilization of land resources among the states of India.
- The land-man ratio explains the population density of a particular region where there are several physical and socio-economic factors that influence the density of the population.
- Land capability classification mainly explains whether the land is suitable or not suitable for cultivation. You have understand about the classes and their subclasses of land capability.
- There are three different types of land degradation associated with soil, water and forests.
- You have also studied some remedial measures to mitigate land degradation.

6.8 TERMINAL QUESTIONS

1. Explain about the nine fold landuse classification.
2. Discuss the land capability classification.
3. What remedial measures do you suggest to restrict land degradation?

6.9 ANSWERS

Short Answer Questions (SAQ)

1. The term landuse can be explained as the utilization of land for a particular purpose.

2. a) Physical factors: climate and soils; Socio-economic factors: political and resource exploitations.

b) Class-I represents nearly level slopes or flat lands and are very good for cultivation.
3. a) The deterioration of the quality and productivity of land for various reasons may be called as land degradation.

b) Afforestation and rotation of crops.

Terminal Questions

1. Refer to Section 6.2.
2. Refer to Sub-Section 6.5.1.
3. Refer to Sub-Section 6.6.1.

6.10 REFERENCES AND SUGGESTED FURTHER READING

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WATER RESOURCES |

Structure

7.1	Introduction	7.3	Multipurpose River Valley Projects
	Expected Learning Outcomes		Damodar Valley Corporation-A Case Study
7.2	Water Resources	7.4	Summary
	Types of Water Resources	7.5	Terminal Questions
	Characteristics of Groundwater Resources	7.6	Answers
	Distribution of Water Resources	7.7	References and Suggested Further Reading
	Utilization of Water Resources		

7.1 INTRODUCTION

You have studied the physiography of India in Block-1 of this course in detail. Block 2 explains you the resource base, in which you have already read about the land resources dealing with their classification, distribution and utilization, land-man ratio, and some important issues related to land degradation in Unit 6. From this Unit 7, you will learn about water resources. We all know that the water is a vital resource without which, life on the planet Earth is impossible. Water covers nearly 71% of the Earth's surface, hence it is named as the "Blue Planet". It plays a very important role in the socio-economic and developmental activities of the country. You might be knowing that water is available on the surface of the Earth, below the ground, as well as in the atmosphere in various forms.

This unit introduces you to the types and characteristics of water resources in Section 7.2. Rainfall is the main source of fresh water in India and a maximum amount of it received and recharged by the ground during the south-west monsoon season. Distribution and utilization of this precious natural resource are explained in Sub-Sections 7.2.3 and 7.2.4. From Section 7.3, you will understand what is a multipurpose river project? and its importance. A case study of the Damodar River Valley Project is also explained for better understanding of the concept of multipurpose river valley projects in India.

Expected Learning Outcomes

After completing the study of this unit, you should be able to:

- elucidate various types and characteristics of water resources;
- describe the distribution of water resources and their utilization; and
- explain about multipurpose river valley project and its significance in India.

7.2 WATER RESOURCES

Can you imagine the life without water on the planet Earth? Yes, absolutely, no one can imagine the life without water. We all die without water. We all know that the survival and maintenance of life on the planet Earth depends on water. Water plays a significant role in the survival of human beings, plants and animals. Water is also essential for successful agriculture, economy, clean energy and livelihood security. Do you know from where we are getting this precious resource? Yes, basically we receive fresh water from rain and melting ice. Water moves continuously on the surface of the Earth, as well as below and above the Earth. It can be understood by studying the hydrological cycle, which you have learnt in the course- BGGCT 131: Physical Geography. We can identify water in all three forms include solid, liquid and gaseous form. However, the availability of fresh water may be an alarming issue for humans and other living organisms on the planet Earth. Let us now study the types of water resources and their important characteristics.

7.2.1 Types of Water Resources

You will understand mainly two types of water resources, namely surface and groundwater resources. Atmospheric water is also part of the water cycle.

1) Surface Water Resources

Surface water refers to the water bodies occurring in the form of rivers, streams, lakes, seas and oceans, etc., on the surface of the Earth. Out of these, the ocean water is highly saline whereas other two types are having fresh water. Oceans regularize the water cycle through the movement of water to and from the surface of the Earth. Monitoring the stream flow on the surface helps in identification of erosion, sedimentation, flooding, etc., that is essential in the protection of human life and property. The surface water flow, sedimentation and quality of water can effectively monitor using stream gauges, satellite imageries, etc. Surface water resources can be divided into two main types, such as inland water resources and oceanic water resources.

a) Inland Water Resources: Rivers, streams, canals, lakes, ponds, reservoirs, creeks, wetlands, marshes and other water bodies come under this category. The surface water available throughout the year is called **perennial water bodies**, whereas the water that persists for only part of the year is known as **non-perennial or ephemeral water bodies**. These water resources directly influence human life and the distribution of population. These can provide services in various ways, including domestic water supply, agricultural activities, industrial energy, hydroelectricity, food, navigation, and tourism, etc.

b) **Oceanic Water Resources:** You know that the oceans occupy nearly 71% of the Earth's surface. Oceans are vast bodies of water that are interconnected. The Pacific, the Atlantic, the Arctic, and the Indian oceans and other seas play a significant role in the economic activities of humans. These are the main sources of supply of moisture for rainfall and control of temperatures, thus influencing the climate. Oceans also provide different mineral and chemical products, variety of fish and other food items. These water resources provide opportunities for water sports, recreation and contributes toward the economic activities through navigation, etc.

2) Groundwater Resources

The surface water that seeps into the ground at certain depths is referred to as **groundwater**. Rainfall is the main contributor for groundwater recharge. This underground water resource comes in the use of plant growth besides recharging the groundwater aquifers and springs. It is also used as a source for drinking and domestic purpose, irrigation and agricultural practices, as well as for industrial supplies. Nearly one third of the rain water goes as runoff into streams, rivers and lakes, etc. Groundwater and surface water both depend on one another, as we see groundwater flowing out through springs to replenish the surface water.

7.2.2 Characteristics of Groundwater Resources

You have been introduced to the types of water resources, such as surface water and groundwater. You now know the characteristics of groundwater resource. In India, groundwater occurs in different formations. You have to know about these formations of the country. Characteristically, the groundwater occurs mainly in two types of rock formations such as soft rock/porous rock formations and hard rock/consolidated formations. We have explained briefly about these formations as follows.

1) Soft Rock Formations

Soft rock formations are also called as **porous rock formations**. These formations can be divided into unconsolidated formations and semi-consolidated formations. The sediments comprising newer alluvium, older alluvium and coastal alluvium are categorized under **unconsolidated formations** which are mainly composed of clays, sand, gravel and boulders, ferruginous nodules, kankar, etc. The admixtures of these materials act as potential groundwater reservoirs. You can find the unconsolidated formations mostly in the Indus-Ganga-Brahmaputra Alluvial (IGBA) tract, Bhabar and Tarai belts, Coastal alluvial zones, Gujarat alluvial plain, Ganga Delta, inter montane valleys, and Aeolian sand tracts, etc. For example, the IGBA tract extends between Jammu (western boundary) and Assam (eastern boundary), storing fresh groundwater in large quantities nearly 600 m below the surface. It was recorded that the thickness of alluvium is 200 m in the deltaic soils of Kolkata and 1830 m in the central portion of Bihar.

On the other hand, the **semi-consolidated formations** are chiefly composed of shales, sandstones and limestone; sedimentary deposits belonging to Gondwana and tertiary formations are also included in this category. These formations typically have a moderate potential for groundwater, for example,

the Lathi and Nagaur sandstones in Rajasthan and the Tipam sandstone in Tripura.

2) Hard Rock Formations

The **hard rock formations** are consolidated formations which holds water, not at very deep levels. It depends on local lithology and structures like joints, fissures, and fractures of the parent rock. Weathering and interconnected geological structures create secondary porosity, which is important in controlling the groundwater reservoir. We can get good yields of water when we identify zones for digging for groundwater abstraction on the basis of lineaments and planes of structural weaknesses in the hard rocks. The consolidated formations can be classified into three types, such as:

- i. **Igneous and Metamorphic Rock Formations:** These include granites, gneisses, charnockites, khondalites, quartzites, schists and associated phyllites, slates, etc. The areas underlain by hard crystalline and meta-sedimentary rocks are able to produce groundwater at a depth of 100 m and sometimes further deeper, nearly 200 m in their fracture system.
- ii. **Volcanic Rock Formations:** In India, basalts are the common type of volcanic rocks. For example, Deccan Trap, in which the groundwater occurrence depends on primary and secondary features. The Deccan trap basalts are widespread in Maharashtra and Madhya Pradesh.
- iii. **Carbonate Rock Formations:** These are comprising of limestone, marble and dolomites which supports low yield of groundwater, hence they are not very productive groundwater reservoirs everywhere. Some areas of Vindhyan limestone (Rajasthan), the Pakhal limestone (Telangana) and limestone in Madhya Pradesh are productive aquifers. In the Himalayan region, the limestone formations have been the source of many springs.

SAQ I

- a) What is a perennial river?
 - b) What are the major sources of groundwater occurrence in hard rock regions?
-

7.2.3 Distribution of Water Resources

United Nations Educational, Scientific and Cultural Organization (UNESCO) recorded that nearly 1.4 billion cubic kilometers of water is covering on the planet Earth. Out of this, only 35 million cubic kilometers (2.5% of total volume) is available as fresh water accounting for 68.9% in the form of ice and permanent snow (spreading in mountains, the Antarctic and Arctic regions), 29.9% as groundwater (depth below upto 2,000 meters), and the remaining small fraction of 0.3% is contributing by lakes and rivers and 0.9% exists as soil moisture, swamp water and permafrost atmosphere. You now know the distribution of the surface water and groundwater resources in India.

1. Distribution of Surface Water Resources

If you observe in the context of water resources of India, precipitation, particularly monsoon rainfall, is the main source of fresh water. According to

the National Commission on Integrated Water Resources Development (NCIWRD) report, the average annual precipitation of the country is received about 4000 billion cubic meters (BCM), out of which nearly 3000 BCM falls in the monsoon months from June to September. The total annual utilizable water resource is assessed as 1121 BCM, from which surface and groundwater contribute 690 BCM and 431 BCM, respectively. Table 7.1 shows the potential water sources of rivers in India. We can observe from the table that the average annual water resource potential is 1869 BCM. As India depends mainly on the agricultural economy, this sector uses about 80% of water resources, followed by the domestic (6%), and industrial sectors (5%).

In India, the **inland water sources** are categorized as rivers and canals, reservoirs, tanks and ponds, flood plain lakes and derelict water bodies and brackish water. You will find the distribution of inland water resources presented in Table 7.2. It can be seen from the table that the total water bodies, excluding rivers and canals, cover an area of about 7.4 Mha, of which reservoirs cover a maximum of 2.9 Mha.

You will also understand our country's surface water potential by studying the given Table 7.1. It explains the areal distribution of river basins in India. A **river basin** is the area of land over which all the surface water flows by a river and all of its tributaries. The river and its basin water ultimately reach into the seas or lakes. There are 20 important river basins/group of river basins in the country. Out of these, twelve are comprised of major basins and eight are composite river basins. The 12 major river basins are (1) Indus (2) Ganga-Brahmaputra-Meghna (3) Godavari (4) Krishna (5) Cauvery (6) Mahanadi (7) Pennar (8) Brahmani-Baitarani (9) Sabarmati (10) Mahi (11) Narmada and (12) Tapi. These basins occupy nearly 43% of the total area. The major rivers and their tributaries are covered by nearly 277 Mha of catchment area by the type of perennial and seasonal flow. You now know the river systems of India which contribute to an enormous surface water potential for the country's needs.

River Systems in India: In India, the river systems may broadly be grouped into four types viz., (i) Himalayan rivers (ii) Deccan rivers (iii) Coastal rivers and (iv) Rivers of the inland drainage basin.

The Himalayan rivers are mostly perennial rivers formed by melting snow and glaciers. These rivers have high surface water potential as these receive water heavily from monsoon rains. The important Himalayan river systems are the Indus, which occupies 3,21,289 sq. km area and the Ganga-Brahmaputra-Meghna system covering nearly 1,097,588 sq. km. The Indus originates near Mansarovar in Tibet and flows through India and Pakistan and merges in the Arabian Sea near Karachi. The major tributaries of the Indus are the Sutlej, the Beas, the Ravi, the Chenab, and the Jhelum. The river Ganga rises near Gangotri in Uttarakhand state and is continuously flowing with the Bhagirathi and the Alaknanda sub-basins water. The Yamuna, the Ramganga, the Ghaghra, the Gandak, the Kosi, the Mahananda, and the Sone are the important tributaries of the river Ganga. The Chambal and the Betwa are the important sub-tributaries which join the Yamuna before it meets the Ganga.

Table 7.1: Surface Water Potential of River Basins in India.

S. No.	Name of the River Basin	Origin of River	Length (km)	Catchment (sq. km)	AAWRP (BCM)	USWR (BCM)
1.	Indus (upto Border)	Mansarovar (Tibet)	1114 (2880)	321289 (1165500)	73.31	46.0
2.	Ganga	Gangotri (Uttaranchal)	2525	861452 (1186000)	525.02	250.0
	Brahmaputra	Kailash Range (Tibet)	916 (2900)	194413 (580000)	537.24	24.0
	Barak & other rivers flowing into Meghna	Manipur Hills (Manipur)	-	41723	48.36	-
3.	Godavari	Nasik (Maharashtra)	1465	312812	110.54	76.3
4.	Krishna	Mahabaleshwar (Maharashtra)	1401	258948	78.12	58.0
5.	Cauvery	Coorg (Karnataka)	800	81155	21.36	19.0
6.	Subarnarekha	Nagri (Ranchi, Jharkhand)	559	29196	12.37	6.8
7.	Brahmani & Baitarni	Ranchi (Jharkhand)	799	39033	28.48	18.3
8.	Mahanadi	Nazri Town (Madhya Pradesh)	851	141589	66.88	50.0
9.	Pennar	Kolar (Karnataka)	597	55213	6.32	6.9
10.	Mahi	Dhar (Madhya Pradesh)	583	34842	11.02	3.1
11.	Sabarmati	Aravalli Hills (Rajasthan)	371	21674	3.81	1.9
12.	Narmada	Amarkantak (Madhya Pradesh)	1312	98796	45.64	34.5
13.	Tapi	Betul (Madhya Pradesh)	724	65145	14.88	14.5
14.	West Flowing Rivers from Tapi to Tadri			55940	87.41	11.9
15.	West flowing Rivers from Tadri to Kanyakumari			56177	113.53	24.3
16.	East flowing Rivers Between Mahanadi & Pennar			86643	22.52	13.1
17.	East flowing Rivers Between Pennar and Kanyakumari			100139	16.46	16.5
18.	West Flowing Rivers of Kutch and Saurashtra including Luni			321851	15.10	15.0
19.	Area of Inland Drainage in Rajasthan			Negligible		
20.	Minor River Draining into Myanmar & Bangladesh			36302	31.00	-
Total					1869.37	690.1

(Note: USWR: Utilizable Surface Water Resources (BCM); AAWRP: Average Annual Water Resources Potential (BCM) and Figures within bracket indicate the total river basin in India and neighbouring countries)

(Source: Ministry of Water Resource, CWC, Govt. of India)

Table 7.2: Distribution of Inland Water Resources of India.

Rivers & Canals	1,95,210 (length in km.)
Reservoirs	2.91 (area in Mha.)
Tanks & Ponds	2.41 (area in Mha.)
Flood Plain Lakes & Derelict	0.8 (area in Mha.)
Brackish Water	1.24 (area in Mha.)

The river Brahmaputra originates in Tibet and flows through Arunachal Pradesh and Assam states of India and then enters Bangladesh debouching into the Bay of Bengal. The river Brahmaputra is called Tsangpo in Tibet and Dihang in Arunachal Pradesh. The Debang, the Lohit, the Subansiri, the Jia Bhareli, the Dhansiri, the Puthimari, the Pagladiya, and the Manas are major tributaries of the Brahmaputra in India. The waters of the Teesta flow into the Brahmaputra in Bangladesh and finally merge into the Ganga. The Padma and the Brahmaputra join inside Bangladesh and continue to flow as the Padma or Ganga.

The Barak river is the main stream of the Meghna river system. It rises in the Manipur hills. The principal tributaries of the river are the Makku, the Trang, the Tuivai, the Jiri, the Sonai, the Rukni, the Katakhal, the Dhaleswari, the Langachini, the Maduva and the Jaitnga. The Meghna meets its major tributary, the Padma, in Chandpur District. Other major tributaries of the Meghna include the Dhaleshwari, the Gomti, and the Fenny. The Meghna empties into the Bay of Bengal in the Bhola District of Bangladesh.

The **Deccan rivers** basically dependent on rainfall, hence they are called **rain fed** and **non-perennial** rivers. The river system of the Godavari, the Krishna, the Cauvery, the Mahanadi, etc. flows into the Bay of Bengal in an easterly direction. The Narmada and the Tapti are major west flowing rivers flowing to the Arabian Sea. Most of the **coastal rivers** and streams are short in length and most of them are non-perennial. These streams are draining into the sea. The catchment of these rivers and streams is occupying relatively less area.

The streams/rivers of the **inland drainage basin** of western Rajasthan are very few and are of an ephemeral character. The desert streams mostly drain into the salt lakes and do not fall into the sea. The Saraswati, the Luni, the Machhu, the Banas, the Rupen, and the Ghaggar are few examples of the desert rivers.

2. Distribution of Groundwater Resources

Groundwater plays a major role in supplying drinking water to rural as well as urban areas. The country's groundwater potential in consolidated/semi-consolidated and unconsolidated formations is presented in Figure 7.1.

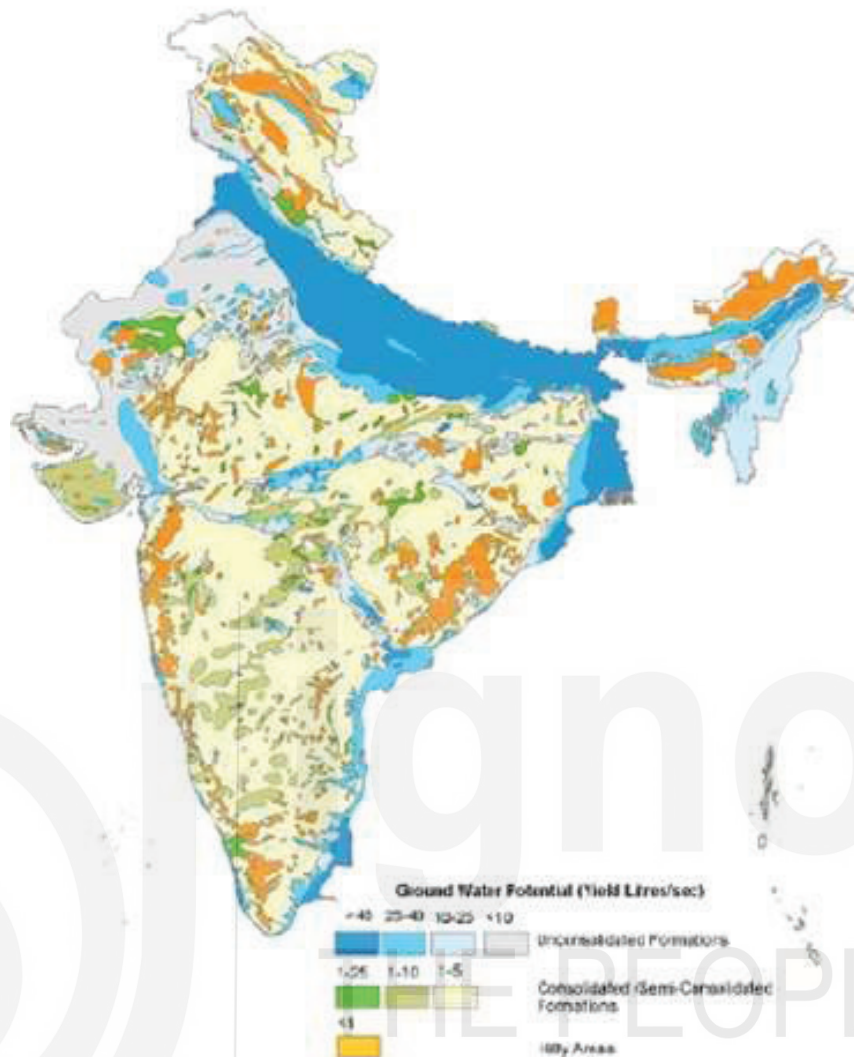


Fig. 7.1: Groundwater Potential Map of India.

(Source: Groundwater Year Book-India 2019-2020, CGWB, Govt. of India, <http://cgwb.gov.in>)

Groundwater supports nearly 80% of the domestic needs of the Indian population. Groundwater is replenished mainly by precipitation, and a major portion (about 73%) of the groundwater recharge occurring during the south-west monsoon season. The annual replenishment of groundwater is estimated to be 431.2 Billion Cubic Meters (BCM). Keeping aside 39.2 BCM for natural discharge, the net annual groundwater resource availability for the entire country is 392.7 BCM. The current net annual groundwater extraction in the country estimated is 248.7 BCM. Out of that, about 90% is used by the irrigation sector and the remaining water resource is utilized for domestic and industrial purposes. Table 7.3 shows annual replenishable groundwater resources available in different States and Union Territories (UTs) of India. The highest net groundwater availability in a year (BCM/y) for future uses is recorded in the states of Assam (21.4), Uttar Pradesh (20.4), Bihar (15.8), Madhya Pradesh (15.8), followed by West Bengal (14.2), Maharashtra (12.9), and Andhra Pradesh (12.3). On the other hand the lowest that is noted in Delhi (0.02), Goa (0.1), Himachal Pradesh (0.2), Mizoram (0.2), Manipur (0.3), Haryana (0.9), Rajasthan (0.9), and Punjab (1.1).

Table 7.3: State-Wise Ground Water Resources of India, 2017 (in BCM).

States/Union Territories	AGWR	ND	GWR	Current Annual Ground Water Extraction				NGWA	GWE (%)
				Irrig.	Ind.	Dome.	Total		
Andhra Pradesh	21.2	1.1	20.2	7.9	0.1	0.9	8.9	12.3	44.2
Arunachal Pradesh	3.0	0.4	2.7	0.0	0.0	0.0	0.0	2.6	0.3
Assam	28.7	4.4	24.3	2.0	0.1	0.7	2.7	21.4	11.3
Bihar	31.4	2.4	29.0	10.8	0.7	1.8	13.2	15.8	45.8
Chhattisgarh	11.6	1.0	10.6	4.0	0.1	0.7	4.7	5.8	44.4
Delhi	0.3	0.0	0.3	0.1	0.0	0.2	0.4	0.0	119.6
Goa	0.3	0.1	0.2	0.0	*	0.0	0.1	0.1	33.5
Gujarat	22.4	1.1	21.3	12.8	0.1	0.6	13.5	8.0	63.9
Haryana	10.1	1.0	9.1	11.5	0.3	0.6	12.5	0.9	136.9
Himachal Pradesh	0.5	0.1	0.5	0.2	0.0	0.2	0.4	0.2	86.4
Jammu & Kashmir	2.9	0.3	2.6	0.2	0.1	0.5	0.8	1.8	29.5
Jharkhand	6.2	0.5	5.7	0.8	0.2	0.6	1.6	4.1	27.7
Karnataka	16.8	2.1	14.8	9.4	*	1.0	10.3	5.4	69.9
Kerala	5.8	0.6	5.2	1.2	0.0	1.4	2.7	2.4	51.3
Madhya Pradesh	36.4	2.0	34.5	17.4	0.2	1.2	18.9	15.8	54.8
Maharashtra	31.6	1.7	29.9	15.1	0.0	1.2	16.3	12.9	54.6
Manipur	0.4	0.0	0.4	0.0	0.0	0.0	0.0	0.3	1.4
Meghalaya	1.8	0.2	1.6	0.0	0.0	0.0	0.0	1.6	2.3
Mizoram	0.2	0.0	0.2	0.0	0.0	0.0	0.0	0.2	3.8
Nagaland	2.2	0.2	2.0	0.0	0.0	0.0	0.0	2.0	1.0
Odisha	16.7	1.2	15.6	5.3	0.1	1.2	6.6	8.9	42.2
Punjab	23.9	2.4	21.6	34.6	0.2	1.0	35.8	1.1	165.8
Rajasthan	13.2	1.2	12.0	14.9	0.0	1.9	16.8	0.9	139.9
Sikkim	5.6	4.1	1.5	0.0	0.0	0.0	0.0	1.5	0.1
Tamil Nadu	20.2	2.0	18.2	13.1	0.0	1.7	14.7	5.7	80.9
Telangana	13.6	1.3	12.4	7.1	*	1.0	8.1	4.3	65.5
Tripura	1.5	0.3	1.2	0.0	0.0	0.1	0.1	1.1	7.9
Uttar Pradesh	69.9	4.6	65.3	40.9	*	5.0	45.8	20.4	70.2
Uttarakhand	3.0	0.2	2.9	1.3	0.1	0.2	1.6	1.3	56.8
West Bengal**	29.3	2.8	26.6	10.8	*	1.0	11.8	14.2	44.6
Total States	431.2	39.1	392.0	221.3	2.4	24.8	248.5	172.8	63.4
Andaman & Nicobar	0.4	0.0	0.3	0.0	0.0	0.0	0.0	0.3	2.7
Chandigarh	0.0	0.0	0.0	0.0	*	0.0	0.0	0.0	89.0
Dadra & Nagar Haveli	0.1	0.0	0.1	0.0	*	0.0	0.0	0.0	31.3
Daman & Diu	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	61.4
Lakshadweep	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	66.0
Puducherry	0.2	0.0	0.2	0.1	*	0.0	0.2	0.1	74.3
Total UTs	0.7	0.1	0.7	0.1	0.0	0.1	0.2	0.4	34.5
Grand Total	431.9	39.2	392.7	221.5	2.4	24.9	248.7	173.3	63.3

Note: *Industrial and domestic draft has not been estimated separately in Goa, Himachal Pradesh, Karnataka, Rajasthan, Tamil Nadu, Uttar Pradesh, Chandigarh, Dadra & Nagar Haveli and Puducherry.
 ** West Bengal-2013 data considered.

AGWR: Annual Ground Water Recharge; **ND:** Annual Natural Discharge; **GWR:** Annual Extractable Ground Water Resource; **NGWA:** Net Ground Water Availability for future use; **GWE:** Stage of Ground Water Extraction; **Irrg.:** Irrigation; **Ind.:** Industrial; **Dom.:** Domestic.

(Source: Groundwater Year Book-India 2019-2020, CGWB, Govt. of India, <http://cgwb.gov.in>)

The average stage of groundwater extraction for the country as a whole works out to be about 63%. It is very high in the states of Punjab (165.8%), Rajasthan (139.9%), Haryana (136.9%), and Delhi (119.6%) explaining that the annual groundwater consumption is more than annual extractable ground water resources. The stage of groundwater extraction is between 70-100% recorded in the states/UTs of Chandigarh, Himachal Pradesh, Tamil Nadu, Puducherry, Uttar Pradesh and Karnataka. Particularly, all the north-eastern states are noted well within the range of 10%.

Central Ground Water Board (CGWB) is a government organization which provides the scientific inputs for management, exploration, monitoring, assessment, augmentation, and regulation of groundwater resources in the country. CGWB had assessed the critical stage of groundwater abstraction in India at Blocks/Mandals/Talukas/Tehsils, etc. considering as unit. Refer to Table 7.4, which explains that these units are further classified as safe, semi-critical, and over-exploited groundwater resources. Nearly 17% of the total number of units (6,881) assessed are categorized as 'Over-Exploited' indicating that the ground water extraction exceeds the total annual groundwater recharge. About 5% of the total show 'critical', 14% are 'semi-critical' and 63% are found to be 'safe'. The remaining 1% (100 assessment units) is categorized as 'Saline'. A major part of the groundwater in the phreatic aquifers of the saline units is brackish or saline. The over-exploited units are the highest in Punjab, followed by Delhi, Rajasthan and Haryana. Salinity is being affected in the Union Territory of Puducherry and the states of Andhra Pradesh and Gujarat (Fig. 7.2).

The another government organization named Rajiv Gandhi National Ground Water Training and Research Institute (RGNGWTRI), which is located at Raipur in Chhattisgarh state conducting various training programmes for the stake holders of the Ground Water Boards and also for the State Govt. Organizations, Academic Institutes and NGOs, etc. You can visit the website <http://ngwtri.org/> for further information.

Table 7.4: Number of assessed units and their categorization for assessing groundwater critical zones in different states of India.

State/Union Territories	Total Units	Safe		Semi-Critical		Critical		Over-Exploited		Saline	
		No.	%	No.	%	No.	%	No.	%	No.	%
Andhra Pradesh	670	501	75	60	9	24	4	45	7	40	6
Arunachal Pradesh	11	11	100	0	0	0	0	0	0	0	0
Assam	28	28	100	0	0	0	0	0	0	0	0
Bihar	534	432	81	72	13	18	3	12	2	0	0
Chhattisgarh	146	122	84	22	15	2	1	0	0	0	0
Delhi	34	3	9	7	21	2	1	0	0	0	0
Goa	12	12	100	0	0	0	0	0	0	0	0
Gujarat	248	194	78	11	4	5	2	25	19	13	5
Haryana	128	26	20	21	16	3	2	78	61	0	0
Himachal Pradesh	8	3	28	1	13	0	0	4	50	0	0
Jammu &	22	22	100	0	0	0	0	0	0	0	0

Kashmir											
Jharkhand	260	245	94	10	4	2	1	3	1	0	0
Karnataka	176	97	55	26	15	8	5	45	26	0	0
Kerala	152	119	78	30	20	2	1	1	1	0	0
Madhya Pradesh	313	240	77	44	14	7	2	22	7	0	0
Maharashtra	353	271	77	61	17	9	3	11	3	1	0
Manipur	9	9	100	0	0	0	0	0	0	0	0
Meghalaya	11	11	100	0	0	0	0	0	0	0	0
Mizoram	26	26	100	0	0	0	0	0	0	0	0
Nagaland	11	11	100	0	0	0	0	0	0	0	0
Odisha	314	303	96	5	2	0	0	0	0	6	2
Punjab	138	22	16	5	4	2	1	109	79	0	0
Rajasthan	295	45	15	29	10	33	11	185	63	3	1
Sikkim	4	4	100	0	0	0	0	0	0	0	0
Tamil Nadu	1166	427	37	163	14	79	7	462	40	35	0
Telangana	584	278	48	169	29	67	11	70	12	0	0
Tripura	59	59	100	0	0	0	0	0	0	0	0
Uttar Pradesh	830	540	65	151	18	48	6	91	11	0	0
Uttarakhand	18	13	72	5	28	0	0	0	0	0	0
West Bengal	268	191	71	76	28	1	0	0	0	0	0
Total States	6828	4265	62	968	14	312	5	1185	17	98	1
Andaman and Nicobar	36	35	97	0	0	0	0	0	0	1	3
Chandigarh	1	0	0	1	100	0	0	0	0	0	0
Dadra and Nagar Haveli	1	1	100	0	0	0	0	0	0	0	0
Daman and Diu	2	1	50	0	0	1	50	0	0	0	0
Lakshadweep	9	6	67	3	33	0	0	0	0	0	0
Puducherry	4	2	50	0	0	0	0	1	25	1	25
Total UTs	53	45	85	4	8	1	2	1	2	2	4
Grand Total	6881	4310	63	972	14	313	5	1186	17	100	1

Note: **Blocks:** Bihar, Chhattisgarh, Haryana, Jharkhand, Kerala, Madhya Pradesh, Manipur, Mizoram, Odisha, Punjab, Rajasthan, Tripura, Uttar Pradesh; **Tehsil:** NCT Delhi

Taluks: Goa, Karnataka, Gujarat, Maharashtra; **Mandals:** Andhra Pradesh, Telangana;

Firka: Tamil Nadu; **Region:** Puducherry; **Islands:** Lakshadweep, Andaman and Nicobar Islands

District/Valley: Arunachal Pradesh, Assam, Himachal Pradesh, Jammu & Kashmir, Meghalaya, Mizoram, Nagaland; **UT:** Chandigarh, Dadra and Nagar Haveli, Daman and Diu

*Uttar Pradesh: There are total 820 block and Cities

** West Bengal-2013 data considered.

(Source: Groundwater Year Book-India 2019-2020, CGWB, Govt. of India, <http://cgwb.gov.in>)

7.2.4 Utilization of Water Resources

There are several utilities of water resources, particularly from human perspective. Some of the significant uses of this precious resource are explained below:

1. **Domestic Water Supply:** Humans use water mainly for drinking, cooking, bathing, and cleaning. We also utilize water for growing crops and plants, and livestock rearing, etc. There are several cities and urban centers across the globe depending on water supply from rivers, underground

water reservoirs, lakes, etc. However, this renewable fresh water resource available on the planet must be used with caution because it is now frequently contaminated by various harmful pollutants as a result of human activities.

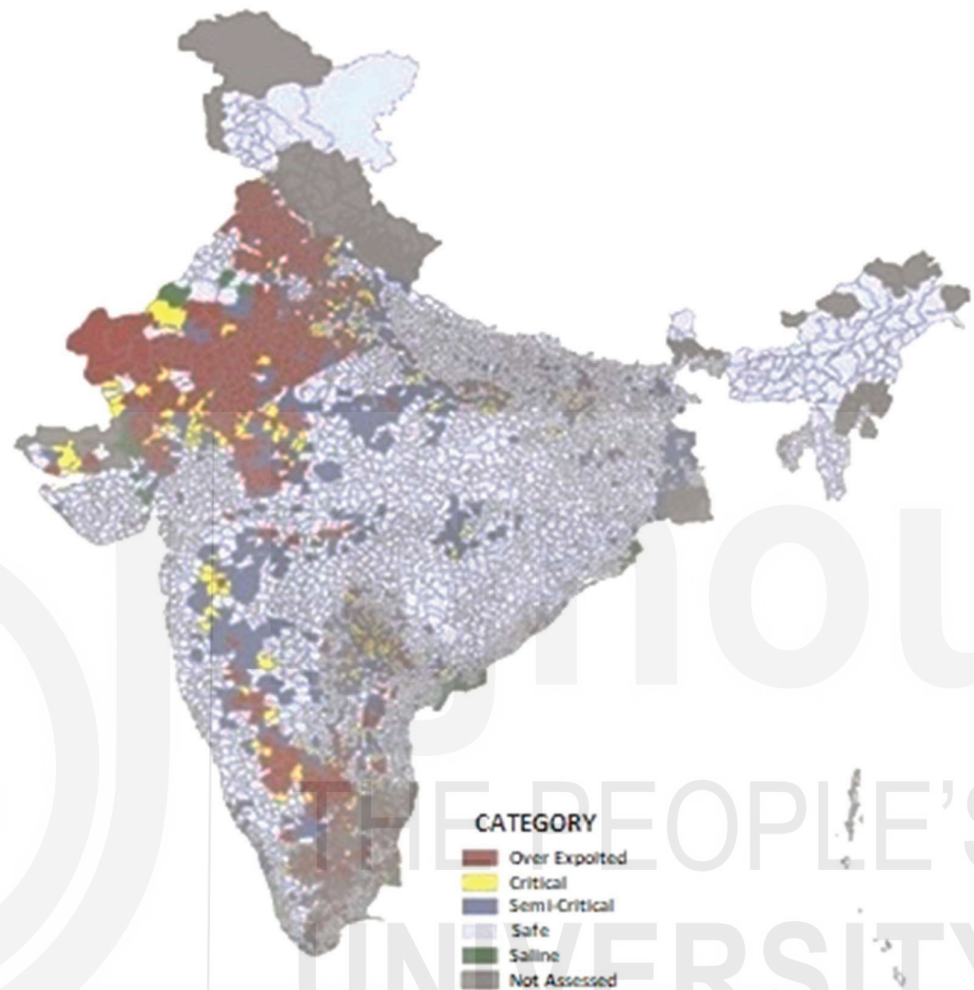


Fig. 7.2: Critical Situation of Groundwater Status in India.

(Source: Groundwater Year Book-India 2019-2020, CGWB, Govt. of India, <http://cgwb.gov.in>)

2. **Industrial Use:** The water used for industrial purposes is mostly drawn from rivers and underground sources. All over the world, several industries and allied manufacturing units are getting water from the rivers as industries require more water than domestic needs. Some industries, for example, textiles, pulp, beverages, chemicals, and pharmaceuticals, require a type of soft water for their uses.
3. **Irrigation:** The water from canals, bore wells, tube wells, tanks/ponds, reservoirs, lakes, or other water bodies is used everywhere for raising crops and for agricultural activities. Based on the availability of water either from rain or other sources, a variety of crops such as rice, sugarcane, wheat, maize, pulses, oil seeds, etc., need to be selected for successful growing and better productivity in any region.
4. **Energy and Navigation:** Water resources are also used for generation of hydro-electricity which is one of the cleanest and cheapest energy

sources. Steam power is used to run machines, including locomotives, and is also used in generating thermal electricity. As we all know that the water transportation system of materials is cheaper than land transportation. The water transport can be done through canals, rivers and lakes. Most of the water bodies extend over large areas in terms of their length and breadth. Some rivers flow across the countries, for example, the Rhine River in Europe. Lakes are also not exceptional because they are spread to greater depths and cover huge areas.

5. **Other Uses:** Fishing is one of the largest source of livelihood security. The rivers, canals, lakes, ponds, tanks and other water bodies provide fish and other source of food for people across the globe and local communities as well. Water bodies are also used as major recreational activities like swimming, boating, and entertainment, etc.

You will find the water stress regions of the world from Fig.7.3. It is clearly discernible from the map that the majority of water stress regions covers in highly populated countries and are mostly of Asian countries. In case of India which falls under high to extreme high category of water stress region. Human activities mainly with large scale groundwater exploitation can impact the groundwater quality as well as its quantity, hence the care must be taken in the rational use of groundwater.

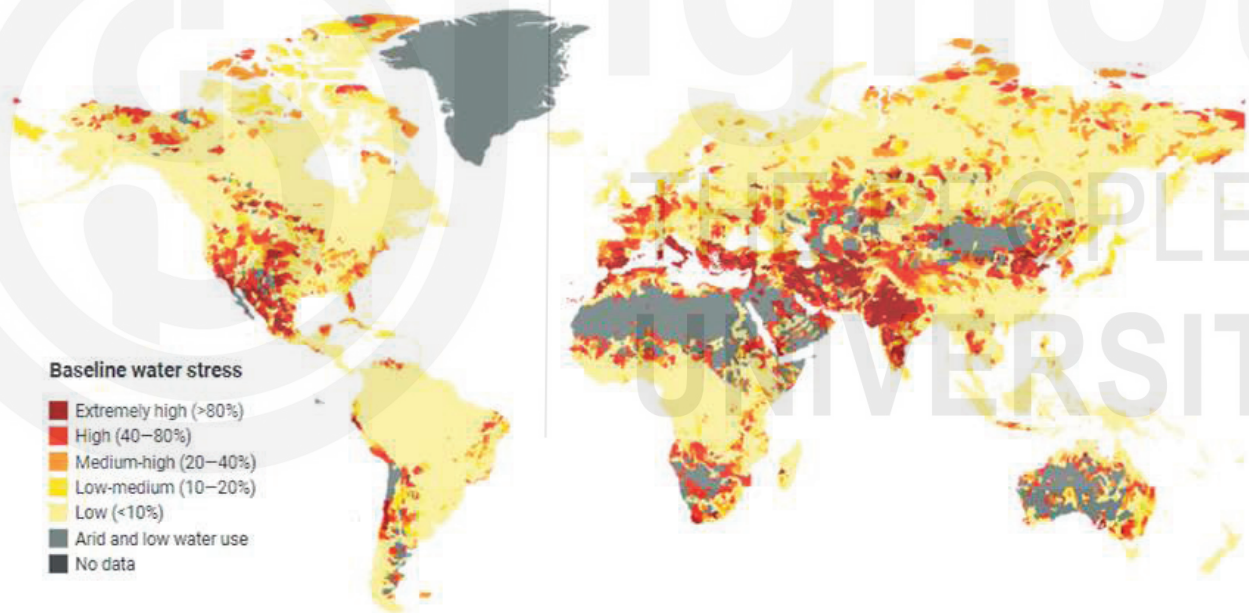


Fig. 7.3: Water Stress Regions of the World.

(Source: WRI (2019); <https://www.wri.org/>)

Note: Baseline water stress measures the ratio of total water withdrawals to available renewable water supplies. Water withdrawals include domestic, industrial, irrigation and livestock consumptive and non-consumptive uses. Available renewable water supplies include surface groundwater supplies and considers the impact of upstream consumptive water users and large dams on downstream water availability. Higher values indicate more competition among users.

SAQ 2

List the major utilities of water in different sectors.

7.3 MULTIPURPOSE RIVER VALLEY PROJECTS

Till now, you have studied different types of water resource and characteristics of groundwater resource. You have also been introduced to some important statistics of the distribution and utilization of water resources. This might be helped you in understanding the importance of water resources. Let us now study about multipurpose river valley projects. What is the main aim of constructing multi-purpose river valley projects in India? Initially, the major dams were designed for their construction mainly to prevent floods due to the experience of heavy rainfall in various parts of the country.

Multipurpose river valley projects became important and essential as these provide several benefits in irrigation, electricity generation, navigation, fishing, tourism, and the supply of water for areas of water scarcity or water deficit, etc. Hence, they are named as multipurpose projects.

The construction of dams and reservoirs for storing water is not new; rather, human beings have been practicing this method for a long time. These structures have helped the people to use water in dry periods and have enabled them to raise agricultural crops through irrigation practices. The control and management of floods, prevention of property loss, development of industries, hydro-power generation, river navigation, improving recreational opportunities, etc. are made possible through these projects. Though, the building of multipurpose projects has numerous uses, they are also a cause of some negative impacts like habitat loss, loss of forest area, submersion of lands, displacement of settlements, generation of huge flood plain areas, etc.

There are several multipurpose river valley projects constructed in India. Some of them are briefly explained below. We have also described about one particular project as a case study i.e., Damodar Valley multipurpose river valley project in the forthcoming Sub-Section.

1) Bhakhra Nangal Project

The project construction was completed jointly by Punjab, Haryana, and Rajasthan states during 1948-1963. The Bhakhra dam has a length of 520 m and 226 m height constructed across the river Sutlej at Bhakhra (Bilaspur district of Himachal Pradesh) with a storage capacity of 9.34 BCM of water. Bhakhra dam is a concrete gravity dam which forms a reservoir named as 'Gobind Sagar' covering about 168.3 sq. km area.

Nangal Dam is another dam constructed 10 km downstream of Bhakra dam in Punjab. However, sometimes both the dams together are called Bhakra-Nangal Dam. Bhakra Main Line or Nangal Hydel Channel and Anandpur Sahib Hydel Channels originate from Nangal dam provides irrigation facility to nearly 14.8 lakhs hectares of land. There are two main power generation plants constructed at Ganguwal and Kotla with a capacity of 1204 MW. Refer to Figure 7.4, which shows the major rivers and dams of India.

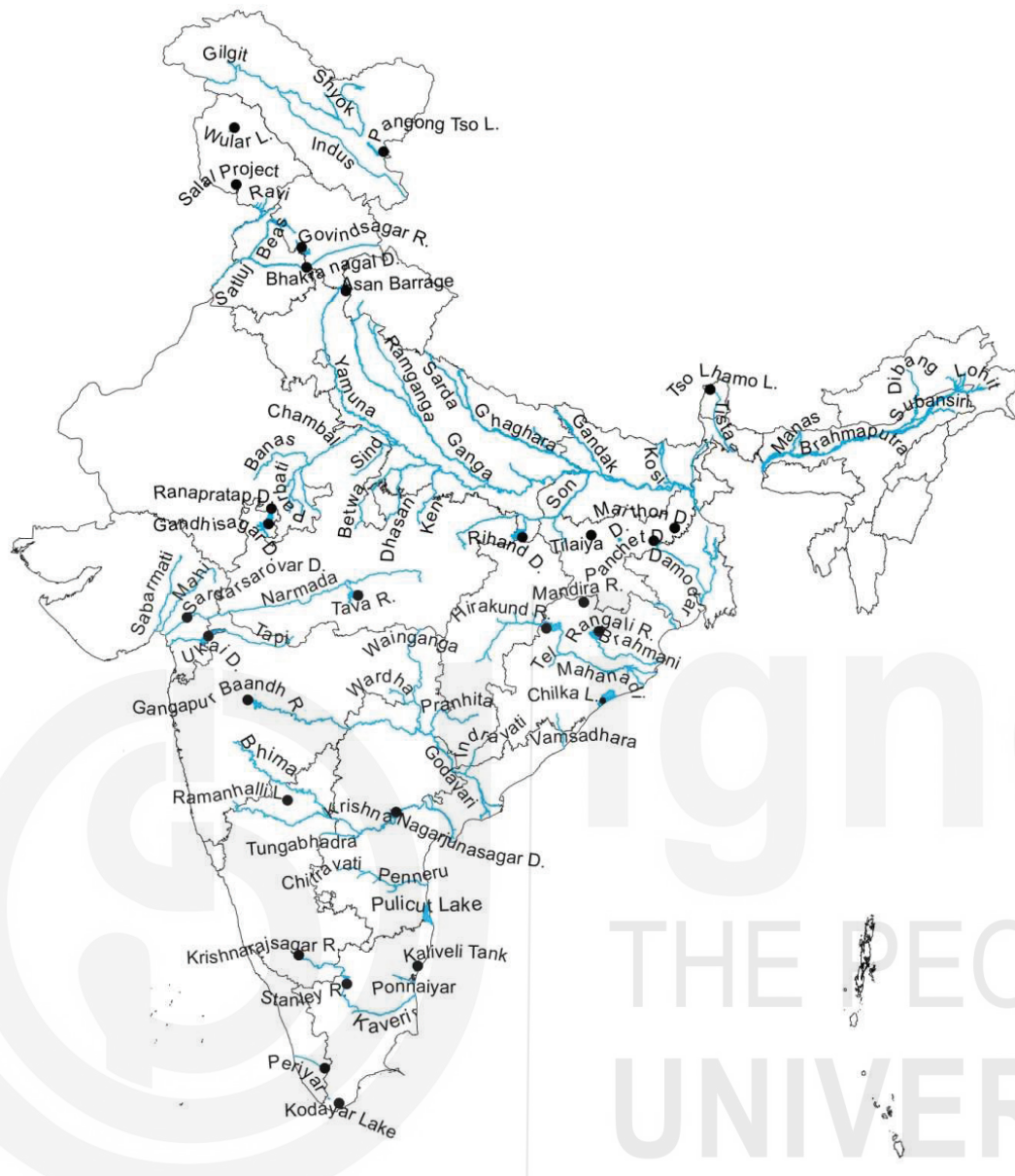


Fig. 7.4: Major Rivers and Dams of India.

(Source: Central Water Commission, Govt. of India, <http://www.cwc.gov.in/river-basin-planning>; <http://jalshakti-dowr.gov.in/annual-report>)

2) Hirakud Project

The construction of Hirakud dam was completed on the river Mahanadi, near Sambalpur in Odisha, with 4.8 km length and 61 m height during 1947-1957. It is recorded as the world's longest dam. This project supports irrigation of nearly 11.98 lakh hectares of land through the three main canals, namely the Bargarh Main Canal, the Sason Canal, and the Sambalpur Canal. The reservoir water is spread over about 743 sq. km with a storage capacity of 8136 MCM. There are two hydroelectric power houses constructed at Burla and Chiplima generating up to 307.5 MW of electrical power.

3) Chambal Valley Project

This multi-purpose river valley project was constructed across the Chambal river, a tributary of the Yamuna river, jointly by Rajasthan and Madhya Pradesh during 1960-1972. The Gandhi Sagar Dam (GSD), built with a 64m

high masonry gravity dam with a live storage capacity of 6,920 MCM, was completed in 1960. The Rana Pratap Sagar dam was constructed downstream of GSD in the year 1970 with 54 m high. The live storage capacity is 1,566 MCM. The Jawahar Sagar Dam is the third dam in the series of Chambal Valley Projects, and is a concrete gravity dam, 45 m high and 393 m long, completed in 1972. The Kota Barrage in Rajasthan is dedicated to irrigation in Rajasthan and Madhya Pradesh through canals on the left and right sides of the river after releasing water from Gandhi Sagar dam, Rana Pratap Sagar dam, and Jawahar Sagar Dams. It was completed in 1960 with the live storage capacity of 99 MCM. It is an earth fill dam with a concrete spillway.

4) Nagarjuna Sagar Project

Nagarjuna Sagar Dam was built with a 150 m high, 1.6-km long across the Krishna River between 1955 and 1967 in the erstwhile Andhra Pradesh state. The dam is now situated on the border of Andhra Pradesh and Telangana states. It is the biggest masonry dam in India which provides water for irrigation of more than 8,600 sq. km of land along with an 816 MW capacity of electricity generation.

7.3.1 A Case Study of Damodar Valley River Project

A) Damodar Valley Corporation (DVC)

The Damodar Valley Corporation (DVC) is the first multipurpose river valley project in India, started way back in 1948. This project was actually initiated by the Indian Government along with the erstwhile Bihar and West Bengal states based on the recommendations of the Damodar Flood Enquiry Committee. It was suggested to construct a total of 07 major dams, including Aiyar and Panchet Hill on the Damodar River; Kaithon, Belpaheri and Tilaiya on the Barakar River; Konar on the Konar River; Bokaro on the Bokaro River; and one barrage at the downstream end of the Konar River. Accordingly, the Damodar Valley Corporation (DVC) came into force in 1948 to execute the Damodar Valley River Project.

At present, DVC is looking into the thermal power sector as well as hydroelectric power since the availability of coal led to the establishment of thermal power stations, and the projects were encouraged to build hydel power stations (Fig. 7.5). The overall capacity of power management is 7237.2 MW, of which 7090 MW comes from 07 thermal power stations and 147.2 MW from 03 hydel power stations.

Some of the prominent industries and organizations utilizing its hydroelectric power are Indian Railways, SAIL, CIL, IISCO, CLW, ECR GOMOH, GARRISON Engineers, TISCO, JUSCO, India Power, etc. along with State electricity boards namely West Bengal State Electricity Distribution Company Limited (WBSEDCL) and Jharkhand Bijli Vitran Nigam Limited (JBVNL) (Table 7.5). The total irrigation potential created by DVC is about 3.64 lakh hectares with a flood reserve capacity of 1172 MCM. The total length of the canal system is occupied about 2494 km. Nearly 4 lakh hectares of land have contributed to reducing soil erosion through development and maintenance of forests, farmlands, and uplands.

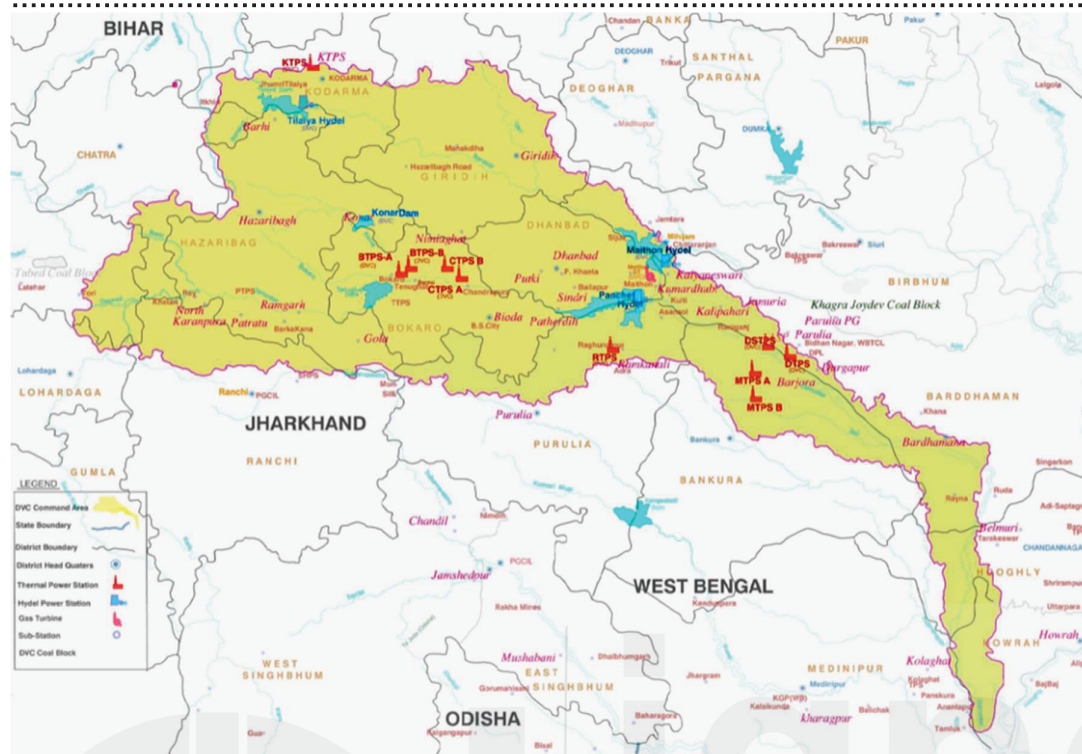


Fig. 7.5: Control Area of Damodar Valley Corporation.

(Source: DVC 2021, https://www.dvc.gov.in/dvcwebsite_new1/dvc-map/)

Table 7.5: Major Consumers of DVC.

BRPL	BSES Rajdhani Power Limited
BYPL	BSES Yamuna Power Limited
TPDDL	Tata Power Delhi Distribution Limited
HPGCL	Haryana Power Generation Corporation Limited
MPPMCL	M P Power Management Company Limited
PSPCL	Punjab State Power Corporation Limited
TSL	Tata Steel Limited
WBSEDCL	West Bengal State Electricity Distribution Company Limited
BESCOM	Bangalore Electricity Supply Company Limited
HESCOM	Hubli Electricity Supply Company Ltd.
MESCOM	Mangalore Electricity Supply Company Limited
GESCOM	Gulbarga Electricity Supply Company Limited
CESC	Chamundeshwari Electricity Supply Corporation Limited
KSEBL	Kerala State Electricity Board Limited
JBVNL	Jharkhand Bijli Vitran Nigam Limited
SAIL	Steel Authority of India Limited
CIL	Coal India Limited
IPCL	India Power Corporation Limited
IR	Indian Railways
JSPL	Jindal Steel and Power Limited

(Source: https://www.dvc.gov.in/dvcwebsite_new1/our-major-consumers/)

B) Damodar River Basin

The river Damodar originates in the Palamau hills of the Chota Nagpur plateau at an elevation of about 610 m in the state of Jharkhand, and it continues to flow down nearly 547 km covering through the hilly terrain of Jharkhand and the plains of West Bengal before merging with the main river Hugli. The climate of the area consists of very mild winters and hot-wet summers. The monsoon season generally starts in the month of June and lasts in October contributing nearly 90% of the mean annual rainfall of about 1,250 mm that occurs during this period. November to May are non-monsoon or dry period, particularly, April and May are the hot weather months, as the basin receives low rainfall.

The catchment area of the river Damodar is about 22,005 sq. km. The main tributaries of Damodar river are Barakar, Bokaro, and Konar. The river was famously known as the River of Sorrow or the Sorrow of Bengal. The river Damodar has been known for causing frequent floods in erstwhile Bihar and West Bengal. The basin area is covered by the 10 districts of Dhanbad, Bokaro, Hazaribagh, Koderma, Chatra, Palamau, Ranchi, Revanah, Lohardaga, Giridih and Dumka of Jharkhand state and 6 districts, i.e. Purba Bardhaman, Paschim Bardhaman, Hoogly, Howrah, Bankura and Purulia of West Bengal.

To mitigate the flood situations in the basin area, the Government of India decided to build a series of dams in the pattern of development in the Tennessee Valley in the United States of America. Accordingly, there are mainly four dams, namely Tilaiya Dam, Konar Dam, Maithon Dam, and Panchet Dam constructed by DVC during the period 1948-1959. We will briefly describe these dams and another barrage called the Durgapur Barrage.

C) Multipurpose Dams and Barrage

1. **Tilaiya Dam:** It is a concrete dam built across the river Barakar with a length of 1200 ft and a height of 99 ft in the Koderma district of Jharkhand during the period 1950-1953. It forms a reservoir with about 36 sq. km area. With a gross storage capacity of 395 MCM, the hydroelectric station produces 4 MW of power and the outflow water is used to irrigate nearly 40,000 ha of land. The catchment area of Tilaiya dam is about 984 sq. km, covering mainly hilly forests, pastures, and cultivated lands. The river Barakar originates in the hills of the Hazaribagh district of Jharkhand at an elevation of 610 m.
2. **Konar Dam:** It is an earthen dam (with a concrete spillway) constructed on the river Konar at 3682 m long and 49 m high during the period 1950-1955. The dam is located in the Hazaribagh district on the upper stream at 30 km from its confluence with the river Damodar. It is the second of the four multipurpose dam projects of DVC. The dam provides 10 MW power generation and it is able to store 337 MCM of water. The reservoir is formed by covering an area of 27.9 sq. km and these waters provide irrigation facilities for nearly 45,000 ha of land. The river Konar rises west of Hazaribagh town, which is a part of the Chhota Nagpur plateau.

3. **Maithon Dam:** It is constructed across the river Barakar, located nearly 50 km away from Dhanbad city. The dam is about 994 m long and 49 m high. The construction was completed with a gross storage capacity of 1357 MCM during the period 1951-1958. The reservoir is formed by these waters, occupying nearly 65 sq. km. The dam with an underground power station generates 60 MW of electric power.
4. **Panchet Dam:** It is built on the river Damodar, situated some 20 km away from Asansol. The dam has 2,545 m length and 49 m height and it forms a reservoir with an area of 27.9 sq. km. The total catchment area of the reservoir occupies 10,961 sq. km. The dam provides 40 MW of electric power and it irrigates nearly 28 lakh ha of land. The gross storage capacity is 1497 MCM.
5. **Durgapur Barrage:** This barrage is constructed on the river Damodar at Durgapur in 1955 to manage the released water from the above 04 dams. It is located 23 km from Raniganj and is regulated through a network of canals for irrigation water. These waters are being utilized by Bankura, Bardhaman, Hugli and Haora districts of West Bengal. The barrage is 692 m long and 12 m high. Two irrigation canals, the Left Bank Main Canal and the Right Bank Main Canal, take off from the Durgapur barrage. The length of the left bank canal is about 136.8 km and its discharge at the head regulator is 260 cubic meters. While, the length of the right bank canal is 88.5 km, the discharge is 64.3 cubic meters. The total length of the main and branch canals is 2,500 km, providing about 4,20,000 ha of land.

D) Utilities of Damodar River Valley Project

Let us now understand the key utilities of the Damodar river valley project.

1. Monitoring of Flood Waters

The south-west monsoon is the main contributor of rainfall in the entire Damodar River Valley project area. The onset of monsoon is generally in the month of June and the same withdraws in the month of October. Based on the heavy inflow into the reservoirs, flood warnings are generally issued from time to time and the same are made available on the DVC's website for general information to the public at large. The tentative time of arrival of waters and quantum of release of waters with different colour codes on category wise-outflows information is also maintained from time to time on real time basis for better flood preparedness and necessary measures.

2. Irrigation Water Supply

Under DVC, the water is released from the Durgapur Barrage for various purposes. The operation and maintenance of this barrage and irrigation system are hold by the Govt. of West Bengal. However, DVC can only release the water for irrigation from Maithon and Panchet reservoirs as per the request of the West Bengal government to utilize the water for Kharif and Rabi cultivation in the lower valley. When surplus water is made available in reservoirs, the water will be released for utilization in Boro irrigation. In the year 2019-20, the water was allocated to 10 lakh acres in Kharif, 70,000 acres in Rabi and 4,88,000 acres in the Boro season.

3. Municipal and Industrial Water Supply

Another major important utility of this project is the supply of water for municipalities and industrial needs in Jharkhand and West Bengal states. The allocated quantity for municipal and industrial uses in Jharkhand is 376 million gallons per day (MGD) and that in West Bengal is 413 MGD.

E) Restoration and Conservation Activities in Damodar River Basin

The hilly terrain is covered with forest, mostly in the upper catchment, whereas the lower catchment is overlaid by silt and loam. The upper portions of the basin area is mostly depended on rainfall for cultivating land. To sustain natural resources, particularly water and forest resources, the following activities have been conducted by the Soil Conservation, Pisciculture and Environment department of DVC in the river basin area.

1. The work of restoration and renovation of water bodies for effective soil and water conservation.
2. Construction of rainwater harvesting structures for example check dams for enhancing groundwater potential in the area. These structures can also prevent soil erosion. The availability of excess water may be utilized for agricultural activities like micro irrigation, multiple cropping system as well as domestic purposes.
3. The afforestation activities conducted particularly in degraded forest areas for the overall development of the river basin.
4. Pisciculture, horticulture, and other practices are encouraged to improve the livelihoods of the population living this basin area.
5. Hydrological monitoring and silt assessment stations established to determine the characteristics of the climate and intensity of water.
6. The schemes related to the development of plantations and greenery, fishing and hatchery development, spawn production, etc. at the local level are encouraged through integrated watershed management practices.
7. The training and awareness programmes conducted to handle various government schemes under the guidelines of National Mission for Sustenance of Agriculture.
8. Multi-layer green development works include Avenues plantation, ash pond plantation and landscaping, etc. conducted in the power projects areas as per the direction of Ministry of Environment and Forest, Govt. of India.
9. Enrichment of existing aquatic resource through spawn production, releasing of fingerlings, training on reservoir and ornamental fisheries and maintenance of hatcheries, etc.

SAQ 3

- a) What are benefits of multipurpose river projects? Give examples.
 - b) What are the major dams built as part of the Damodar Valley River Project?
-

7.4 SUMMARY

In this unit you have studied so far:

- Surface water and groundwater are two important types of water resources. The groundwater available in India is mainly in two formations such as consolidated and unconsolidated formations.
- Only 2.5 percent of the total volume of water on the Earth is available as fresh water.
- The river basins of India have been categorized mainly into four types, namely the Himalayan rivers, Deccan rivers, coastal rivers and rivers of the inland drainage basin.
- There is an increasing trend in groundwater extraction that is greater than the total annual groundwater recharge at many places within the country.
- The utility of water resources is enormous, including domestic, industrial, irrigation, energy, recreation, sports and navigation.
- The construction of dams and reservoirs for storing water has helped in economic development and enables people to raise agricultural crops through irrigation practices.
- The control and management of floods and prevention of droughts are also major benefits of multipurpose river valley projects.
- The Damodar river valley project is the first Indian multipurpose project initiated in 1948. Under which, 04 dams and 01 barrage were constructed to control flood waters and provide irrigation facilities and generation of hydroelectricity.

7.5 TERMINAL QUESTIONS

1. Discuss hard rock and soft rock formations of India.
2. Explain the distribution of surface water resources of India?
3. Describe the utilization of water resources.
4. Write a note on Damodar River Valley Project.

7.6 ANSWERS

Self-Assessment Questions (SAQ)

1. a) The water exists in a river throughout the year is called perennial river.
b) Joints, faults, fissures and weathering zones.
2. Drinking, agriculture, industry, tourism, etc.
3. a) Multipurpose river projects facilitate water for irrigation, electricity generation, navigation, fishing and tourism, and drinking water. Examples are Nagarjuna Sagar, Damodar Valley River Project, etc.

b) Tilaiya Dam, Konar Dam, Maithon Dam, and Panchet Dam.

Terminal Questions

1. Refer to Sub-Section 7.2.2.
2. Refer to Sub-Section 7.2.3.
3. Refer to Sub-Section 7.2.4.
4. Refer to Section 7.3.

7.7 REFERENCES AND SUGGESTED FURTHER READING

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FOREST RESOURCES |

Structure

8.1	Introduction		Deforestation
	Expected Learning Outcomes		Afforestation
8.2	Forest Resources		Conservation
	Characteristics of Forest	8.5	Summary
	Resources	8.6	Terminal Questions
	Distribution of Forest Resources	8.7	Answers
8.3	Types of Forests	8.8	References and Suggested
8.4	Issues Related to Indian		Further Reading
	Forests		

8.1 INTRODUCTION

In the previous Units 6 and 7, you have learnt about the land resources and water resources of India. You came to know about the availability, types, distribution and utilization of these vital resources. In this Unit 8, you will learn that forest resources are considered as a storehouse of biodiversity which is extremely vital for the functioning of myriad of ecosystems and associated services in the biosphere. The importance of trees and forest resources are also mentioned in ancient religious texts which states that one tree is equal to ten sons and not only highlights the importance of trees for the human race and wellness of planet Earth, but also treats it as a organic and living entity like human beings. Additionally, it is also pertinent for the overall health of the planet Earth for the incessant supply of energy and matter to the life forms. Forest resources also act as a medium for carbon sink which is very important for the health of biodiversity. You will learn that generally forest resources covers almost all the geographical realms and regions on the planet Earth dependent on the prevailing climatic conditions and soil type. However, some regions having extreme climatic conditions like too cold and too hot conditions doesn't support the growth of any kind of forests. Broadly, India is endowed with tropical monsoon type of climate and associated climatic conditions (which varies from torrid to arctic) helps to support the luxuriant growth of many diverse range of plant varieties including both endemic and foreign species. Only few countries of the world possess such diverse plant varieties having equal size of geographical area comparable with India. It has a spectacular range of forest types ranging from tropical wet evergreen, semi-

evergreen, deciduous, thorn, subtropical, tropical dry deciduous, mangrove and dry alpine scrub etc.

This unit is organized into various Sections dealing with different aspects of the forest resources of India. You will study about the forest resources, its characteristics and distribution from Section 8.2. Careful reading of this Section will enable you to understand the characteristics and distribution of forest resources of India. In Section 8.3, you will study about the types of forests commonly found in India. It will help you to not only understand the types of forests and its diversity but also sensitize about the issues, problem area and challenges in an apt manner. The study of Section 8.4 will definitely help you to envisage the nature and kind of topical issues related to Indian forests along with challenges and constraints.

Expected Learning Outcomes

After completing the study of this unit, you should be able to:

- know about the forest resources of India;
- describe the characteristics and distribution of the forest resources of India;
- describe the types of forests and forest resources in India; and
- understand the issues related to the forest resources i.e., deforestation, afforestation, and conservation.

8.2 FOREST RESOURCES

In general, all of you are well aware of the meaning of forest and forest resources. However, there are certain distinct characteristics and distribution pattern that happens in consonance with the type of geographical regions on the surface of planet Earth. Forest is one of the major parts of environmental amenities, other being the water. Hence, both are extremely valuable resources for the survival and sustenance of floral and faunal species on the Earth. Forests are well known for providing a range of ecosystem services to the human beings since time immemorial. You are well aware about few of such services such as wood (on the basis of availability) which has a versatile usage in the form of fuel both for domestic and commercial purposes.

You know that forest refers to the good amount of naturally growing trees (variety of species) in almost any geographical region of the world. This may exclude the areas experiencing too dry and too cold climatic conditions particularly covering the tundra and permanently frozen areas. You all are well aware of the distribution and geographical location of such extreme areas. Forests are also a storehouse of vast number of wetlands. We assume that you are familiar with the wetland which we know as a body of water having distinct ecosystem, which remains flooded with water either permanently or seasonally.

In India, an apex institution named 'Forest Survey of India' (FSI) has been entrusted to take care of all the aspects related to forest resources, policies and guidelines, forest cover mapping and control etc., located at Dehradun in Uttarakhand state. The main work of the institute is to assess and map forest cover of the country on a two-year cycle basis by using latest

remotely sensed satellite data products. They do so for the entire country at state and district level and also prepare forest cover maps on 1:50,000 scale. The story of forest mapping began with the first assessment carried out in 1987. So far, sixteen assessments have already been successfully done. Since last three decades, the methodology of forest cover mapping is constantly improving in India in consonance with the scientific and technological advancements. The real-time ground information on forest cover is procured from state-of-the-art remotely sensed satellite images. Surely, remote sensing has given a much better coverage which can even capture and cover the minute details lying on the Earth's surface as compared to visual interpretation techniques in which data concerning the forest cover was used to be interpreted in analogous manner.

You will agree with us that the ideal or very good forest cover is the answer to many of the problems being faced by the denizens of the country. The ill-effects of degradation of forests have started manifesting in the form of growth of unwanted viral and bacterial diseases. Such kind of negative effects has started transcending into the local, regional, national and international boundaries altogether in recent times and began disrupting the daily rhythms of life on a mega scale.

You can say that the well-being and growth of forest resources directly depends upon the natural forces of climate coupled with topographic, edaphic and other factors. Thus, a good forest cover is extremely inevitable for the effective functioning of all the major and minor biomes of the natural environment in a hassle free manner.

8.2.1 Characteristics of Forest Resources

We believe that you know forests are considered as the green lungs of an area as they contain rich flora and fauna. They also immensely help to provide the pollination services through numerous varieties of insects and bees which thrive on diverse flora that helps in the setting of tropical and temperate fruits during its budding stage across a variety of environments. Human beings are known to derive variety of resources for making out their livelihood from the forests since time immemorial. Forests are well known for providing various ecological services including clean air, water, humus for the proper growth of soil that in turn helps to grow various foodgrain and non-foodgrain crops, maintenance of soil-moisture balance and control of soil erosion. Besides, one of most crucial role which a forest cover provides is concerned with the regulation of climate change and global warming by acting as a storehouse of carbon sink through the process of carbon sequestration. Forests also act as a sole and inevitable medium (for which there is no alternative) to maintain and preserve the environmental stability and ecological balance. The Earth's surface areas with vast tracts of natural forests support a myriad of flora and fauna which are known as hub of biodiversity. A good forest cover especially in desert environment immensely helps to check and prevent the expansion of infinite quantities of sand thereby helps to arrest the formation of sand-dune to stop the process of desertification. As per the National Forest Policy, a healthy forest cover is very necessary in order to prevent the land degradation.

Forest is a true treasure of the nature that immensely contributes in the upkeep of each and every ecosystem under natural or homeostatic

equilibrium. It also helps to sustain the seamless growth and development of various kinds of flora and fauna which in turn helps the human societies to maintain their health and decent standards of living in a harmonious manner. Under characteristics, we will briefly discuss and try to highlight the key ingredient which makes the forest resources very-very important on many counts. These may encompass natural or ecological value, economic value, personal, and socio-cultural values etc. We can say that forest resources are the spectacular bounties or more appropriately miraculous wonders of the nature bestowed to the human beings for myriad of usages. In general, the chief characteristics of forests can broadly be clubbed under three main types and their sub-types on the basis of functions along with various services which they provide directly as well as indirectly are discussed as under:

1. Natural Services: Under the natural services, there are some specific functions and services, which include the following:

If a geographical region is having adequate forest cover, then it helps to stabilize the global climate (by affecting natural cycles like carbon and hydrological cycles etc.), protects the diverse and crucial life sustaining elements of ecobiodiversity and geodiversity and also supports the natural ecological systems and their associated processes. Besides, a forest also help to check and arrest soil erosion, helps to minimize the impact of landslides, cyclones, floods, siltation of water bodies and also helps to improve air quality and availability of moisture supply etc. However, in their absence, these vital natural ecosystems along with their sub-systems bring a crisis that may ultimately adversely affect the human-environment relationships. Therefore, there is no alternative which can be pitched to substantiate the role of forest resources for its invincible role as well as importance for one and all kinds of denizens of the planet Earth. In terms of Earth's gigantic systems and their processes also, forests inevitably play a vital role for their continued and seamless functionality and vitality both in the short and long run.

2. Economic Services: It is one of the largest renewable resources of the nature like that of wind, sun, and geothermal energy etc. However, it takes considerable period of time to regenerate as compared to other renewable resources soon after decay. You are well aware about the array of products and services derived from the forest resources. Besides providing the fresh oxygen to breathe, it is also well known for providing diverse array of fruits and vegetables, valuable items (honey, ivory, wax etc.), fuel, timber, oil, resins, tannins and dyes, gums, katha, tendu leaves, grasses, bamboo, canes, medicinal herbs and plants along with open pastures areas for grazing the domesticated livestock resources etc., to the human societies since time immemorial. Even after the decay, the litter of trees provides a source material for the formation of fossil fuels which is very much essential for carrying out economic activities including transportation and industrial sector. They thrive on the fossil fuels and make use of it as one of the prime source of energy. You have studied about the kind of industries which run on the basis of raw-material derived from the forest resources. In addition, it is also well known for providing variety of life saving substances for the production of medicines in pharmaceutical sector, insecticides, pesticides

and herbicides for use in the agriculture and its allied activities. In nutshell, a forest resource immensely contribute in the Gross Domestic Product (GDP) of the nation and provides avenues of employment to many people of working age-groups, ecosystem services and livelihood to the people directly and indirectly.

3. Socio-Cultural Services: As all of you are already familiar with the fact that forests also form the cohesive part of socio-cultural practices since the very beginning of human civilization. Forests are also revered by many tribal communities since time immemorial in India. Many of the tribal communities of India and elsewhere worship forests. One of the community namely Bishnoi of Rajasthan worship 'Khejri' (local name) tree. They are very well known for their conservational efforts all over the country. The importance of sacred grooves is well known. Two variety of sacred trees are of national importance in India namely Pipal and Banyan (national tree), being worshipped across the country. As a whole, forests are universally known for providing aesthetic, recreational, spiritual and religious services.

We anticipate that you have learnt the various characteristics of forest and their importance in the daily rhythm of life and economic activities in a nutshell.

8.2.2 Distribution of Forest Resources

India has a total geographical area of ~ 32 lakh square kilometer. Out of this, a major proportion of area is covered under the forest resources of one type or other. As per the Forest Survey of India report (2019), it is 23.34% with considerable inter-state level variations. This is quite below the norms set forth in the National Forest Policy of India which states that 33% of total geographical area should come under forest cover. Forest cover and tree cover together are taken as a parameter to monitor the progress under this national policy to bring threshold area of 33% under forest resources. Tree cover refers to all patches of trees (less than 01 hectare in size) including scattered tree cover lying outside the Reserved Forest Area (RFA). Table 8.1 depicts the total percentage of recorded forest areas in different states and Union Territories of India. You can observe that the prominent states and UT's having more than national average of forest cover includes eleven states and two UT's. Among the states, the maximum proportion was recorded by the state of Sikkim having 82.31% and minimum by Goa with 33.09%. Among the two UT's, Andaman and Nicobar recorded the highest proportion to the tune of 86.93% while the UT of Dadar and Nagar Haveli recorded 41.55%. Rest of the states and UT's registered below national average value of 33% of total geographical area under forest cover with varying proportions. The six states and one UT recorded minimum proportion in the order of less than 10% of total geographical area under forest cover in the descending order including Rajasthan, Jammu and Kashmir, Bihar, Uttar Pradesh, Punjab, Haryana and Daman and Diu clearly signaling a alarming trend. However, the UT of Lakshadweep recorded nil forest cover that indicates towards the worrying state of affairs. In general, the good forest cover is found in the Himalayas (stretching from Pamir knot in the extreme North to Arunachal Pradesh in the extreme East) and hill ranges of western and eastern ghats,

north-eastern hill ranges, plateau region of Bundelkhand and Baghelkhand in Central India along with hills of peninsular India etc.

Table 8.1: Recorded Forest Areas (RFA) under Different Classes in States and UTs of India.

S. No.	State/UT	Total Geographical Area	Total Recorded Forest Area	% of Total Geographical Area
1.	Andhra Pradesh	162,968	37,258	22.86
2.	Arunachal Pradesh	83,743	51,407	61.39
3.	Assam	78,438	26,832	34.21
4.	Bihar	94,163	6,877	7.30
5.	Chhattisgarh	135,192	59,772	44.21
6.	Delhi	1,483	102	6.88
7.	Goa	3,702	1,225	33.09
8.	Gujarat	196,244	21,647	11.03
9.	Haryana	44,212	1,559	3.53
10.	Himachal Pradesh	55,673	37,033	66.52
11.	Jammu & Kashmir	222,236	20,230	9.10
12.	Jharkhand	79,716	23,605	29.61
13.	Karnataka	191,791	38,284	19.96
14.	Kerala	38,852	11,309	29.11
15.	Madhya Pradesh	308,252	94,689	30.72
16.	Maharashtra	307,713	61,579	20.01
17.	Manipur	22,327	17,418	78.01
18.	Meghalaya	22,429	9,496	42.34
19.	Mizoram	21,081	5,641	26.76
20.	Nagaland	16,579	8,623	52.01
21.	Odisha	155,707	61,204	39.31
22.	Punjab	50,362	3,084	6.12
23.	Rajasthan	342,239	32,737	9.57
24.	Sikkim	7,096	5,841	82.31
25.	Tamil Nadu	130,060	22,877	17.59
26.	Telangana	112,077	26,904	24.00
27.	Tripura	10,486	6,294	60.02
28.	Uttar Pradesh	240,928	16,582	6.88
29.	Uttarakhand	53,483	38,000	71.05
30.	West Bengal	88,752	11,879	13.38
31.	Andman and Nicobar Islands	8,249	7,171	86.93
32.	Chandigarh	114	35	30.70
33.	Dadra & Nagar Haveli	491	204	41.55
34.	Daman & Diu	111	8	7.21
35.	Lakshadweep	30	0	0
36.	Puducherry	490	13	2.65
Total		3,287,469	767,419	23.34

(Source: India State of Forest Report, State Forest Departments, 2019)

Even if we compare our national average with other countries, then it is quite low. A few countries far exceed the set norm like Democratic Republic of Congo (65%), Brazil and Peru (58% each), Indonesia (50%), Russian Federation (48%), and Canada (35%) respectively.

SAQ I

Discuss any one characteristics of the forest resources.

8.3 TYPES OF FORESTS

You may have noticed that forests are also of different types, if you happen to travel across the country in different environments of plateau, desert, coastal and mountainous areas. You will agree with us that each type of environment will certainly support different kinds of trees barring few exceptions here and there with matching environmental conditions. However, each type of environment naturally supports the growth of slightly different species and kinds of trees. You will be amazed to know that precipitation is the most important and decisive factor to determine the type of forests that grows in a particular geographical region. The type of forest almost directly corresponds to the rainfall zones in India. Exceptions can be seen in the form of minor regional variations on account of height in the hilly and mountainous region on one hand and salinity in and around coastal regions on the other hand. There are many factors that contribute in the type of forests apart from these factors as mentioned above.

In India, Forest Survey of India has broadly classified the forest cover into four main classes on the basis of varying proportion of canopy density. These are known as very dense forest, moderately dense forest, open forest and mangrove. Classification scheme of the forest cover into dense and open forests are taken from the internationally adopted norms of forest classification schemes. And, the fourth class of mangroves has been discretely classified on the basis of its characteristic tone and texture along with unique ecological functions. Apart from these four main classes, one more class is also classified known as scrub and rest of the area comes under non-forest.

You can study from Table 8.2 that moderately dense forest has the largest proportion of area to the tune of 9.39% closely followed by open forest with 9.29% area and very dense forest with only 3.02% area. It is interesting to note that more than three-fourth area is non-forested that mean devoid of any forest cover. The category of scrub occupies less than 2% of the total geographical area. This itself indicates that the minimum threshold of 33% of total geographical area under forest as mandated by the National Forest Policy of India is not found in many parts of the country.

There are many scholars who have classified the Indian forests. Prominent among these are H.G. Champion and Seth, Carl Troll, Puri and others. Carl Troll has also devised a separate classification scheme of Himalayan vegetation zone into seven natural types. You have studied about the vegetation as per the scheme devised by Champion and Seth (a standard

classification scheme for forest types also as shown in Fig. 8.1) in Unit 5, Block 1 of the same course.

Table 8.2: Classification Scheme.

S. No.	Type	Characteristics	Area	
			Sq. km	%
1.	Very Dense Forest	All lands with tree cover (including mangrove cover) of canopy density of 70% and above	99, 278	3.02
2.	Moderately Dense forest	All lands with tree cover (including mangrove cover) of canopy density between 40% and 70% above	3,08,472	9.39
3.	Open forest	All lands with tree cover (including mangrove cover) of canopy density between 10% and 40%	3,04,499	9.26
Total			7,12,249	21.67
4.	Scurb	All forest lands with poor tree growth mainly of small or stunted trees having canopy density less than 10%	46,297	1.41
5.	Non Forest	Any area not included in the above classes	25,28,923	76.92
Total Geographical Area			32,87,469	100.00

(Source: Indian State of Forest Report, 2019)

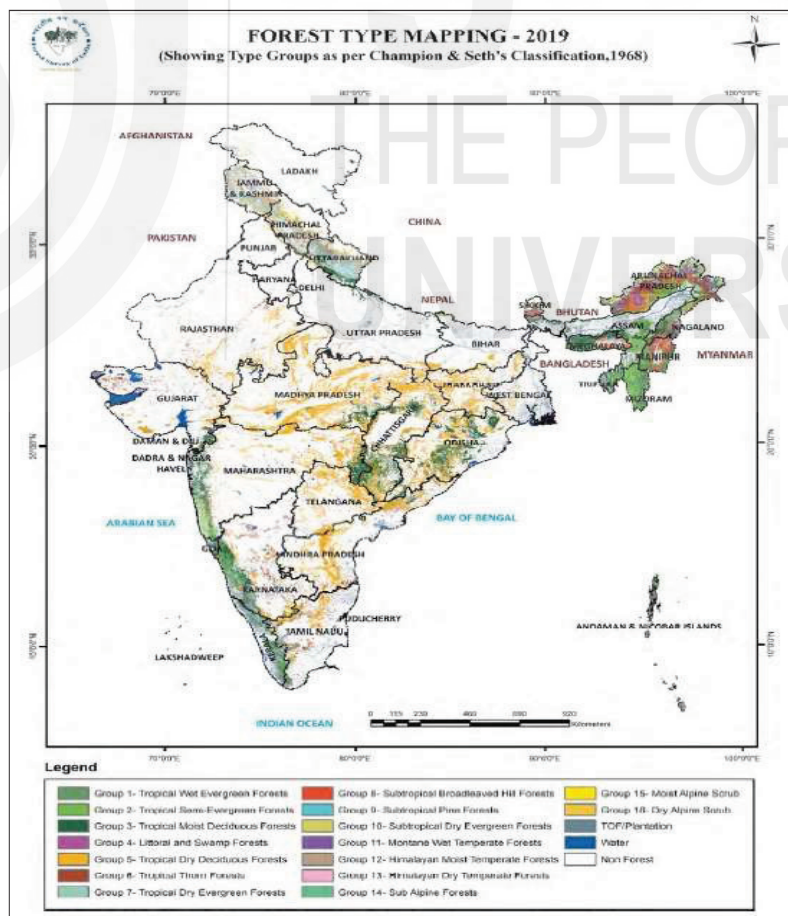


Fig. 8.1: Forest Types of India.

(Source: Indian State of Forest Report, 2019)

Champion and Seth's (1968) modified scheme of classification of forest types in India is a three-tier seminal scheme based on climatic parameters. Besides, floristic, edaphic, and physiographic parameters were also taken into consideration. Other than these scholars, a renowned British geographer L.D. Stamp also classified the Indian forests into four types based on average annual amount of rainfall. These four categories are 1) Evergreen forests experiencing more than 200 centimeter of rainfall lying in the humid zone, 2) Monsoon forests with 100 to 200 centimeter of rainfall lying in the semi-humid zone, 3) Dry forests with 50 to 100 centimeter of rainfall lying in the dry zone and, 4) Desert forest having less than 50 centimeter of rainfall lying in the very dry zone. Figure 8.2. shows some types of forest in India. Besides the above schemes, we will also discuss about the minor classification schemes prevalent in India. These are based on the administrative, ownership status, composition, and exploitation etc.

1. **Constituion based classification:** There are three categories namely i) state forests (under the complete control of State/UT's governments), ii) commercial forests (owned and managed by the macro level local authorities like municipal corporations and boards, town areas, district boards and village panchayats etc.) and iii) private forests (under the private ownership). The first type is the largest and covers nearly more than three-fourth portion of total geographical area of the country. Second and third type together covers approximately less than 10% of total geographical area of the country.

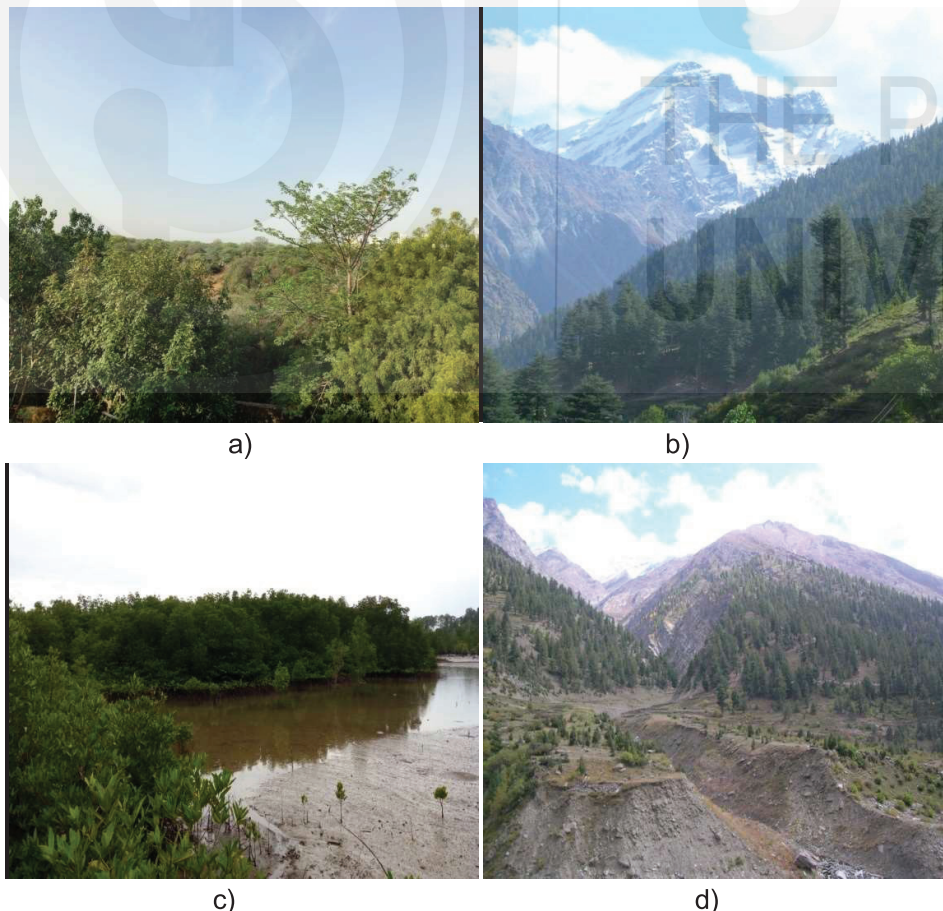


Fig. 8.2: Some Forest Types a) Tropical deciduous, b) Dry Temperate, c) Mangrove and d) Dry Alpine.

2. Administration based classification: The type of forest area classified on the basis of administration is primarily aimed to arrest the indiscriminate and wanton destruction of the trees and forest cover. These are classified into three kinds 1) Reserved 2) Protected, and 3) Unclassed forests. First two types of forests form a part of permanent forests constituting approximately 54% and 19% of the total geographical area, whereas last category accounts for nearly 15% area. This classification scheme also provides a legal statutory provisions to bring out a desired proportion of area under forest cover i.e., one-third of total geographical area as envisaged in National Forest Policy 1988 of India. The state-wise and union territory-wise distribution of these three different categories of forests as a proportion of total geographical area is shown in Table 8.3.

It can be seen from the table that Sikkim occupies the first place with largest proportion of area i.e. 76.% under reserved forest. It is followed by Andaman and Nicobar islands (68.04%), Uttarakhand (49.64%), Dadra and Nagar Haveli (40.53%), and Tripura (39.81%). Only three states and UT's have very good amount of reserved forest satisfying the national threshold criteria of bringing more than 33% of total geographical area under forest cover. Rest of the states and UT's recorded area below this threshold national value. However, the state of Nagaland and few UT's like Chandigarh, Daman and Diu, Lakshadweep and Puducherry didn't register any area under first category of reserved forests. In the second category of protected forests, only one state namely Himachal Pradesh recorded the largest proportion i.e., 59.51% surpassing the national threshold value. Rest of the states and UT's recorded below this value in varying proportions. In the last category of unclassified forests, Manipur recorded the maximum proportion (50.60%) closely followed by Nagaland (50.60%), Arunachal Pradesh (37.06%) and Meghalaya (37.32%). Rests of the states have recorded varying proportion of area below the national average. Some states and UT's didn't record any area under unclassified forests.

3. Ownership based classification: The forests are mainly controlled by the government agencies through state and UT's forest departments across the country. In few isolated instances, a minor proportion of forests are also owned by the entrepreneurs or corporate houses engaged in the forest based industries like wood and pulp, resin and others etc. In addition, a tiny proportion of forests to the tune of approximately less than one percent are owned by the individuals privately in few states of India.

4. Composition based classification: This scheme is based on the genetic composition of the forest. Two main types are identified such as 1) Coniferous and 2) Broad leaved. You have already studied about these two types of forests along with their characteristic features in detail in Unit 5 of Block-1.

5. Exploitation based classification: On the basis of this scheme, forests are classified into three broad classes. These are exploitable forests, forests which carry the potential of exploitation and other forests. It is estimated that more than fifty percent of our forest resources are exploitable in nature mainly for non-timber resources. Out of the total, nearly one-fourth proportion carries the potential for exploitation. First two types of exploitable and potentially exploitable forest cover spans the states of Arunachal Pradesh, Assam, and Tripura in the north-east.

Table 8.3: Proportion of Area under Different Classes of Forests in India.

State/UT	Geographical Area	Different Categories of Forests			% of Reserved Forest	% of Protected Forest	% of Unclassified Forest
		Reserved Forests	Protected Forests	Unclassified Forests			
Andhra Pradesh	1,62,968	31,959	5,069	230	19.61	3.11	0.14
Arunachal Pradesh	83,743	10,589	9,779	31,039	12.64	11.68	37.06
Assam	78,438	17,864	0	8,968	22.77	0.00	11.43
Bihar	94,163	693	6,183	1	0.74	6.57	0.00
Chhattisgarh	1,35,192	25,782	24,036	9,954	19.07	17.78	7.36
Delhi	1,483	78	24	0	5.26	1.62	0.00
Goa	3,702	253	0	972	6.83	0.00	26.26
Gujarat	1,96,244	14,373	2,886	4,388	7.32	1.47	2.24
Haryana	44,212	249	1,158	152	0.56	2.62	0.34
Himachal Pradesh	55,673	1,898	33,130	2,005	3.41	59.51	3.60
Jammu & Kashmir	2,22,236	17,643	2,551	36	7.94	1.15	0.02
Jharkhand	79,716	4,387	19,185	33	5.50	24.07	0.04
Karnataka	1,91,791	28,690	3,931	5,663	14.96	2.05	2.95
Kerala	38,852	11,309	0	0	29.11	0.00	0.00
Madhya Pradesh	3,08,252	61,886	31,098	1,705	20.08	10.09	0.55
Maharashtra	3,07,713	49,546	6,733	5,300	16.10	2.19	1.72
Manipur	22,327	1,467	4,171	11,780	6.57	18.68	52.76
Meghalaya	22,429	1,113	12	8,371	4.96	0.05	37.32
Mizoram	21,081	4,483	0	1,158	21.27	0.00	5.49
Nagaland	16,579	234	0	8,389	1.41	0.00	50.60
Odisha	1,55,707	36,049	25,133	22	23.15	16.14	0.01
Punjab	50,362	44	1,137	1,903	0.09	2.26	3.78
Rajasthan	3,42,239	12,475	18,217	2,045	3.65	5.32	0.60
Sikkim	7,096	5,452	389	0	76.83	5.48	0.00
Tamil Nadu	1,30,060	20,293	1,782	802	15.60	1.37	0.62
Telangana	1,12,077	20,353	5,939	612	18.16	5.30	0.55
Tripura	10,486	4,175	2	2,117	39.81	0.02	20.19
Uttar Pradesh	2,40,928	12,071	1,157	3,354	5.01	0.48	1.39
Uttarakhand	53,483	26,547	9,885	1,568	49.64	18.48	2.93
West Bengal	88,752	7,054	3,772	1,053	7.95	4.25	1.19
Andman and Nicobar Islands	8,249	5,613	1,558	0	68.04	18.89	0.00
Chandigarh	114	32	0	3	28.07	0.00	2.63
Dadra & Nagar Haveli	491	199	5	0	40.53	1.02	0.00
Daman & Diu	111	0	0	8	0.00	0.00	7.21
Lakshadweep	30	0	0	0	0.00	0.00	0.00
Puducherry	490	0	2	11	0.00	0.41	2.24
Total	32,87,469	4,34,853	2,18,924	1,13,642	13.23	6.66	3.46

(Source: Computed from India State of Forest Report, 2019)

Besides, one of the unique forms of forest known as '**mangrove**' is also found in India. It refers to a salt tolerant variety of plant community found in tropical and sub-tropical inter-tidal regions which can withstand strong wind velocity, high temperature, and muddy anaerobic soils. All such conditions are hostile in case of other plant communities. Mangrove is very rich in biodiversity and act as a natural mechanism of carbon sink. It is also a very good source of livelihood to many tribal and non-tribal communities living near mangrove forest areas. They have a characteristic complex root system unlike temperate plants which helps to protect the land adjoining the coasts from

storm surge, tsunami and soil erosion. They act as a kind of bridge between terrestrial and marine ecosystems. Mangrove forest occupies nearly 0.15% of total geographical area of the country, nearly 3 and 8% of the global and Asia's mangroves. It is mainly confined to 09 states and 03 UT's having a coastline on both sides of Western and Eastern Ghats. These states are Andhra Pradesh, Goa, Gujarat, Karnataka, Kerala, Maharashtra, Odisha, Tamil Nadu, West Bengal and UT's include Andaman and Nicobar Islands, Daman and Diu and Puducherry etc. West Bengal has the largest proportion followed by Gujarat and Andaman and Nicobar islands. With the passage of time due to the triple phenomenon's of population explosion, industrialization and urbanization further coupled with the onset of LPG drive during post-1990s, mangrove forest came under pressure and threat due to the increasing amount of anthropogenic interventions. Timber, fuel wood, fodder and many kinds of produce (wax, honey, tannins and fish etc.) are extracted in large amounts without thinking about the delicate ecological balance, hydrological, and climatological concerns comprehensively.

SAQ 2

Discuss in brief the administration based classification of forests.

8.4 ISSUES RELATED TO INDIAN FORESTS

Since the time of industrial revolution during the 18th century, you all know that the anthropogenic activities of human beings have started expanding at a much faster rate. Commensurate with the rise in the number of people or more appropriately population explosion, human beings required more and more land for a variety of domestic and industrial purposes. This ever-increasing need and demand for land thus necessitated the clearing of forest cover and forest resources rapidly which once covered vast tracts of geographical areas barring some physical and natural barriers (like rivers and mountains etc). Earlier, it involved the burning, felling and clearing of various types of tress from the naturally growing forests to meet domestic, agricultural, and industrial needs of the human societies and nations. Such interactions got a momentous kickstart soon after the industrial revolution which generated greater demands and also necessitated a modern way of living. Two factors played major roles and provided a thrust for large scale exploitation of trees and forest resources with technological innovations and capital investments and increasing population. Forest land was cleared for shelter, for growing cereal and non-cereal foods, for setting-up factories, industrial units and for the creation of various infrastructural amenities (roads, railways, govt. offices, markets and many others). All such needs of human beings set up a stage for the large scale harnessing and eventually exploitation of the forest resources in India like many other parts of the world. There are few countries in the world which maintains ideal forest cover as per the prevailing national norms. Some countries also provide incentives to its citizenry particularly farmers to bring the portion of their agricultural piece of land (possibly culturable waste and slopy lands) under forest cover. Few of such countries are located in the Scandinavian region. By now, you must have understood that some of the major activities of human beings have started degrading and deteriorating the

forest resources in enormous volumes. Now, we will discuss some of the pertinent issues pertaining to the Indian forests and forest resources in the following sub-sections.

8.4.1 Deforestation

It refers to the cutting down or indiscriminate felling of trees for variety of purposes. With the advent of industrial revolution in 1850, the issue of deforestation has started surfacing as a major threat to the environment. It has started disturbing the geographical, hydrological, and climatological patterns evident through the temperature rise resulting into global warming and climate change. The story of deforestation goes back to the colonization era, when the vast tracts of natural forests were cut-down on a massive scale to meet the various needs of the economy both at destination and source of origin of the colonizing forces. The natural forest cover in the high altitude mountainous slopes of Himalayas particularly northern portions and elsewhere were stripped off resulting into flooding in many of the perennial Himalayan rivers almost every successive year. Such mass scale unnatural process of deforestation also induces and triggers a irreversible damage not only amongst the floral and faunal species but also disturbs the rythum of cyclic processes across the major systems of the planet earth (like carbon cycle, nitrogen cycle, and hydrological cycle, etc.). For example, it not only takes away the natural habitat of numerous birds and insects but also renders many wild animals homeless. This in turn may also generate a chain reaction manifesting in the form of human-animal conflict for survival often seen in both rural and urban set-ups in recent times. Lot of deforestation also took place to meet the timber demands for house construction, logs for laying of railway lines, furniture making, dam construction, and other developmental projects. Apart from these, some other prominent causes include shifting cultivation, illegal encroachment, illegal cutting of trees, forest fires and overgrazing etc. Many social community level movements were spearheaded to save the cutting of trees. Some of the prominent movements well known to all of you are Chipko and Apiko movements etc.

8.4.2 Afforestation

It refers to the plantation of trees aimed to rejuvenate and transform the derelict and degraded agricultural and other lands into forests. It also includes plantation of tree seedlings and trees in a non-forested areas as well by adopting both mediums like natural or artificial. The process of afforestation may also incorporate the plantation done through reforestation process to rejuvenate the degraded forest cover in a patch of forest.

There are many success stories of afforestation in India. One of the socio-culturally rich devotional practices of afforestation is being practiced by the Bishnoi community in India since long back as mentioned earlier. The villagers of Piplantri located in the Rajasamand district of Rajasthan state have started a unique practice of planting 111 trees to celebrate the birth of a every new-born girl child since 2006. This noble philanthropic work has been initiated by a renowned social worker Shri Shyam Sunder Paliwal (as a Sarpanch of Village/Gram Panchayat) for which he has been honoured with the fourth highest civilian award 'Padmashree' recently in 2021. He is the

person whose creativity followed with persistent efforts with the help of community participation helped to catalyse the pioneering drive which revolves around the crucial issues of protection of girl child and their empowerment, forestry along with the conservation of water. It has tremendously helped to increase the greenery on otherwise desert landscape on one hand and also helped to recharge the groundwater aquifer and led to increase in the pasturelands.

One more successful example of natural resources management with a component of afforestation (through massive plantation of fast growing commercial variety of Khair trees) pertains to the 'Sukhomajri' village lying in the foothills of Shiwalik hills in the Ambala district of Haryana State under the banner of Joint Forest Management Programme' initiated in 1976. All across the country, joint forest management programme are helping to increase the green cover with community participation. Afforestation is a very essential component enacted in the national forest acts and policies through an umbrella of national forestry programmes to renew the degraded forest resources. Such kind of the programmes laid an emphasis on the plantation of fast growing varieties of trees which can satisfy the needs of wood based industries having an economic and industrial value. Besides, there are many afforestation programmes started by the forest departments across the country to increase the green cover substantially. The plantation efforts run under the banner of National Afforestation Programme of Govt. of India is also helping to increase the forest cover.

8.4.3 Conservation

In general parlance, conservation refers to the conscious and genuine efforts which are carried out by an individual, societies and institutions (both governmental and non-governmental) with a view to protect the natural resources found over the planet Earth. In other words, you can understand that conservation is a kind of management mechanism to minimize the unnatural and unscientific destruction in order to preserve the duo of eco and geodiversity for the good health of natural environment. One of the most famous dictums coined by father of our nation Mahatma Gandhi is being often cited in this context, which states that mother planet Earth has enough to satisfy the needs of each and every individual but not the greed. In simple terms, it seems to be corresponding to the Brundtland Commission's (of United Nation) definition later coined on the concept of sustainable development in a manner '***development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs***'.

Our nation is witnessing a rapid phase of population growth with each passing moment. It generates a multi-fold demand for the expansion of agricultural land, industrialization, and urbanization in a cyclic manner. The large number of population coupled with unscientific industrial and urban development activities have started manifesting into a range of environmental problems encompassing diminishing wildlife (pushing some species to the limits of extinction which plays a vital role in the sustenance of ecosystem), air and water pollution, deforestation, overuse of fossil fuels (coal, oil, and natural gas) and others. In turn, such wanton actions are generating erratic local to

global level ecosystem related issues and problems including desertification, devastation of rich natural biodiversity regimes, climate change and global warming and depletion of ozone layer etc., to name few prominent ones.

There are many policies and programmes as framed by the FSI and other agencies aimed to conserve the forest and forest resources. These programmes are designed keeping in mind the type of ecosystem and its ecological sensitivity in close consideration. In India, one ethnic community popularly known as 'Bishnoi' not only conserve the trees but they also worship along with some other ethnic tribal groups as well. Trees and forest cover have a particular place in their life and its cycles. Besides, there are many social afforestation programmes being managed by the individuals and non-governmental organizations. The Govt. of India has started many programmes since long back aimed towards the conservation of forest resources in the country for enhancing the green cover to meet the minimum one-third of the total geographical area as envisaged in the National Forest Policy. These are briefly discussed as under:

Forest Protection: It is a centrally sponsored scheme to deal with the adverse effects of growing incidences of forest fires. This scheme also led to the formulation of another comprehensive scheme titled 'forest fire prevention and management'.

National Afforestation Programme Scheme: The major objectives are to protect and conserve natural resources with active community participation, to check land degradation, deforestation and biodiversity loss among others.

National Mission for Green India: It is a part of one of the eight missions of national action plan to deal with the issue of climate change. The major aim is to protect and enhance the thin forest cover so as to combat the issue of climate change.

Forestry Research: There are dedicated research institutions of Govt. of India. Some of the prominent ones include:

Indian Council of Forestry Research and Education (ICFRE): It is an autonomous apex body created in 1987 to deal with the holistic development of forestry research, education and extension services concerned with all the components of forestry located at Dehradun. There are nine research institutions and four centres devoted to the study of myriad aspects of forests in varied forest zones and environments under the umbrella of ICFRE. These are including 1) Forest Research Institute, Dehradun; 2) Tropical Forest Research Institute, Jabalpur; 3) Arid Forest Research Institute, Jodhpur; 4) Himalayan Forest Research Institute, Shimla; Institute of Forest Productivity, Ranchi; 5) Institute of Forest Biodiversity, Hyderabad; 6) Institute of Forest Genetics and Tree Breeding, Coimbatore; 7) Rain Forest Research Institute, Jorhat; 8) Institute of Wood Science and Technology, Bengaluru; 9) Forest Research Centre for Skill Development, Chhindwara; 10) Forest Research Centre for Bamboo & Rattan, Aizawl; 11) Forest Research Centre for Eco-Rehabilitation, Prayagraj; and 12) Forest Research Centre for Livelihood Extension, Agartala.

Indira Gandhi National Forest Academy (IGNFA): It imparts the professional training to the forest personnel concerned with various aspects of forest management.

There are some key policies and acts that deals with the conservation of forest resources of India as discussed under:

1. The Indian Forest Act, 1927: This act is created keeping in consideration the consolidation of the law related to the forests. It deals with the transit of forest related produce and products along with the duty leviable on timber and other forest products.

2. Forest Conservation Act, 1980: This act was created with an aim to conserve the forest resources of the nation. It necessitates the prior approval of the Central Government for diversion of forest lands into non-forestry purposes. Its basic objective is to regulate the indiscriminate diversion of forest lands for non-forestry uses and to maintain a logical balance between the developmental needs of the country and the conservation of natural heritage. This act has tremendously helped to bring down the quantum of land diversion from ~1.43 lakh hectare per annum prior to the enactment of this act to 15000 hectares per annum during present times. The prominent areas to meet the developmental needs allowed for diversion are drinking water projects, irrigation projects, transmission lines, railway lines, roads, power projects, defense related projects, and mining etc. However, in turn, this act also mandates the implementation of provision of compensatory afforestation, catchment area treatment plan, wildlife habitat improvement plan and rehabilitation plan etc. This is primarily done to mitigate the ill-effects of diversion of forest into non-forestry purposes. Furthermore, a national level authority known as 'Compensatory Afforestation Management and Planning Authority (CAMPA)' has also been constituted in order to monitor the effective implementation of the compensatory afforestation programmes in its entirety.

3. National Forest Policy, 1988: The principal aim is to ensure the environmental stability and maintenance of ecological balance by bringing a minimum of one-third of total geographical area of the country under forest or tree cover. It is being revised so as to incorporate the contemporary thematic issues of importance for comprehensive coverage and treatment. Besides, it also mandates to ensure the essential participation of local community living in and around the forest areas aimed towards the conservation and development of forests. The implementation of this policy mandated to develop a clear roadmap to manage the degraded forest land under the custody of State Forest Departments (SFDs) with help of the local communities and voluntary organizations. Accordingly, the states developed their own guidelines in the form of resolutions dealing with the issues of Joint Forest Management (JFM) in their respective states.

4. Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006: This act is created to recognize the rights of forest-dwelling Scheduled Tribes and other traditional forest dwellers of India.

Besides the above-mentioned acts and policies, a separate body namely '**National Green Tribunal (NGT)**' as a special vehicle was also established by the Government of India in 2010. Most of you might be aware of it. It deals

with the issues of environmental protection and conservation of forests and other natural resources. Besides, India also actively takes part in several international summits and conventions related to the conservation and sustainable development of forest along with wildlife and environment. Some of the prominent forums dedicated to forestry include:

- United Nations Forum on Forests (UNFF);
- Committee on Forestry (COFO) of Food and Agriculture Organization (FAO) of the United Nations;
- Asia Pacific Forestry Commission (APFC) of Food and Agricultural Organisation (FAO);
- Centre for International Forestry Research (CIFOR);
- Asia Pacific Forest Invasive Species Network (APFISN);
- International Poplar Commission of Food and Agricultural Organisation (FAO);
- UN-REDD of United Nations Framework Convention on Climate Change etc.

Along with increasing the forest cover, all such concerted efforts in unison with global community are also aimed towards mitigating and arresting the ill-effects of climate change and global warming.

SAQ 3

Highlight any one major issues related to the forests and forest resources of India?

8.5 SUMMARY

In this unit, you have studied so far:

- The characteristics of forest resources and their distribution in India.
- The various types of forests, their distinct characteristics, relevance and other associated aspects to the human society and nation at a large.
- You have also learnt about the various types of contemporary issues related to the Indian forests encompassing deforestation, afforestation, and conservation etc.
- Lastly, in nutshell, you got an idea about the various aspects and factors that affects and gets affected by the forest resources in India.

8.6 TERMIAL QUESTIONS

1. Discuss about the major characteristics of forest with apt examples.
2. Highlight the key features of spatial distribution of forest in India.
3. Discuss in detail the various functional classification schemes of forest in India.

4. Deforestation is a serious threat to both the natural environment and human beings. Elaborate with suitable cases.

8.7 ANSWERS

Self-Assessment Questions (SAQs)

1. There are three major characteristics or services related to the forest resources. These are natural or ecological, economic, and socio-cultural etc. The economic characteristics or services provides array of product to the forest based industries including providing many other crucial life sustaining produce and services.
2. Administration based classification is mainly done to arrest the indiscriminate and wanton destruction of the trees and forest cover. It is of three kinds namely reserved, protected, and unclassed forests.
3. Deforestation refers to the indiscriminate cutting of trees to meet various needs. These may include agricultural, industrial, township and urbanization and many developmental projects including roads, dams and bridges etc.

Terminal Questions

1. Your answer should cover the major features of the forest resources. You may refer to Section 8.2.
2. While answering this question, highlight the pattern of spatial distribution and compare with the national average in terms of surplus and deficit. You may refer to Section 8.3.
3. Highlight the main category of forests and their salient features for each classification scheme. You may refer to Section 8.3.
4. Refer to Section 8.4.

8.8 REFERENCES AND SUGGESTED FURTHER READING

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MINERAL RESOURCES |

Structure

9.1	Introduction		Distribution and Utilisation of
	Expected Learning Outcomes		Metallic Mineral Resources
9.2	Minerals and their		(Non- Ferrous)
	Characteristics		Distribution and Utilisation of
9.3	Classification of Mineral		Non-Metallic Minerals
	Resources	9.5	Conservation of Mineral
9.4	Distribution and Utilisation of		Resources
	Mineral Resources in India	9.6	Summary
	Spatial Pattern of Mineral	9.7	Terminal Questions
	Distribution	9.8	Answers
	Distribution and Utilisation of	9.9	References and Suggested
	Metallic Mineral Resources		Further Reading
	(Ferrous)		

9.1 INTRODUCTION

In this block on “Resource Base”, so far, you have studied about land, water, and forest resources of India. Now you are familiar with terms like land-man ratio, landuse capability and land degradation. You are also aware of water resources of India and several multipurpose river valley projects functioning here that manages the water resources of the country. You have also been acquainted with forest resources and various issues related to forests, like deforestation and its conservation.

In this Unit 9, you will learn about mineral resources. The word ‘mineral’ must have been introduced to you in your geography classes when you were at school level. So now you can recall that a mineral is naturally occurring substance with a definite chemical composition and recognisable physical properties. Minerals are classified into fuel, metallic and non-metallic. The fuel or power resources would be discussed in the next Unit. In this Unit, Section 9.2 will give you a brief introduction to the minerals and their characteristics. Since minerals are classified into different groups on the basis of physical and chemical properties, so Section 9.3 will get you acquainted with different classes of mineral resources. Minerals are used in almost all areas of human activity. The potential wealth of any country depends upon the natural endowment of mineral resources. So, it is important for you to study about the

mineral resources and their distribution and utilisation. Section 9.4 gives a detailed description of distribution of different mineral resources in India. Most of the mineral resources are found under the ground. The extraction of these resources requires a high degree of precision for proper utilisation. This section also familiarizes you with the utilisation of mineral resources. You should also know that minerals are finite and non-renewable resources. So we should also focus on its judicious usage and measures for conserving it for future generations. Lastly, Section 9.5 is discussing on the conservation of mineral resources.

Expected Learning Outcomes

After completing the study of this unit, you should be able to:

- define minerals and explain their characteristics;
- classify minerals and distinguish between them;
- describe the distribution of minerals in India;
- analyze the various methods of extraction and utilization of these mineral resources; and
- assess the existing conservation measures as well as give possible options for future conservation of these valuable non-renewable resources.

9.2 MINERALS AND THEIR CHARACTERISTICS

The minerals are naturally occurring substances with a definite chemical composition and recognizable physical properties. We all use minerals in our everyday life. Right from early in the morning, the toothpaste we use contain minerals, the cosmetics we use are made up of a variety of minerals. The food we eat, the gemstones we wear, the house we live in, the automobiles we travel in, and even the cell phones we use so frequently are made up of minerals. Our entire body is made up of so many minerals. This is the extent to which we are dependent on minerals. Minerals have some distinct characteristics about which we should know. Although thousands of minerals have been identified on the earth, only a few of them occupy most of the area on earth. Let us first learn about some of the basic characteristics of mineral.

In order to fulfill the conditions needed for a mineral, any substance should have five basic characteristics. These are i) naturally occurring ii) inorganic iii) solid iv) definite chemical composition and v) crystalline structure. Let us discuss now each one of them briefly.

i) Naturally Occurring

Minerals are naturally occurring substances and are not made by humans. Some substances that are prepared in a laboratory may look like minerals, but they are not. Similarly some naturally occurring substances do not confirm to be minerals as they might have one or two characteristics of minerals but they are lacking in other basic characteristics of minerals.

ii) Inorganic

Minerals are inorganic, that is, they are not made up of any living organisms nor do they belong to any class of organic compounds like carbohydrates, proteins and fats which are made by living beings. So they can contain carbon but carbon does not bond with hydrogen in minerals to form long chains as in carbohydrates and fats in living organisms.

iii) Solid

Minerals are solids at standard temperature and pressure. They have a high degree of order that is, the atoms are bonded closely which gives them a fixed volume and shape and a rigid structure of a solid. This means that the bonding is so strong in a mineral that the particles are not free to move as in liquid and gaseous substances. Solids can be crystalline or amorphous but minerals are crystalline which is another important characteristic of minerals and we will discuss this separately.

iv) Crystalline Structure

Atoms in a mineral are arranged in a systematic and repeating pattern. This repeating part of the crystal is a unit and the arrangement of atoms is similar in a particular mineral. Crystalline shapes are of six types though most of the mineral crystals have cubic and tetrahedral shape. There are two prominent ways of formation of crystals. The molten rocks in the form of magma or lava solidify to form crystals. Do you know that some of the most precious metals like diamonds etc. are formed under intense heat and pressure in the volcanic vents. Mineral crystals are also formed in the oceans as water deposits enormous solutes which form crystals once water evaporates. Apart from crystalline structure, minerals also have a definite chemical composition which you should know.

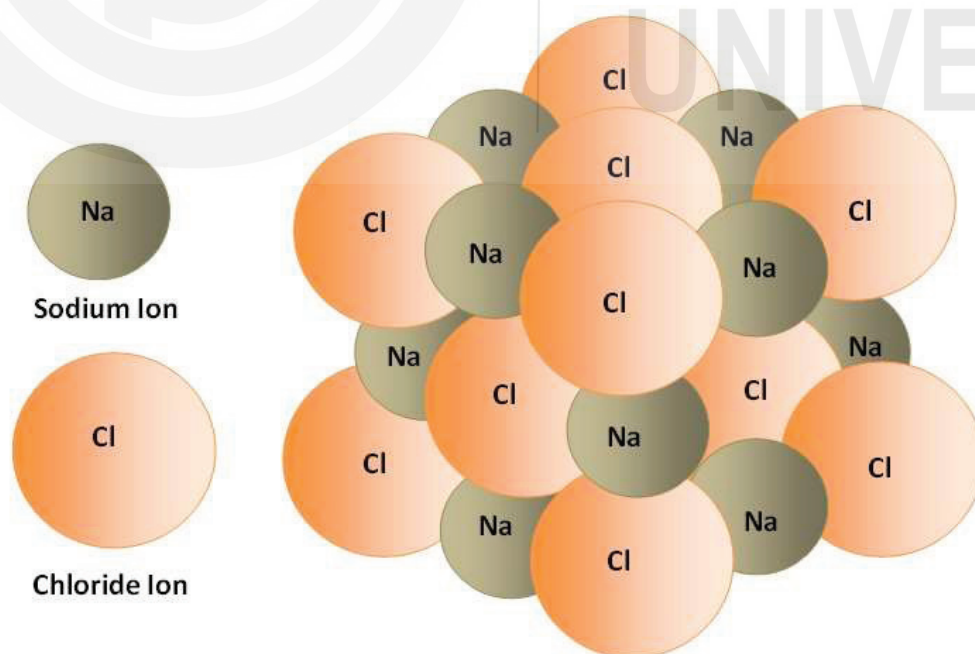


Fig. 9.1: Arrangement of Sodium and Chloride Ions in Halite.

v) Chemical Composition

Each mineral has a fixed combination of atoms which are bonded together in a definite crystalline structure. This is supposed to be specific for a particular mineral. Take for example mineral “halite” or common salt has a chemical composition of sodium chloride (NaCl). Thus it is made up of equal number of sodium and chlorine atoms which are electronically charged ions (in this case) bonded together in a repeating pattern in all directions which is actually cubic in case of NaCl. Refer to Fig. 9.1 to see the arrangement of Sodium and Chloride ions in Halite.

SAQ I

List five basic characteristics of minerals. Is wood a mineral?

9.3 CLASSIFICATION OF MINERAL RESOURCES

On the basis of chemical and physical properties, minerals may be grouped under two main sub-heads: Metallic and Non Metallic.

A. Metallic Minerals

Metallic minerals, as the name suggests contain metal and so are the source of metals. Iron ore, copper, manganese, gold etc., all produce metals and so fall under this category. **Metallic minerals** are further divided into **ferrous** and **non-ferrous** minerals. The word “*Ferrous*” refers to iron. All those minerals which have iron content in them are referred to as **ferrous minerals**. Some important examples of ferrous minerals are iron ore, manganese, tungsten, nickel, cobalt, etc. Metallic minerals having no iron content are grouped under **non-ferrous metallic minerals**. Gold, silver, copper, lead, bauxite, tin, magnesium belong to this category

B. Non- Metallic Minerals

Non-metallic minerals are those minerals which do not contain any metal in it. Examples are fossil fuels, mica, limestone etc. **Non-Metallic minerals** are also divided into **organic** and **inorganic** minerals. Organic minerals are those minerals which contain organic matter. Examples of this type include fossil fuels as they are derived from organic remains of plants and animals. So fossil fuels like coal, petroleum etc. fall under this category. Inorganic minerals are those minerals that do not contain any organic matter, for example mica, limestone, graphite, etc.

From an economic viewpoint, minerals are also classified as precious and semi-precious minerals (Diamond, Emerald, Garnet, Gold etc.), strategic minerals (Cobalt, Molybdenum, Nickel, Rare Earth etc.), fertilizer minerals (Rock Phosphate, Potash, Sulphur etc.), refractory minerals (Andalusite, Graphite, Kyanite etc.), ceramic and glass mineral (Wollastonite), other industrial minerals (Asbestos, Borax etc.) and minor minerals (Barytes, Bentonite, Calcite, Chalk, China Clay etc.).

Now do you know about ores? It is important for you to know about ores. Ores are concentrations of minerals in rock that are high enough to be economically extracted for use. An ore is an occurrence of rock or sediment that contains sufficient minerals with economically important elements, typically metals, that can be economically extracted from the deposit.

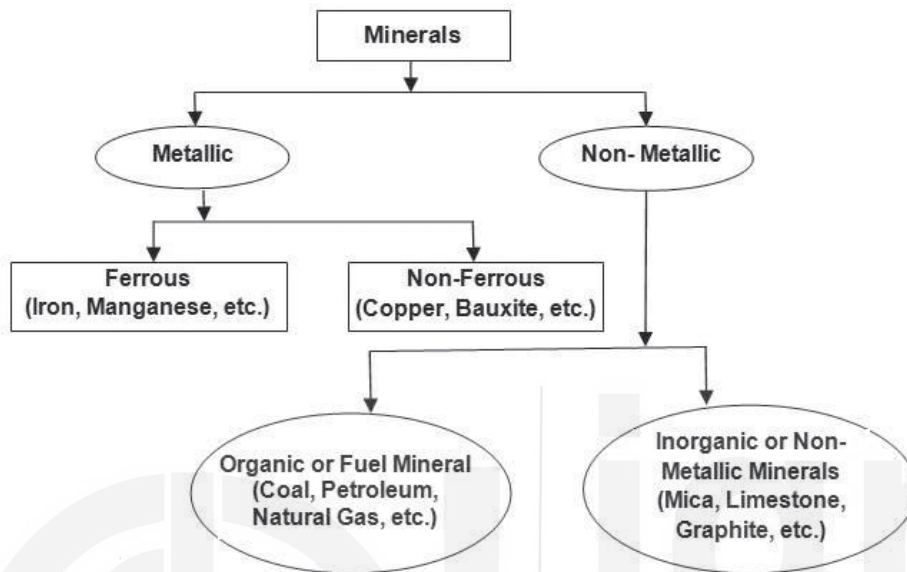


Fig. 9.2: Classification of Minerals.

The **United Nations Framework Classification (UNFC)** for fossil energy and mineral reserves and resources prescribes a standard mineral classification based on three fundamental criteria, that is, **economic viability**, **feasibility assessment** and also **geological assessment**. Thus, it follows a three dimensional system of classification on the basis of these three axis. Refer to Fig. 9.3 (a) to get a clear idea of this.

So as per UNFC, the Total Mineral Resources = Reserves + Additional or Remaining Resources

With the help of these three fundamental criteria or axis, national inventory of minerals is prepared for any country. A **three-digit-code** is generated in which the first digit denotes the economic viability axis, the second digit denotes the feasibility axis, and the third digit denotes the geologic axis. The degree of economic viability is given in codes 1, 2 and 3 in which the **code 1** represents resources that are economically mineable, **code 2** represents those which are possibly economically viable subject to changes in few conditions and **code 3** representing the **remaining resources**. Feasibility study/mining reports are also described in the UNFC by the codes 3, 2 and 1 respectively. Geological assessment categories as per UNFC are represented by 4 codes, i.e., 1 (detailed exploration), 2 (general exploration), 3 (prospecting) and 4 (reconnaissance). Thus as per UNFC classification the highest category of resources will have the code 111 and lowest category, the code 334. Refer to Fig. 9.3 (b) to understand this.

Now when you will study the distribution of various minerals in India in the next section, you will get information on the reserves as well as remaining resources of the different minerals in India.

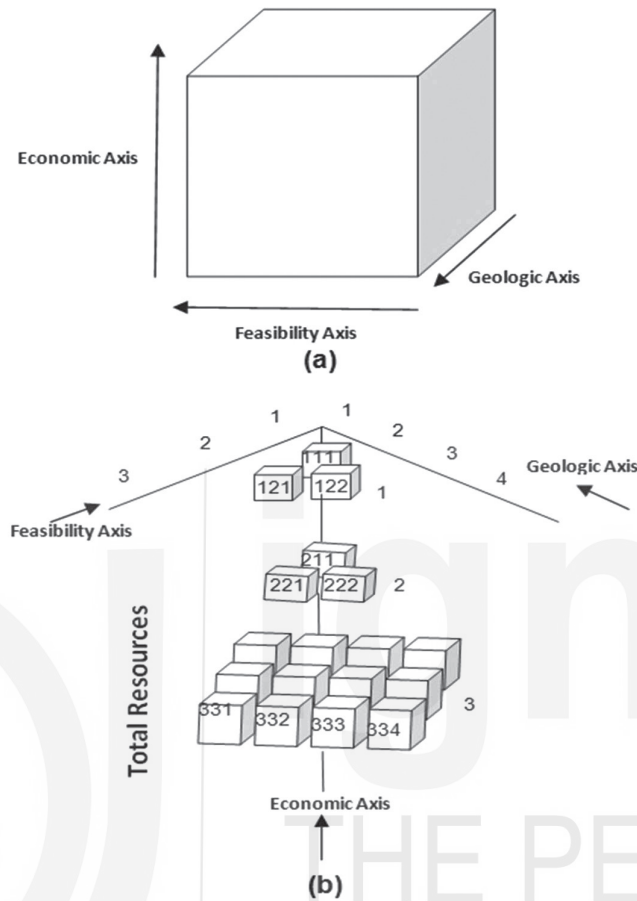


Fig. 9.3: (a) The Three Axis of UNFC (b) Three Digit Codification System of UNFC.

(Source: Redrawn from UNFCemr.pdf by Author)

SAQ 2

Distinguish between the following:

- (i) Metallic and Non-Metallic Minerals
- (ii) Ferrous and Non-Ferrous Minerals
- (iii) Organic and Inorganic Minerals

9.4 DISTRIBUTION AND UTILISATION OF MINERAL RESOURCES

India is richly endowed with a wide variety of mineral resources. So mining forms an important segment of Indian economy. As per Annual Report 2017-18 of the Ministry of Mines, the country produces around 95 minerals which include 4 fuel, 10 metallic, 23 non-metallic, 3 atomic and 55 minor minerals (including building and other materials). India occupies a dominant position in the production of many minerals across the globe. You may go through Table

9.1 to know the statistics of indigenous and world production of principal minerals.

Table 9.1: Contribution and Rank of India in World Production of Principal Minerals and Metals (2018).

Sector	Unit of Commodity	Production Quantity		Contribution (percentage)	India's rank in World order \$
		World	India*		
Metallic Minerals					
Bauxite	'000 tonnes	326000	23688	7.27	5 th
Chromite	'000 tonnes	40800	3971	9.23	4 th
Iron ore	million tonnes	2923	206	7.05	4 th
Manganese ore	'000 tonnes	53000	2820	5.32	7 th
Industrial Minerals					
Magnesite	'000 tonnes	29500	147	0.50	15 th
Apatite & rock phosphate	'000 tonnes	232000	1285	0.55	16 th
Metals					
Aluminium (Primary	'000 tonnes	62700	3936	5.89	4 th
Copper (refined)	'000 tonnes	23900	454	1.90	11 th
Steel (crude/liquid)	million tonnes	1812	110.92	6.12	2 nd
Lead (refined)	'000 tonnes	12000	620	5.17	4 th
Zinc (slab)	'000 tonnes	13300	696	5.23	3 rd

(Source: World mineral production data compiled from World Mineral Production, 2014-2018, British Geological Survey, * Figures relate to 2018-19)

Let us now understand the spatial pattern of distribution of minerals in India.

Geomorphologically, India is divided into three parts:

- Peninsular India
- Extra-Peninsular (Himalayas and Naga Lushai belt), and
- Indo-Gangetic Brahmaputra Alluvium (including desert).

The total area of the country is 3.287 million sq. km. Out of this 2.386 million sq. km (Peninsular and Himalayan region) comprises of hard rock whereas 0.901 million sq. km is comprised of quaternary formations of less than one million years old. So the country has rock formations ranging from Archean (pre 2500 million years) to recent. Minerals are formed over a period of millions of years in the earth's crust. So Archean Proterozoic rocks hosts most of the metallic and non-metallic minerals in India. In simple words, you can understand that minerals are contained in older rock formations of peninsular plateau region. The northern alluvial plains having quaternary formations have scarce mineral resources. The Himalayas on the other hand has complex rock structure which makes extraction of mineral resources very difficult. So the geological structure itself accounts for uneven distribution of mineral resources in India.

9.4.1 Spatial Pattern of Mineral Distribution

Minerals are concentrated in four belts in India. Let us learn about those belts. They are:

- North-Eastern Plateau Region
- South-Western Plateau Region
- North-Western Region
- Himalayan Region

Let us now get some idea about these mineral rich belts or regions.

i. North-Eastern Plateau Region

Of the four regions mentioned above this is the richest mineral belt and comprises of Chhotanagpur (Jharkhand), Odisha Plateau, West Bengal and parts of Chhattisgarh. It has good reserves for iron ore, coal, manganese, bauxite, mica etc. Now you can reason out why some of the major iron and steel industries are localized in this region.

ii. South-Western Plateau Region

This region extends over Karnataka, Goa and neighboring upland areas of Tamil Nadu and Kerala. It accounts for some of the good quality or high grade iron ore. Compared to the north eastern mineral belt, this region does not have diversified mineral deposits. However, it has a few exceptions, like Kerala has reserves of monazite and thorium, bauxite clay and Goa has iron ore deposits. This region is also deficit in coal and other power reserves. Lignite deposits are only found in Neyveli. You should remember one important point that this region hosts all the three gold fields of India.

iii. North-Western Region

This belt engulfs parts of Gujarat and the Aravalli range in Rajasthan. It has good reserves of petroleum and natural gas which is found along Gujarat coast. Rajasthan part is rich in building stones i.e. sandstone, granite, marble. Dolomite and limestone provides base for cement industry. Gypsum and Fuller's earth are also found in abundance in this region. This region also has rich sources of rock salt.

iv. Himalayan Region

This is another belt which is rich in copper, lead, zinc, cobalt and tungsten. This region also has mineral oil deposits along Assam valley.

Before we move to the next sub-section regarding distribution, production and utilization of some prominent minerals in India, try answering an SAQ.

SAQ 3

Match List 1 with List 2

List 1

Chotanagpur
Neyveli
Aravalli
Assam

List 2

Lignite Coal
Limestone
Mineral Oil
Iron Ore

9.4.2 Distribution and Utilisation of Metallic Mineral

Resources (Ferrous)

You may recall that minerals having iron content are referred to as ferrous minerals. Let us study the distribution of iron ore, manganese, nickel, chromite and tungsten under this category.

A. Iron Ore

Distribution: India is richly endowed with high grade and easily accessible iron ore being free from impurities like sulphur and phosphorous. Hematite (Fe_2O_3 with iron content of 55%) and Magnetite (Fe_3O_4 with iron content ranging from 25-62%) are the two important ores of iron found in India. India has the largest reserves in Asia and occupies the 5th position in the world. Iron ore deposits occur as hill ranges of altitude less than 450 m. The ore is mined by open cast method. As per UNFC system, the total resources of hematite in India as in 2015 are estimated at 22,487 million tonnes of which 5,442 million tonnes are under reserves category while 17,045 million tonnes are placed under remaining resources. As per UNFC system, the total resources of magnetite in India as in 2015 are estimated at 10,789 million tonnes of which the reserves constitute a mere 53 million tonnes while 10,736 million tonnes are placed under remaining resources. Major resources of magnetite occur in four states of Karnataka (72%), followed by Andhra Pradesh (13%), Rajasthan (6%) and Tamil Nadu (5%). Major resources of hematite deposits occur in Odisha (34%), Jharkhand (24%), Chhattisgarh (22%), Karnataka (11%) and Goa (5%). Singhbhum district of Jharkhand and the adjoining districts of Keonjhar, Mayurbhanj and Sundargarh in Odisha form the richest reserves of high grade hematite. These deposits of hematite belong to the pre-cambrian iron ore series. The chief mining centres of iron ore are Noamundi, Gua and Manoharpur located in Singhbhum district and Badampahar and Sulaipat in Mayurbhanj districts, Dhali and Rajhara hills in Durg, Bailadila and Rowghat in Bastar district, Pipalgaon and Lohara in Chandrapur (Chanda) districts, Kemmangundi in Bababudan hills of Chikmagalur district of Karnataka. Other areas rich in iron ore deposits are Kudremukh in Chikmagalur district (Karnataka), Sandur ranges in Bellary-Hospet area (Karnataka) and Salem and Ratnagiri districts. Refer to Fig. 9.4 to have an idea about the location of iron ore deposits in India.

India produced 246 million tonnes iron ore consisting of Lumps, Fines and Concentrates in 2019-20. Odisha topped the list in the production of iron ore accounting to 59.64% of total production of the country followed by Chhattisgarh (14.11%), Karnataka (12.76%), Jharkhand (10.93%) and remaining (2.56%) production which was reported from Andhra Pradesh, Madhya Pradesh, Maharashtra, and Rajasthan.

Utilisation: Iron ore is the basic raw material used in the making of pig iron, sponge iron, steel and alloy. Other important iron ore consuming industries are cement, coal washeries and ferro-alloys industries. Iron ore from the mines in Jharkhand and Odisha are supplied to iron and steel works at Jamshedpur, Asansol, Durgapur and Raurkela. Bhilai steel plant is also located in the vicinity of Dhali and Rajhara hills from where it gets rich supply of good quality iron ore. Similarly, Kemmangundi in Bababudan hills of

Chikmagalur district of Karnataka supplies iron ore to the steel plant located at Bhadravati. Iron ore found in Goa is also located in the vicinity of navigable rivers from where it reaches the port of Murmagao for export. Daitri iron ore mine in Cuttack (Odisha) is also export oriented and utilizes the port facilities at Paradip for this. Kundremukh mine is also for export of iron ore pellets from Mangaluru port. Refer to Fig. 9.4 to see the ports that are exporting iron ore.

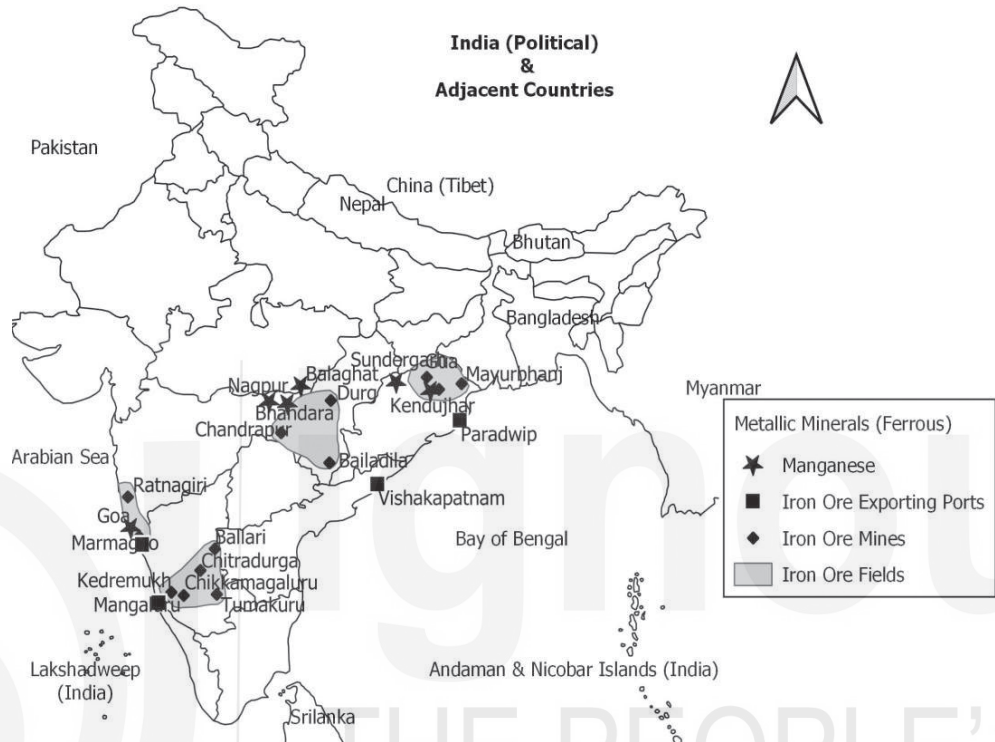


Fig. 9.4: Distribution of Metallic Minerals (Ferrous) in India.

(Source: Figure drawn by Author)

B. Manganese

Distribution: As per UNFC system, the total reserves of manganese ore in India as in 2015 is 496 million tonnes. Of these 94 million tones are categorized as reserves and the balance 402 million tones are in the remaining resources category. Manganese deposits are predominantly associated with Dharwar formations, although they are found in all geological formations. Odisha tops the list with 44% of the total reserves of Manganese in the country. It's mines are located in the vicinity of iron ore mines. Important mines for manganese in Odisha are Bonai, Kendujhar, Sundergarh, Gangpur, Koraput, Kalahandi, and Bolangir. Karnataka is having 22% of reserves of manganese ore. The mining areas of manganese in Karnataka are Dharwar, Ballari, Belagavi, North Canara, Chikmagalur, Shivamogga, Chitradurg, and Tumakuru. Other regions having reserves of manganese are Nagpur, Bhandara and Ratnagiri districts in Maharashtra and Balaghat-Chhindwara-Nimar-Mandla and Jhabua districts of Madhya Pradesh. Telangana, Goa, and Jharkhand also produces manganese but to a smaller extent. Refer to Fig. 9.4 to have a brief knowledge about the distribution of manganese mining areas in India. India produced 2,904 thousand tonnes of manganese ore in 2019-20. Madhya Pradesh continued to be the largest producer of Manganese ore contributing 32.99% in the total output of the country.

Utilisation: Manganese is an important mineral used in the smelting of iron and also in manufacturing ferro alloys due to which its consumption has increased in the recent years. It also forms a constituent of paint and glass industries. Manganese dioxide is used in dry cell batteries.

C. Nickel

Distribution: As per UNFC estimation of 2015, the total provisional resources of nickel ore have been estimated at 189 million tonnes. About 92% resources; i.e., 175 million tonnes are in Odisha. The remaining 8% of the reserves are distributed in Jharkhand (9 million tonnes), Nagaland (5 million tonnes) and Karnataka (0.23 million tonnes).

Utilisation: Nickel, when added in small quantity to iron, improves its quality and makes the product hard and stainless. The reason behind the demand of 66% primary nickel in the entire world is for the production of stainless steel. It is also used in plating due to which the surface becomes tarnish-resistant and provides polished appearance.

D. Chromite

Distribution: The total resources of Chromite in India as per UNFC System as on 2015 are estimated at 344 million tonnes, comprising 102 million tonnes reserves (30%) and 242 million tonnes remaining resources (70%). In India, 96 per cent of chromite reserves are located in Odisha, mostly in the Sukinda valley in Jajpur and Keonjhar districts and the remaining 5% resources are distributed in Manipur, Nagaland, Karnataka, Jharkhand, Maharashtra, Tamil Nadu, Andhra Pradesh and Telangna. India produced 3,929 thousand tonnes of chromite in 2019-20. Odisha reported almost entire production of chromite.

Utilisation: Chromite is an ore of chromium. This metal is used in making stainless steel, nichrome, and chrome plating. When it is alloyed with iron and nickel, it produces an alloy known as "nichrome" which can stand high temperatures. Thus it is used in making heating units, ovens, and other appliances. Thin coatings of chromium alloys are also used for plating auto parts, appliances, and other products. These are thus given the name "chrome plated."

E. Tungsten

Distribution: The total reserves of tungsten ore in the country, as per 2015 UNFC system have been estimated at 87.4 million tonnes containing 1,42,094 tonnes W03 content. All these resources are placed under, 'remaining resources' category. Tungsten reserves are mainly distributed in Karnataka (42%), Rajasthan (27%), Andhra Pradesh (17%) and Maharashtra (9%). Remaining 5% resources are in Haryana, Tamil Nadu, Uttarakhand and West Bengal.

Utilisation: Tungsten is capable of tolerating very high temperatures and has extremely low vapour pressure, due to which it is used in light bulb filaments. Tungsten has the highest melting point of all metals and so it is alloyed with other metals to provide additional strength and durability. Tungsten increases the hardness and cutting capacity of steel. Tungsten is used as arc-welding electrodes and heating elements in high-temperature

furnaces. It also serves as a reagent in the form of high purity sodium tungstate in biochemical analysis.

9.4.3 Distribution and Utilisation of Metallic Mineral Resources (Non-Ferrous)

You may recall that minerals having no iron content are grouped under non-ferrous minerals. Examples of this type of minerals are bauxite, copper and some precious and semi-precious minerals like gold, silver etc., in which India is poorly endowed. Let us study the distribution of bauxite, copper and some precious minerals under this category.

A. Bauxite

Distribution: Total resources of bauxite as per UNFC in India are placed at 3897 million tones of which 656 million tones are reserves while 3240 million tones are the remaining resources. Bauxite is mainly associated with laterite rocks belonging to tertiary formation. The state of Odisha leads in the production of bauxite where Kalahandi, Sambalpur, Bolangir, and Koraput are the important producing areas. The plateau areas of Jharkhand near Lohardagga also produces bauxite. Other regions producing bauxite are Bhavanagar, and Jamnagar in Gujarat, Amarkantak plateau in Chhattisgarh, Katni-Jabalpur area and Balaghat in M.P, Kolaba, Thane, Ratnagiri, Satara, Pune and Kolhapur in Maharashtra are important producers. Some states like Tamil Nadu, Karnataka and Goa also produces bauxite in minor amount. Refer to Fig. 9.5 to get acquainted with the bauxite producing areas in India.

India produced 21,824 thousand tones of Bauxite during 2019-20. Odisha with 70.95% contribution was the leading producer of bauxite followed by Gujarat (9.50%), Chhattisgarh (7.18%), Jharkhand (6.50%), Madhya Pradesh (3.14%), and Maharashtra (2.73%).

Utilisation: Bauxite is the ore, which is used in producing aluminium. It is used in the manufacture of electric cables, aluminium powder (used in paints), special alloys and utensils. You may know that aluminium being light and tough is also used in aeroplanes and automobile engines, and building bodies of other vehicles like buses, railway coaches etc. Bauxite is also used in the manufacture of refractories, cement and chemicals.

B. Copper

Distribution: The total reserves of copper ore in India as in 2015 are estimated at 1511.50 million tonnes with about 12.16 million tonnes of copper metal. Of these only 207.77 million tonnes fall under reserves category, while 1303.73 million tonnes are the remaining resources. The major copper producing districts are Singhbhum district in Jharkhand, Balaghat district in Madhya Pradesh and Jhunjhunu and Alwar districts in Rajasthan. However it also occurs at Agnigundala in Guntur District (Andhra Pradesh), Chitradurg and Hasan districts (Karnataka) and South Arcot district (Tamil Nadu) which happens to be the minor producers of the metal. Refer to Fig. 9.5 to get an idea of copper producing areas in India. In the year 2019-20, India produced 3,952 thousand tonnes of copper ore.

Utilisation: Being a good conductor of electricity and being ductile, it is used extensively in electrical industry. You must have noticed that electric wires are made of copper. It is also used in other electrical items like electric motors, transformers and generators. It is also mixed with precious minerals in jewels to provide strength.

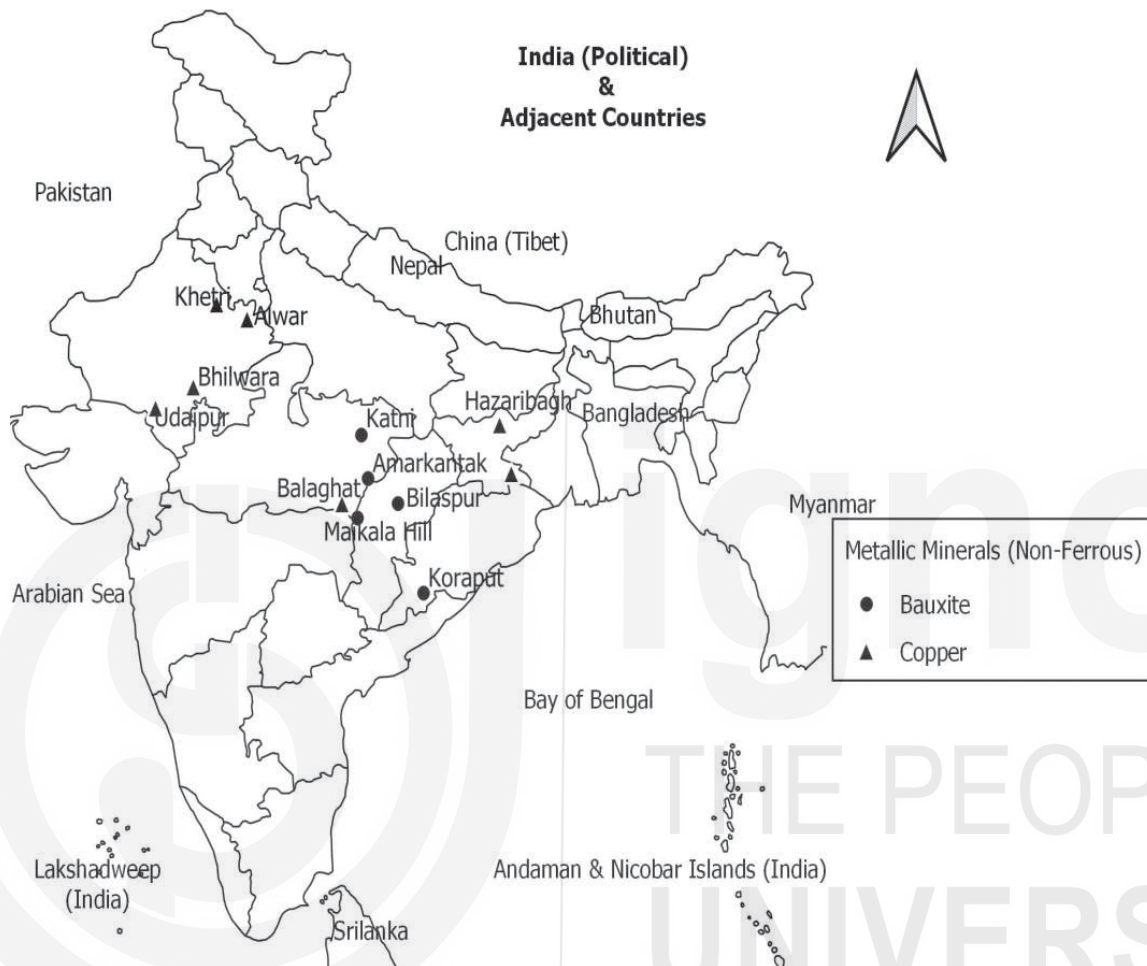


Fig. 9.5: Distribution of Metallic Minerals (Non-Ferrous) in India.

(Source: Figure drawn by Author)

C. Lead-Zinc

Distribution: The total reserves of lead and zinc ores in India as in 2015 as per UNFC system are estimated at 749.46 million tonnes. Of these 106.12 million tonnes (14%) fall under reserves while 643.34 million tonnes (86%) are classified as remaining resources. Lead-Zinc resources are located in Rajasthan, Bihar, Maharashtra, Madhya Pradesh, Andhra Pradesh, Gujarat, Uttarakhand, West Bengal, Odisha, Sikkim, Tamil Nadu, and Meghalaya. Rajasthan is endowed with largest reserves of lead-zinc followed by Andhra Pradesh, Madhya Pradesh, Bihar, and Maharashtra. India produced 14.48 million tonnes of lead & zinc ores in 2019-20. Rajasthan was the sole producing state of lead and zinc ores and its concentrates.

Utilisation: Lead is used in the manufacture of plates of storage batteries, soldering and paints. Zinc resists corrosion and so it is used to galvanise iron sheets. It alloys easily with copper and the results in the formation of brass

which is used in making utensils, watches and automobile parts. Zinc is also used in die-casting, dry cell batteries etc.

D. Gold

Distribution: The total resources of gold ore in India as in 2015 as per UNFC system are estimated at 527.96 million tonnes. Of these 17.23 million tonnes were placed under reserves category while remaining 510.73 million tonnes are classified as remaining resources. The largest reserves of gold ore (primary) are located in Bihar (44%), followed by Rajasthan (25%) and Karnataka (21%), West Bengal and Andhra Pradesh (3%), Telangana and Madhya Pradesh (2%). It is also found in meagre quantity in Chhattisgarh, Jharkhand, Kerala, Maharashtra and Tamil Nadu. India produced 591 thousand tonnes of gold ore in the year 2019-20. Almost entire production of gold ore and bullion was reported from Karnataka.

Utilisation: Since gold is visually pleasing and workable and does not tarnish or corrode, it is one of the first metals to attract human attention and is used in the manufacture of jewellery and ornaments. It has high electrical conductivity (71% that of copper) and inertness due to which it is also used in electric and electronics industry for plating contacts, terminals, printed circuits and semiconductor systems. Thin films of gold that reflect up to 98% of incident infrared radiation have also been employed on satellites to control temperature and on space-suit visors to afford protection.

9.4.4 Distribution and Utilisation of Non-Metallic Minerals

Since we are dealing with organic or fuel minerals in the next unit, let us learn about some inorganic non-metallic minerals under this sub-section.

A. Mica

Distribution: Important mica bearing pegmatite occurs in Andhra Pradesh, Bihar, Jharkhand, Maharashtra, Bihar, and Rajasthan. The total resources of Mica in India as per UNFC system as in 2015 are estimated at 635,302 tonnes. Andhra Pradesh leads with 40% of country's resources followed by Rajasthan accounting for about 28 per cent resources, Odisha (16%), Maharashtra (13%) and Bihar (2%) and Jharkhand and Telangana accounting for less than 1%. Mica mainly occurs in veins of metamorphic rocks particularly mica schists.

Utilisation: Mica is used in the production of mica powder, mica bricks and micanite. Mica powder is used in the manufacture of paint and rubber goods. Since mica is a bad conductor of electricity and can withstand high temperatures, mica bricks are used as insulating material in steel and thermal power plants and petroleum refineries. Micanite is used in the manufacture of electrical appliances and it is made by mica splitting with insulating cements.

B. Gypsum

Distribution: As per UNFC system, the total resources of mineral gypsum in India as in 2015 are estimated at 1,330 million tonnes of which 37 million

tonnes have been placed under 'reserves' and 1,293 million tonnes under remaining resources' category. Rajasthan alone accounts for 81 per cent resources. Here it occurs as lacustrine deposit in dried up salt lakes. The erstwhile state of Jammu & Kashmir has 14% of the resources. The remaining 5% resources are in Tamil Nadu, Gujarat, Himachal Pradesh (Sirmaur), Karnataka, Uttarakhand, Andhra Pradesh and Madhya Pradesh.

Utilisation: Gypsum is mainly utilised in Cement industry and also in the manufacture of plaster of paris.

C. Limestone

Distribution: The total resources of limestone of all categories and grades as per UNFC system as in 2015 are estimated at 203,225 million tonnes. Karnataka is the leading state having 27% of the country's resource, followed by Andhra Pradesh (12%), Rajasthan (12%), Gujarat (10%), Meghalaya (9%), Telangana (8%), Chhattisgarh (5%). India produced 359 million tonnes of limestone during 2019-20.

Utilisation: Limestone is used in building and construction industry where rock is cut into slabs or blocks. Limestone is used as a food additive to provide calcium ions for strong teeth and bones. It is also used as a raw material in chemical industry, in glass and plastic production. It is used in agriculture to neutralise acidic soil. Limestone is a source of lime (calcium oxide), which is used in steel manufacturing, water treatment and purification.

D. Dolomite

Distribution: Total resources of dolomite as per UNFC system as in 2015 are placed at 8415 million tonnes, out of which Reserves are 679 million tones. 88% of the dolomite resources are distributed in the states of Madhya Pradesh, Andhra Pradesh, Chhattisgarh, Odisha, Karnataka, Gujarat, Rajasthan and Maharashtra.

Utilisation: Dolomite is a Calcium magnesium carbonate and a rock forming mineral. It is the primary component of the sedimentary rock known as dolostone and the metamorphic rock known as dolomitic marble. Limestone that contains some dolomite is known as dolomitic limestone. The most common use for dolostone is in the cement and construction industry. Dolomite is used as a source of magnesia (MgO), a feed additive for livestock, a sintering agent and flux in metal processing, and as an ingredient in the production of glass, bricks, and ceramics. Dolomite serves as the host rock for many lead, zinc, and copper deposits. Dolomite also serves as an oil and gas reservoir rock.

E. Diamond

Distribution: As per the UNFC system as in 2015 diamonds are placed at around 31.84 million carats, out of which about 0.96 million carats are under reserve category and remaining 30.87 million carats are under remaining resources category. Diamond deposits occur in three types of geological settings such as kimberlite pipes, conglomerate beds and alluvial gravels. The main diamond bearing areas in India are Panna belt in Madhya Pradesh, Munimadugu-Banganapalle conglomerate in Kurnool district, Wajrakarur

kimberlite pipe in Anantapur district, the gravels of Krishna river basin in Andhra Pradesh and diamondiferous kimberlite in Raipur, Bastar, and Raigarh districts in Chhattisgarh. Reserves have been estimated in Panna belt, Madhya Pradesh; Krishna Gravels in Andhra Pradesh; and in Raipur district, Chhattisgarh.

Utilisation: When we think of diamonds, one thing comes to our mind, that is, jewellery. Diamonds are extensively used in jewellery because of its shiny luster and durability. Apart from this, diamonds are known for their hardness. Due to this, diamond-tipped tools are used for cutting, drilling and polishing. These are even used in highway construction and repair.

Diamond is also used in beauty products as facial for exfoliating skin and reducing wrinkles. Many industries – including automotive, mining, and military – use diamond saws and drills. Diamonds are also used in automobile industry. These days every high-tech car has 1.5 carats of diamonds present in them.

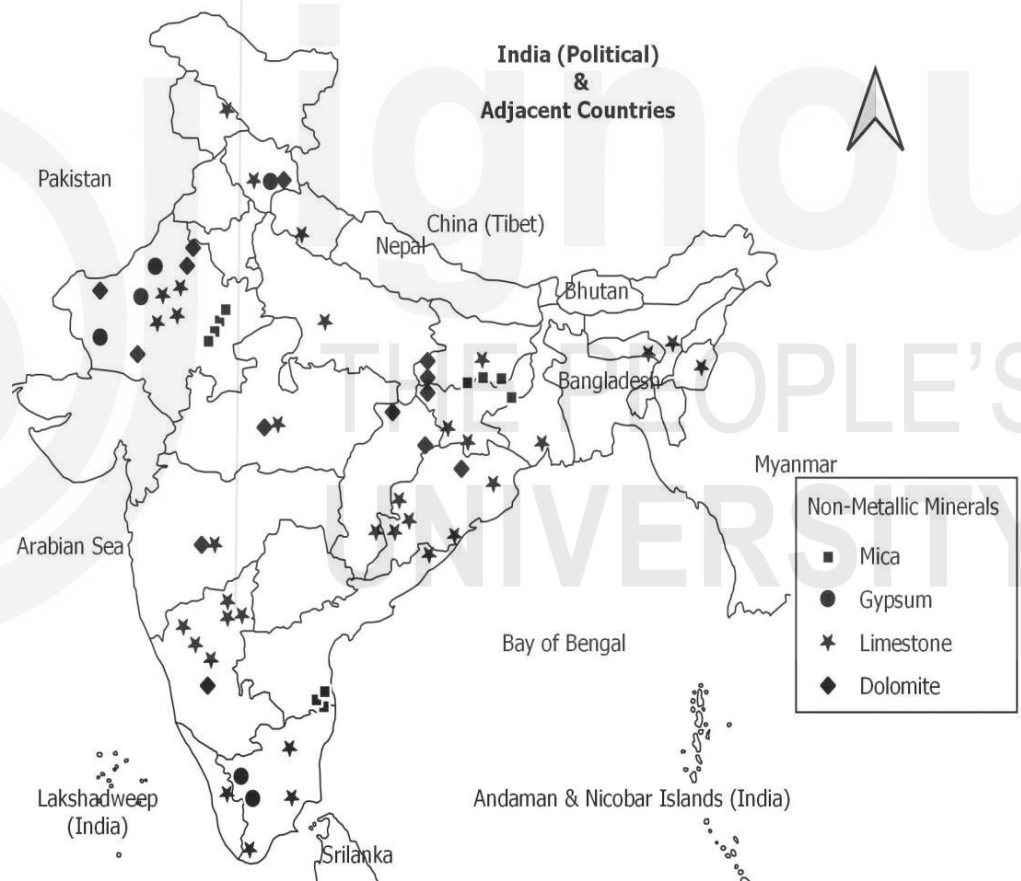


Fig. 9.6: Distribution of Non-Metallic Minerals in India.

(Source: Figure drawn by Author)

9.5 CONSERVATION OF MINERAL RESOURCES

Minerals are the major resource for the core industrial sectors of the economy. There is a huge demand for minerals in view of the rapid urbanisation and the projected growth in the manufacturing sector.

Since mineral resources are finite and non-renewable, so there is an urgent need to conserve mineral resources for future generations. Traditional methods of mining generate a lot of wastes. So National Mineral Policy 2019 aims at promoting zero-waste mining to prevent sub-optimal and unscientific mining. Minerals should be used in a planned and sustainable manner by re-using, recuperating and recycling methods. In case of metallic minerals, use of scrap metals will enable recycling of metals. Use of scrap is especially significant in metals like copper, lead and zinc in which India's reserves are meagre. In many cases, the cost of recuperating and recycling is much higher than fresh extraction and processing of minerals. Use of alternatives and renewable substitutes can help in conservation of minerals and also reduce their consumption and depletion. Export of strategic and scarce minerals must be reduced, so that the existing reserves may be used for a longer period. Substitutes of scarce minerals that are found in plenty can be used instead to conserve the scarce minerals.

Although India is blessed with ample resources of minerals, regional and detailed exploration has to be carried out systematically, scientifically and intensively over the entire geologically conducive mineral bearing area. The new mineral policy of India emphasises on the exploration of minerals in which the country has a poor resource-cum-reserve base despite having the geological potential for large resources.

Extraction of minerals has a negative impact on the environment. So, mining shall be undertaken within the parameters of a comprehensive Sustainable Development Framework keeping in view the needs of development as well as needs of protecting the forests, environment and ecology and to conserve biodiversity of mining areas.

Let us now recapitulate what we have learnt so far in this unit.

9.6 SUMMARY

In this unit, you have studied so far:

- Minerals are naturally occurring substances with a definite chemical composition and recognizable physical properties.
- Minerals are solids at standard temperature and are arranged in a systematic and repeating pattern, that is, they have a definite crystalline structure.
- Minerals are classified as metallic and non-metallic mineral based on the presence and absence of metal content in them respectively.
- Metallic minerals are further classified as ferrous and non-ferrous minerals based on the presence and absence of iron content in them respectively.
- Non-Metallic minerals are further divided into organic based on the presence of organic content or derivation from organic matter and inorganic minerals based on the absence of organic matter in them.

- The United Nations Framework Classification (UNFC) for Fossil Energy and Mineral Reserves and Resources prescribes a standard mineral classification based on three fundamental criteria, that is, economic viability, feasibility assessment and also geological assessment.
- Since minerals are unevenly distributed and non-renewable resources, so it should be conserved for future generations.

9.7 TERMINAL QUESTIONS

1. Explain the basic characteristics of minerals.
2. Illustrate with a suitable figure, the distribution and utilization of iron ore and manganese in India.
3. What are the ways we can conserve our mineral wealth? Explain briefly.

9.8 ANSWERS

Self-Assessment Questions (SAQ)

1. Minerals are naturally occurring, inorganic substances in solid state with a crystalline structure and having a definite chemical composition.

Wood is not a mineral because it is organic.

2. **Metallic Minerals** are those minerals which contain metal e.g. Iron ore, copper, manganese, gold etc. **Non-Metallic minerals** on the other hand are those minerals which do not contain any metal in it, e.g. fossil fuels, mica, limestone etc.

Ferrous minerals are those metallic minerals which have iron content in them e.g. Iron ore, manganese, tungsten, nickel, cobalt, etc, while metallic minerals having no iron content are called **non-ferrous metallic minerals** e.g. gold, silver, copper, lead, bauxite, tin, magnesium etc.

Organic minerals are those non-metallic minerals which contain organic matter. Examples of this type include fossil fuels like coal, petroleum etc. **Inorganic minerals are those non-metallic minerals** that do not contain any organic matter, for example mica, limestone, graphite etc.

3. Chotanagpur-Iron Ore
Neyveli-Lignite Coal
Aravalli-Limestone
Assam-Mineral Oil

Terminal Questions

1. First list all the important characteristics of minerals. Then explain them and draw figures or sketches wherever necessary. Refer to Section 9.2 of this unit.
2. On a rough sketch of India mark the areas where iron ore and manganese are found and describe their distribution. Also explain the importance of iron ore and manganese in terms of their utilization. Refer to Sub-Section 9.4.2.
3. Focus on re-use, recuperation and recycling methods. Also mention promoting zero-waste mining etc. Refer to Section 9.5.

9.9 REFERENCES AND SUGGESTED FURTHER READING

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ENERGY RESOURCES |

Structure

10.1	Introduction		Non-Conventional Sources
	Expected Learning Outcomes	10.5	Conservation of Energy
10.2	Characteristics of Energy		Resources
	Resources	10.6	Summary
10.3	Classification of Energy	10.7	Terminal Questions
	Resources	10.8	Answers
10.4	Distribution and Utilization of	10.9	References and Suggested
	Energy Resources		Further Reading
	Conventional Sources		

10.1 INTRODUCTION

Can you think of a day in your life without electricity or other sources of energy such as fuels for cooking and transport? Energy is required in all facets of human life. We cannot think about the human progress and development in modern times without energy resources. There is a close relationship between energy consumption and economic growth as measured in terms of the growth of Gross Domestic Product (GDP) in any country. It is now argued that the cost and availability of energy are two major factors promoting economic growth of a society or a country as a whole. As the energy intensive industrial economies have expanded, their adverse impact on the environment has started increasing. This aspect has come under closer scrutiny in the past few decades. An understanding of the role of energy in economic and social development will help us to develop models of eco-friendly and sustainable use of energy resources.

Therefore, we begin our discussion of the energy as resource with an understanding of the multi-faceted role of energy in economic and societal development in Section 10.2. We have discussed classification of energy resources in Section 10.3. In Section 10.4, we have described about the distribution and utilization of major renewable and non-renewable energy resources. Finally, we have explained various energy conservation methods in Section 10.5.

Expected Learning Outcomes

After completing the study of this unit, you should be able to:

- describe the characteristics of energy resources;
- classify the energy resources;
- describe the distribution and utilization of energy resources in India; and
- explain various conservation methods of energy resources.

10.2 CHARACTERISTICS OF ENERGY RESOURCES

The demand for energy doubles every 14 years and is taken as one of the indicators of development of a country. India, with 16% of the world's population consumes roughly 3% of the total energy produced in the world, in comparison to USA which has 6.25% of the world's population and utilizes 30% of the energy produced. Despite continuous increase in energy use, per-capita consumption in India is still very low compared with other countries. Even today, a large number of our population continues to depend on fuel wood, dung and agricultural wastes. We know that non-renewable sources of energy such as fossil fuels, coal and petroleum, are not going to last for long. It has become, therefore, necessary to think of alternative, non-conventional sources of energy.

Now let us study the characteristics of the available energy resources.

- (i) **Nature of Availability:** You know that some of the energy resources are finite in nature. What does this mean? This means these are fixed in quantity. If we use it recklessly then days are not far that these resources would be finished. Secondly these resources are not ubiquitous in nature. In other words, these are location specific. You might be thinking that how does this matter? It matters a lot because every resource has a specific location in terms of their origin and other characteristics.
- (ii) **Environmental Impact:** Exploration of these energy resources provides economic benefits and helps in economic development but with lots of detrimental effects. Forests are being depleted at the alarming rate due to indiscriminate felling of trees for various kind of uses.
- (iii) **Renewable sources of energy have lots of potential but have been less explored:** Most of the renewable sources of energy are called as clean and green energy. Do you know what clean energy is? In simpler terms, clean and green energy refers to those energy which is mostly non-polluting and environment friendly. You have already studied in Block 1 that India is a country of diversity. This diversity acts as a boon for the development of renewable energy namely solar, wind and tidal.

10.3 CLASSIFICATION OF ENERGY RESOURCES

Energy resources can be broadly divided on the basis of traditional use and on the basis of availability. On the basis of traditional use energy resources can be grouped as conventional and non-conventional. Similarly on the basis

of utility and availability it can be grouped as renewable and non-renewable energy resources (Fig. 10.1). In this unit, we have used the classification based on traditional use. Non-conventional sources of energy resources include solar, wind, biomass and geothermal to name a few. Conventional sources of energy like petroleum, natural gas, coal, and hydro power energy.

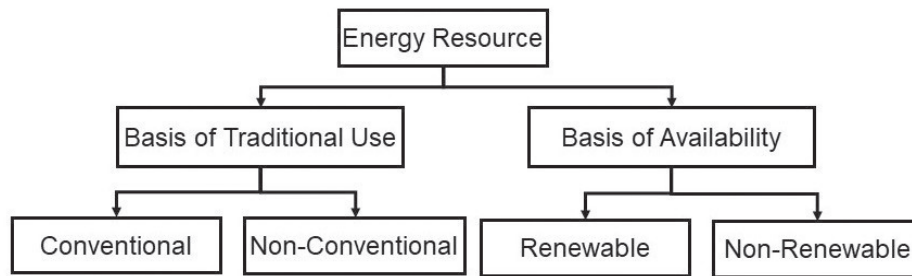


Fig. 10.1: Classification of sources of energy.

Let us discuss the above-mentioned classifications in brief.

A) Classification based on Traditional Use

On this basis, energy resources are divided into two types namely conventional and non-conventional.

- (i) **Conventional sources of energy:** Coal, oil, and natural gas are the examples of the conventional sources of energy. The conventional sources of energy are non renewable by any natural process. These resources are available in a limited quantity. Conventional sources of energy can also be further classified as commercial and non-commercial energy resources.
- (ii) **Non-conventional sources of energy:** Solar, wind, bio-fuel, bio-mass, tidal, and ocean energy are the examples of non-conventional energy resources. They are renewable and eco-friendly in nature. These resources are available in an unlimited quantity and considered as clean fuel.

B) Classification based on Availability

On this basis, energy resources are divided into two types namely renewable and non-renewable.

- (i) **Renewable sources of energy:** Renewable source of energy are those energy resources which can replenish themselves at the rate those resources are used. Examples of renewable resources include wind, solar, tidal, and geo-thermal.
- (ii) **Non-Renewable sources of energy:** Non-renewable resource has a limited supply. These resources are finite in nature. Non-renewable resources include coal, oil, and natural gas.

You should remember that any particular resource can be classified into different categories based on different basis of classification. Let us discuss one example. Coal is classified as conventional source of energy on the basis

of traditional use whereas it is classified as non-renewable source of energy on the basis of availability.

SAQ I

Fill in the blanks with suitable words:

- (i) On the basis of availability, energy resources can be divided into _____ and _____.
 - (ii) Solar energy is a _____ source of energy based on traditional use.
 - (iii) Petroleum is a _____ source of energy based on availability.
 - (iv) Most of the renewable energy sources are _____ and _____.
-

10.4 DISTRIBUTION AND UTILISATION OF ENERGY RESOURCES

In this section, we will discuss the distribution and utilization of some selected conventional and non-conventional sources of energy resources. In conventional sources of energy, we will discuss about coal, petroleum, natural gas and hydro-electricity. Under non-conventional sources we will describe solar, wind, tidal, geothermal, biomass and bio-gas.

10.4.1 Conventional Sources

The conventional sources of energy like coal, oil, natural gas, and hydel lags far behind the current demand of consumption in agriculture, industry, transport and other needs of people. On the other hand, we are not able to generate the huge deficit of our requirements from non-conventional sources. As a result of which we are importing energy resources like petroleum, good quality coal, natural gas etc., from other countries.

(i) Coal

Coal is broadly divided into four types based on their origin, carbon content, and other characteristics. These are peat, lignite, bituminous and anthracite. Let us discuss them in brief.

- (a) Peat:** This is the lowest grade coal as far as carbon content is concerned. It contains up to 30% carbon. This type of coal is rarely found in India.
- (b) Lignite:** This is also known as brown coal. This is regarded as the second stage of coal formation after peat. It contains about 35% carbon and lots of moisture. Therefore, it produces more smoke and less heat. Lignite are generally found in the state of Tamil Nadu, Rajasthan and Gujarat.
- (c) Bituminous:** Its carbon content is higher than the other two types. It varies between 40 to 80 %. Moisture and volatile content varies between 15 to 40 %. Bituminous coal can further be subdivided into two types: sub-bituminous and bituminous.

- (d) **Anthracite:** This is the best quality of coal in which carbon content is highest. This is mostly used by the thermal power plants and industries.

India depends on coal for more than half of its total energy needs. Nearly three quarters of the country's electricity and 63% of commercial energy comes from coal. India has huge coal reserves accounting for 8% of the world's total. It is the third leading coal producer in the world after China and the United States. Most of its coal demand is satisfied through domestic production with the only exception being coking coal that is in short supply. Despite India's wealth in coal reserves, only about 3% of its reserve is coking coal. Hence India's steel industry has been importing coking coal to meet about 25% of its annual needs.

Distribution of Coal in India: If we look at the distribution of coal in India, it is concentrated in some pockets of peninsular and extra-peninsular regions of India. In peninsular region, coal occurs in Damuda series of Gondwana rock system whereas in extra-peninsular region it occurs in the tertiary rocks of the Eocene-Oligocene formations. If we analyse the distribution of Gondwana rocks, it has been observed that it has developed along two sides of a triangular area. Its northern side roughly coincide with Narmada and Sone whereas Narmada valley trending east-west. The southern side of the triangle runs along the Godavari valley with a north-west to south-east trend. The third side of the triangle is formed by the east coast of the peninsula from the Godavari valley to the Rajmahal hills. In the interior of the triangle, is a subsidiary belt along the Mahanadi valley. Let us discuss distribution of Gondwana and Tertiary coal in detail.

Gondwana Coal: The coal fields of Gondwana origins are associated with the river valleys. Some of the major coal bearing river valleys located in different states are as follows:

- (a) Damodar - Jharkhand and West Bengal
- (b) Sone - Bihar, Madhya Pradesh and Uttar Pradesh
- (c) Mahanadi - Chhatisgarh and Odisha
- (d) Godavari-Wardha - Maharashtra, Andhra Pradesh and Telangana
- (e) Pench-Kanha-Tawa-Madhya Pradesh (Fig. 10.2).

Tertiary Coal: As mentioned in the beginning of this section, this type of coal is generally found in the tertiary rocks of the Eocene-Oligocene geological period. This type of coal is generally found in the north-eastern states of Assam, Meghalaya, Nagaland, Arunachal Pradesh, and Jammu and Kashmir.

Lignite: Over 90% of the lignite reserves are found in the state of Tamil Nadu. Within the state of Tamil Nadu, major reserves are located in Neyveli areas of Cuddalore district. Other important mining areas in the state are Jayamkonda-Cholapuram of Trichy district, Manargudi and East of Veeranam. Apart from Tamil Nadu, other important states where lignite is found are Rajasthan, Gujarat, Jammu and Kashmir, and Kerala.

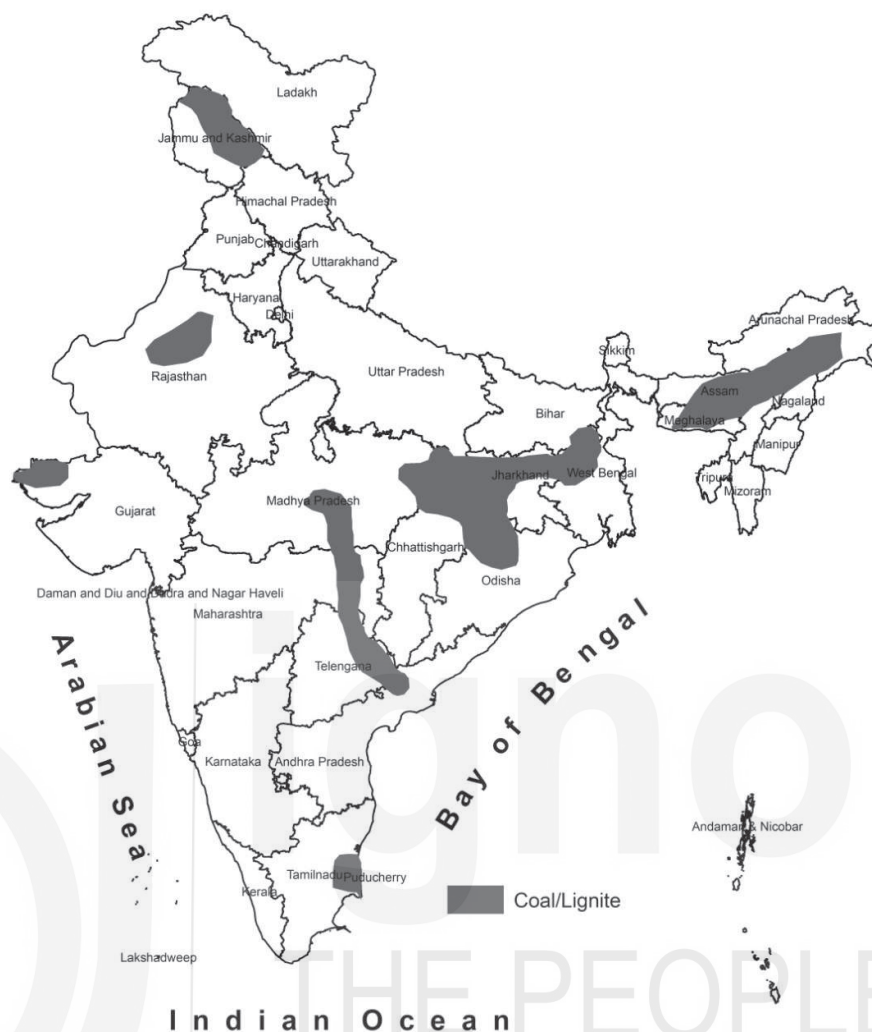


Fig. 10.2: Distribution of Coal in India.

(ii) Petroleum

This is an important source of energy which is much in demand to accelerate the economic development. As you know petroleum provides lubricants and raw materials for a number of chemical industries apart from an important fuel resource. It includes diverse products namely kerosene, diesel, petrol, aviation fuel, synthetic rubber, synthetic-fiber, thermoplastic resins, benzene-methanol, polystyrene, acrylates, detergents, aromatics, gasoline, carbon-blacks, dyes, colours, food colours, pigments, explosives, printing ink, film-photography, greases, cosmetics, paints, lubricant oils, paraffin and wax.

Petroleum is a naturally occurring inflammable fluid. It is a mixture of liquid and gaseous hydrocarbons. It also contains solid bitumens in soluble state and a soluble admixture of organic compounds of oxygen, sulphur and nitrogen. The hydrocarbons found in petroleum are of the methane, naphthalene, and aromatic series. Do you know how petroleum has originated? It is commonly agreed that its origin is linked to shallow water planktons and diatoms and associated rocks are marine sediments namely shales, silts and limestone of the Mesozoic and Tertiary times.

Distribution of Petroleum in India: Petroleum is generally found onshore as well as offshore in India. India's highly prospective basin for petroleum and natural gas are Bombay High, Khambhat, Upper Assam, Krishna-Godavari delta region, Assam-Arakan and Cauvery basins (Fig. 10.3). Do you know why do we get petroleum and natural gas in this region? This is because most of the occurrences are associated with anticlines and fault traps in the rock formations of the lower and middle tertiary period.

Petroleum accounts for about 30% of India's total energy production. Oil consumption in the country was approximately 1.93 million barrels per day (bpd) in 1999 and now it is about 4.7 million bpd in 2017. In 2017, India imported about 198 million tonnes of crude oil and its products. Oil reserves are estimated at 4.7 billion barrels. The Bombay High oil Field is India's largest producing oilfield. It generated 250,000 barrel per day in 1998 and 210,000 barrel per day in 1999. However, if we compare production with consumption, it has been observed that there has been a huge gap between production and consumption. Consumption of petroleum products rose from 57 million tons in 1991-1992 to 196 million tons in 2016. The India Hydrocarbon Vision 2025 report estimates future refinery demand at 368 million tons by 2025. Thus, India is becoming a major global market for petroleum products.

(iii) Natural Gas

Natural gas is generally found along with petroleum. Whenever a well is drilled for the extraction of petroleum, natural gas is available before petroleum. We have already discussed about the distribution of petroleum in India in the previous section. Therefore you can guess the distribution of natural gas in India. India has made a rapid stride after 1985 in terms of new discovery of gas fields. As a result of which gas is making a significant contribution towards meeting the energy requirements of the country. About 7% of India's energy needs are met by natural gas.

Distribution of Natural Gas in India: About three-fourths of the total gas in India comes from Bombay High. Over 11 percent of the total gas comes from Ankleswar and Gulf of Khambhat in the state of Gujarat. The rest is obtained from Godavari and Krishna basin in Andhra Pradesh, Barmer district of Rajasthan, Thanjavur and Shingleput of Tamil Nadu and from the gas fields of Assam and Tripura. Natural Gas is generally used in power generation, fertilizers, and petrochemical productions. Natural gas can serve to reduce dependence on foreign oil. Absence of sulphur dioxide and reduced levels of carbon dioxide and nitrogen oxide are major environmental benefits of using natural gas. Currently, India's natural gas consumption is 50 billion cubic metres (bcm) and is mostly met by domestic production. In 2017, India imported 27,570 million cubic metres of natural gas.

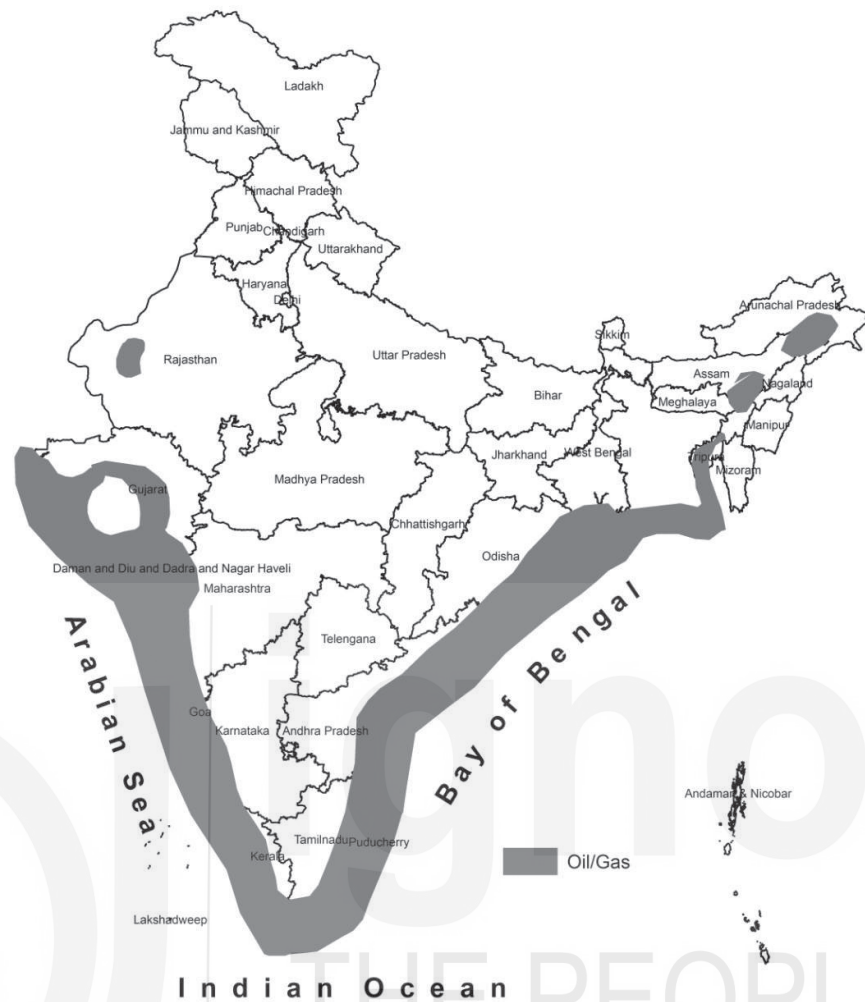


Fig. 10.3: Distribution of Oil and Natural Gas in India.

(iv) Hydro-Electric Power

Hydro-electric power is the cheapest and cleanest and, hence, regarded as the best source of energy (Fig. 10.4). Before independence there were very few hydro-electricity projects in India. The growth and development of hydro-electricity project picked up a momentum after independence.



Fig. 10.4: A Hydro Power Project with Water Discharging Sluice Gates.

(Source: <http://www2.emersonprocess.com/SiteCollectionImages/News%20Images/Agua%20Verm080.jpg>)

Factors responsible for the location of the hydro-electricity power

project: Can you name the factors responsible for the development of the hydro-electricity power project. Major factors responsible for this are perennial and seasonal characteristics of rivers and their monthly regime, undulating topography, suitable rock formations for the construction of dam and demand for energy. Let us explain these factors in details:

- (i) **Perennial and seasonal characteristics of rivers and their monthly regime:** There should be perennial flow of large volume of water which depends upon the amount of rainfall (in rain fed areas) or melting of snow from the snow fields to feed the rivers.
- (ii) **Sufficient height for Natural Waterfall:** The water should fall from a sufficient height. This height may be in the form of a natural waterfall or a fall obtained by constructing a dam across the river. It may also be obtained by diverting the water from one river basin to another.
- (iii) **Availability of market:** A readily available market is an essential requirement for generating HEP as electricity cannot be stored.
- (iv) **Huge Capital Investment:** The generation of HEP requires huge capital investment as it is capital intensive activity.
- (v) **Technological Advancement:** It also requires technological advancement because production, distribution and utilization are closely related to the technological level of the concerned area.

Regional Pattern: Due to variations in these abovementioned factors, hydro-electric power projects are unevenly distributed in the country. If we critically analyse the location of hydro-power project, it has been observed that majority of the power project are located in Andhra Pradesh, Karnataka, Tamil Nadu, Kerala, Maharashtra, Odisha, Punjab, Madhya Pradesh and Uttar Pradesh. However, hydro-electric power projects are scattered all over the country. Some of the major hydro-electric power projects located in different states of India is listed in Table 10.1. However, obtaining electricity from mega dams has given rise to many controversies in recent times and small hydro power plants are emerging as viable alternatives. These plants serve the energy needs of remote and rural areas where the grid supply is not available.

Table 10.1: Important Hydro-Electric Plants in Different States of India.

States	Name of the Hydroelectric Plants
Andhra Pradesh	Lower Sileru, Upper Sileru, Srisailem (Krishna)
Bihar	Kosi
Gujarat	Ukai (Tapi), Kadana (Mahi), Sardar Sarovar
Jammu and Kashmir	Lower Jhelum, Salal on Chenab, Dool Hasti, Karrah and Banihar
Jharkhand	Subarnarekha, Maithon, Panchet, Tilaiya
Karnataka	Tungabhadra, Saravati, Kalindi, Mahatma Gandhi (Jog fall), Bhadra, Sivasamudram (Kaveri), Shimasapura, Munirabad, Lungnamakki
Kerala	Iddikki (Periyar), Sabarigiri, Kuttiaddy, Sholayar, Sengulum, Pallivasal, Kallda, Neriamaangalam, Parambikulam Aliyar, Poringal, Ponniar

Madhya Pradesh	Gandhi Sagar on Chambal, Pench, Bargi on Narmada, Bansagar-Tons
Maharashtra	Koyana, Bhivpuri, Khopoli, Bhola, Bhira, Purna, Vaiterna, Paithon, Bhatnagar Beed
North-eastern state	Dikhu, Doyang in Nagaland, Gomuti in Tripura, Loktak in Manipur, Kopili in Assam, Khondong and Kyrdemkulai in Meghalaya, Serlui and Barabi in Mizoram, Ranganadi in Arunachal Pradesh
Odisha	Hirakund (Mahanadi), Balimela, Machkund, Rengali (Brahmani), Indravati
Punjab and Himachal Pradesh	Bhakra-Nangal on Satluj, Dehar on Beas, Giri Bata, Andhra, Binwa, Rukti, Rongtong, Bhabanagar, Bassi, Baira Siul, Chamera, Nathpa-Jhakri on Satluj
Rajasthan	Ranapratap Sagar and Jawahar Sagar on Chambal.
Tamil Nadu	Pykara, Mettur, Kodayar, Sholayar, Aliayar, Sakarpathi, Moyar, Suruliyar, Papanasam
Telangana	Nizam Sagar and Nagarjun Sagar on Krishna
Uttarakhand	Tehri dam on Bhagirathi
Uttar Pradesh	Rihand, Khodri, Chibro on Tons
West Bengal	Panchet

(v) Atomic Energy

As the name suggests, energy derived from the atomic minerals are known as atomic energy. Do you know about the atomic minerals from which we derive atomic energy? Some of the important atomic minerals are uranium and thorium. Other atomic minerals are beryllium, lithium and zirconium. Despite of so many atomic minerals, uranium is widely used for producing atomic energy. This is because uranium atoms split apart relatively easily.

The energy released by splitting of atom in a controlled manner can be utilized for generation of electricity. The device used for this purpose is called an atomic reactor (Fig. 10.5). Nuclear reactors produce heat, which is used to generate steam, for rotating turbines for generating electricity. It is estimated that 1 kg of natural uranium, written as U^{235} , generates energy equal to that produced by 35,000 kg of coal.

Energy production from nuclear fuels like uranium is relatively clean, efficient, and can serve as a substitute for coal and petroleum. However, nuclear reactors need to be situated at places far away from human habitation. They have to be operated under strict safety control, to prevent any accidental leakages of radioactive material. The radioactive wastes have to be carefully disposed off. Currently, Nuclear Power Corporation of India Limited (NPCIL) is opening 21 nuclear power reactors with an installed capacity of 5780 MW at seven different sites. These plants are located at Tarapur in Maharashtra, Kalpakam and Kudankulam in Tamilnadu, Rawatbhatta in Rajasthan, Narora in Uttar Pradesh, Kaiga in Karnataka, and Kakrapar in Gujarat.



Fig. 10.5: Outside view of an Atomic Power Plant.

(Source: <http://www.power-eng.com/content/dam/Pennenergy/online-articles/2013/February/Sequoyah-Nuclear-Plant.jpg> & <http://seco.cpa.state.tx.us/images/manure-biogas.gif>)

SAQ 2

a) Fill in the blanks with suitable words.

- (i) Over 90% of the lignite reserves are found in the state of _____.
- (ii) About three-fourths of the total gas in India comes from _____.
- (iii) In Southern India, highly prospective basin for petroleum and natural gas are _____ and _____.

b) Match the following:

Hydro-electricity Power Project	River
(a) Hirakund	(i) Krishna
(b) Bhakra-Nangal	(ii) Mahanadi
(c) Nagarjun Sagar	(iii) Chambal
(d) Gandhi Sagar	(iv) Satluj

10.4.2 Non-Conventional Sources

There are various non-conventional sources of energy in India which we will discuss in this section. As mentioned in the Section 10.3, we have briefly discussed the sources which have high potential for generation of renewable energy in India for solar, wind, small-hydro power, biomass, bagasse-based cogeneration in sugar and waste to energy. According to statistics given in "Energy Statistics 2020" by National Statistical Office, Ministry of Statistics and Programme Implementation, Government of India that the total potential for renewable power generation in the country as on 31.03.2019 is estimated at 1097465 MW. This includes solar power potential of 7,48,990 MW (68.25%), wind power potential of 302251 MW (27.54%), small-hydro power (SHP) potential of 21134 MW (1.93%), Biomass power of 17,536 MW (1.60%), 5000 MW (0.46%) from bagasse-based cogeneration in sugar mills and 2554 MW (0.23%) from waste to energy.

The geographic distribution of the estimated potential of renewable power as on 31st March 2019 reveals that Rajasthan has the highest share of about 15% (162223 MW), followed by Gujarat with 11% share (122086 MW) and Maharashtra and Jammu and Kashmir with 10% share (113925 MW and

112800 MW respectively). This was mainly on account of solar power potential except Gujarat where the share of Wind Power is the highest. Let us now discuss some of the important non-conventional energy resources having future prospects in India. These resources are solar and wind.

(i) Solar Energy

Solar energy is the most readily and freely available abundant source of energy. You might know that it is also non-polluting. Now a days, we have technical knowledge to harness solar energy for various purposes. Can you name some of the areas in which we are using solar energy? Solar energy has been used directly to give us hot water during winter and for room heating in colder regions (Fig. 10.6).

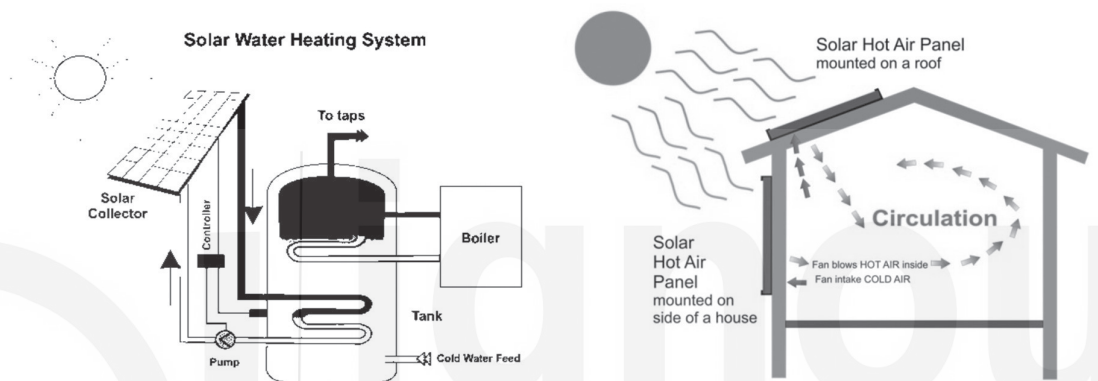


Fig. 10.6: Solar Energy Used for Heating Water and Room.

We have solar cookers that are being used in many homes to cook food. It has also been used to run a refrigerator (Fig.10.7). With the help of "photo voltaic cells" electricity is being produced for driving vehicles, for illumination and above mentioned purposes as discussed in the previous paragraphs. Since this is an unfailing source of energy, it would be a great advantage to develop cheap and efficient photocells or photovoltaic devices to harness solar energy.

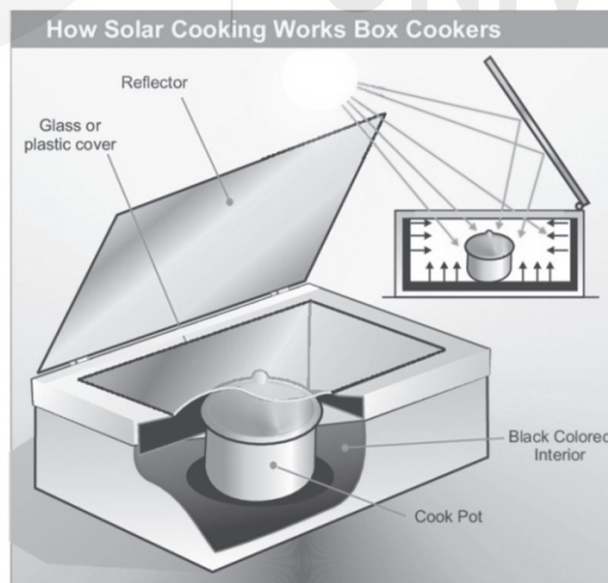


Fig. 10.7: Solar Refrigerator and Cooker.

On an average, the 60 million sq. km. of tropical seas absorb solar radiation equivalent to the heat content of 245 billion barrels of oil. Solar radiation gets converted into electricity directly in Solar Photovoltaic (SPV) panels installed on buildings or in open spaces. This electricity can either be used as it is or can be stored in the battery to be used for domestic lighting, street lighting, village electrification, water pumping, desalination of salty water, powering of remote telecommunication repeater stations and railway signals. Solar passive buildings use solar energy in building designs and cut down on energy consumption for heating and cooling. This technology is fast gaining acceptance in urban architecture.

As far as India is concerned, solar power, one of the potential energy sources, is a fast developing industry in India. The country's solar installed capacity has reached 28.18 GW as on 31.03.2019 as compared to 21.65 GW on 31.03.2018. Major states that have potential capacity to generate solar energy are Rajasthan, Jammu and Kashmir, Madhya Pradesh, and Maharashtra.

(ii) Wind Energy

Wind Energy has been used for hundreds of years for sailing, grinding grain, and for irrigation. Wind energy systems convert the kinetic energy associated with the movement of air to more useful forms of power. Wind turbines transform the energy in the wind into mechanical power, which can then be used directly for grinding, lifting water or to generate electricity. Wind turbines can be used singly or in clusters called 'wind farms'. Windmills have been used since long in many countries, but in India they have only been recently introduced (Fig. 10.8).



Fig. 10.8: The picturesque view of wind mills.

(Source: <https://en.wikipedia.org/wiki/File:Turbines-thar-india.jpg>)

(iii) Tidal Energy

Energy can also be obtained from waves and tides. These waves and tides are another source of energy which is perpetual and can be harnessed for generating electricity (Fig. 10.9), particularly where sea water can move into a narrow cut, such as is provided naturally where rivers flow into the sea. Both incoming and outgoing tides are held back by a dam. The difference in water levels generates electricity in both directions as water runs through reversible turbo generators. Energy carried by water has also been widely used in India's hilly regions, since a wheel with pedals can be made to turn when it is put in a fast flowing stream. Flour mills of small size built on this principle

were used in Kashmir for a long time. In fact, large “hydroelectric” power stations work on the same principle. A natural or artificial water fall is made to turn a modern kind of pedal wheel, called a turbine, which upon rotation generates electricity. In India, the first wave energy project with a capacity of 150 MW, has been set up at Vizhinjam near Thiruvananthapuram. A major tidal wave power project costing Rs. 5000 crores, is proposed to be set up in the Hanthali Creek in the Gulf of Kachchh in Gujarat.

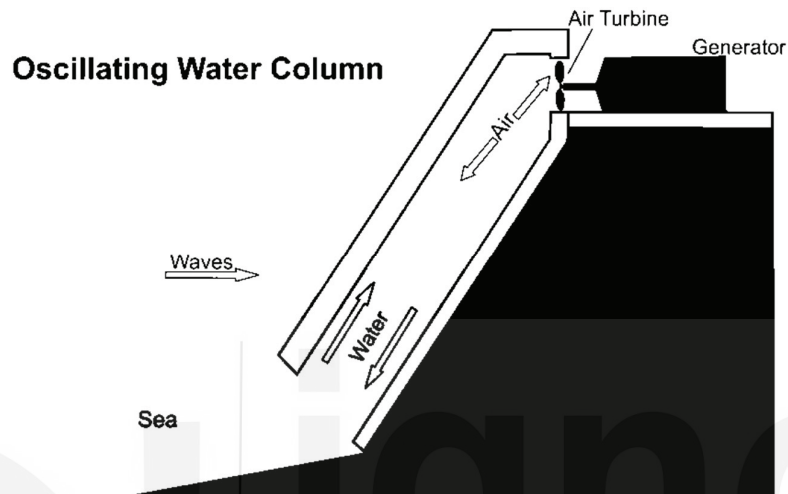


Fig. 10.9: Tidal Power Station.

(iv) Geothermal Energy

Volcanoes, hot springs, and geysers, and methane under the water in the oceans and seas are sources of geothermal energy. Geothermal means heat from the Earth. In some countries, such as in the USA, water is pumped from underground hot water deposits and used to heat people's houses. Hot water and superheated steam of hot springs can be used to generate electricity (Fig. 10.10). In our country there are about 46 hydrothermal areas where the temperature of the spring water exceeds 150°C. The thermal energy of hot springs can be used for generating electricity, heating buildings and homes of glass-houses in colder areas for growing vegetables.

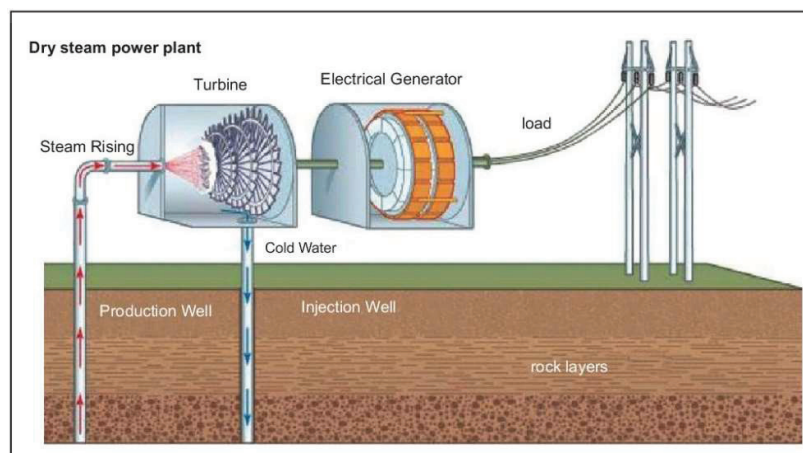


Fig. 10.10: The geyser is the geothermal power operation which produces the energy directly from steam.

In India, the North-western Himalayas and the western coast are considered suitable for harnessing geothermal energy. Remote sensing satellites have played an important role in locating geothermal areas by using infrared images of the ground. The Geological Survey of India has already identified more than 350 hot spring sites, which can be explored as areas to tap geothermal energy. An experimental 1 KW generation project in the Puga valley in the Ladakh region is being used for poultry farming, mushroom cultivation, and pashmina-wool processing.

(v) Biomass Energy

This is a renewable energy source derived from plant resources, animal waste and the waste of various human activities. It is also derived from the by-products of the timber industry, agricultural crops, raw materials of the forest, major parts of household wastes and wood. Biomass is an important source of energy and the most important fuel worldwide after coal, oil and natural gas. Biomass does not add net carbon dioxide to the atmosphere as it absorbs the same amount of carbon in growing as it releases when consumed as fuel. Its advantage is that it can be used to generate electricity with the same equipment or power plants that are now burning fossil fuels. Biomass fuels used in India accounts for about one third of the total fuel used in the country. Over 90% of the rural households and about 15% of the urban households use biomass fuels such as wood, cow dung cakes, crop residues and sawdust. The inefficient burning of such fuels in traditional chulhas is causing a serious problem of indoor air pollution and consequent health hazards. Moreover, the unsustainable level of consumption of fuel wood leads to deforestation and desertification, which degrades the environment. Thus proper management of biomass as a resource is very essential.

In this context, technological solutions, institutional arrangements, financial support and training schemes for ensuring adequate and affordable clean energy systems and services using biomass assume great significance. An initiative in this direction has come from the Ministry of Non-conventional Energy Sources (MNES). It has been promoting indigenously developed technologies for efficient utilization of biomass fuels with a focus on extraction of more energy, reduction of household consumption of firewood, generation of employment and improvement in the living standards of rural population.

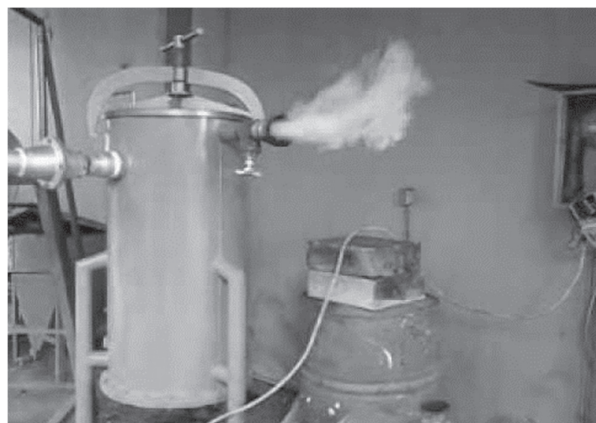


Fig. 10.11: Biomass Gasifier.

(Source: https://i.ytimg.com/vi/837XxbF4_ss/hqdefault.jpg)

(vi) Biogas

You may have heard of the use of cattle dung for production of biogas which is a source of energy used for cooking (Fig. 10.12). Through a simple process cattle dung is used to produce a gas that contains 55-70% inflammable methane gas, and is clear and efficient fuel for use in rural areas. Water weeds like water hyacinth, water lettuce, salvinia, hydrilla, duck weeds and algae are found to be useful supplement to cattle dung. Biogas can also be used to raise steam, which in turn may be used for running engines or machines in factories or for running turbines to generate electricity. It has been found that large biogas plants can supply the needs of a number of families or even small villages. The residual dung or the digested slurry left after generating, biogas can be used as manure for agricultural purposes. This is an economical way of obtaining energy from organic wastes. In China and India, great efforts are being made to install tens of thousands of biogas plants in rural areas.

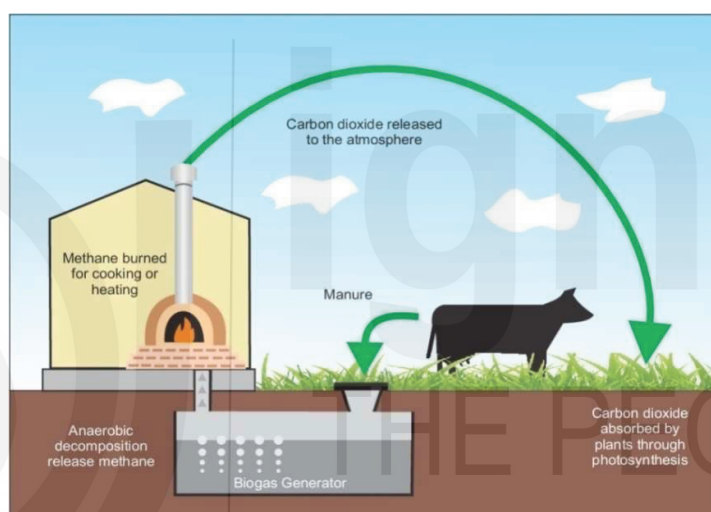


Fig. 10.12: Biogas Plant.

India has tremendous potential in non-conventional sources of energy. Our diverse geographical settings help in promotion of non-conventional energy sources of energy namely solar, wind and tidal. Looking at the future potential in generating solar energy, the International Solar Alliance was established in the year 2015. Major initiatives were taken by India for the establishment of this alliance. This would help us in developing clean and green energy that would address the problems emerging due to the use of conventional sources of energy like coal, petroleum and radio-active minerals. Therefore we can say that these above mentioned non-conventional sources are the energy of the future. But, today our major energy sources are coal, fossil fuel, natural gas, hydro-power and atomic energy. These sources of energy are known as conventional sources of energy.

SAQ 3

Tick mark the correct options.

- i) Biomass energy is not derived from
 - a) Plants resources b) Animal wastes c) Agricultural crops d) Wind
- ii) Which of the following is not the source of geothermal energy?

a) Volcanoes b) Carbon Dioxide c) Methane d) Geysers

iii) Reactor generates

a) Biogas b) Geothermal energy c) Atomic energy d) Wind Energy

10.5 CONSERVATION OF ENERGY RESOURCES

Till now you must have realized that energy conservation is the need of the hour. This situation has been arising due to over-exploitation of non-renewable sources of energy resources by humans. Excessive utilization of coal and oil for generation of electricity leads to the multiple problems namely acid rain, and rising carbon dioxide level leading to atmospheric pollution and global warming. Major dams have also made substantial contributions to economic development in terms of providing electricity in developing countries like India. However, reservoirs inundate forests, farmland and wildlife habitats and uproot entire communities of indigenous people. The answer to the country's energy needs can only lie in adopting non-conventional sources of energy. A beginning is being made by Government of India to give the same type of resources and support to developing alternative sources of energy as have so far been extended to the development of conventional energy sources.

Below given are some of the measures implemented for the conservation of energy resources. Let us discuss them in brief.

(i) Improving Efficiency of Energy Resources: Looking at the finite nature of various energy resources namely coal, petroleum, natural gas, atomic minerals etc. it is very much essential to increase efficiency of these resources so that we can get more benefit out of a fixed amount. How can we do it? This is possible by following certain technological upgradation. Some of the measures in this direction are given below.

- Using LED lights instead of incandescent lights. This is because LED lights save about 25% of energy as compared to incandescent lights which save only 10%.
- Using CNG enabled vehicles to avoid causing air pollution.
- Replacing conventional coal plants with supercritical ones as the latter are 45% more efficient than their counterparts.

(ii) Prevention of Wastage: This is an utmost need of the hour. India is one of the few countries where we lose a substantial amount of electricity during transmission. Similarly, we are not using energy resources judiciously. Therefore there is a need for awareness and practice it in our use. Some of the suggestive measures are as follows:

- Switching off electricity and appliances when not in use.
- Substituting old sockets with new ones.
- Using smart grid technologies.

- Prefer commuting through public transports and opt for carpooling to reduce air pollution.

(iii) **Optimum Utilization of Energy Resources:** This is another effective measure for energy conservation. Some of the important measures under this category are:

- Appropriate infrastructures of industrial, office, or private buildings.
- The right selection of building materials.
- Green buildings optimization for renovating residential areas and environmental surroundings.
- Reduction in energy and water usage via green building initiative.

(iv) **Use of Clean Technologies:** Energy conservation can be achieved through the following technological advancements namely cogeneration, off-grid renewable power and Perform, Achieve and Trade (PAT). Let us discuss this technological advancement in brief:

- Cogeneration refers to the industrial process of utilizing the processed steam out of the electricity generation plants. This steam can be reused for heating purposes.
- Off-grid renewable power refers to the use of wind, biomass, and hydel energies for conservation.
- Perform, Achieve, and Trade (PAT) refers to financial service that allows industries to trade energy saving certificates and increase their cost-effectiveness.

(v) **Use of Renewable Sources of Energy:** To conserve energy, it is best to use energy resources that can be iteratively reused and replenished. According to energy statistics provided by Government of India (Refer Energy Statistics 2020, Ministry of Statistics and Programme Implementation). India plans to set up 175 GW of renewable energies in the country which includes 100 GW of solar power plants, 60 GW of wind power plants, 10 GW for biomass efficient energies and 5 GW for small hydropower plants.

Try the following SAQ to see what you have understood of the various non-conventional sources of energy. Compare your answers with those given 'at the end of this unit.

SAQ 4

State whether the following statements are true or false.

- Replacing conventional coal plants with supercritical ones as the latter are 45% more efficient than their basic counterparts.
 - Perform, Achieve, and Trade (PAT) is not one of the strategies for the use of clean technologies.
 - Substituting old sockets with new ones and using smart grid technologies are the strategies for optimum utilization of energy resources.
-

10.6 SUMMARY

In this unit, you have studied so far:

- Today's modern industrial societies are characterized by the intensive use of energy. You cannot think of life without electricity or other source of energy. The amount of energy consumed per person each year is a useful measure of standard of living. India consumes roughly 3% of world's total energy.
- Energy resources can be broadly divided on the basis of traditional use and on the basis of availability. On the basis of traditional use energy resources can be grouped as conventional and non-conventional whereas on the basis of availability it can be grouped as renewable and non-renewable energy resources.
- In this unit we have used the classification based on traditional use. Mainly there are two sources of energy viz. i) Non-conventional sources such as biomass, solar, geothermal, and wind energy, ii) Conventional sources of energy like petroleum, natural gas, coal and hydro power energy.
- Renewable energy sources are virtually inexhaustible. They are generated with minimal pollution. Renewable energy sources have no fuel costs and are freely available. Switching to clean, renewable energy will bring us cleaner air and water while improving human health and increasing energy security.
- Conservation of energy sources is urgently required as its excessive consumption is not only costly but also leads to multiple problems. Some of the conservation measures are improving efficiency of energy resources, wastage prevention, optimum utilization of energy resources, use of clean technologies and use of renewable sources of energy.

10.7 TERMINAL QUESTIONS

1. Differentiate between conventional and non-conventional sources of energy with suitable examples?
2. Describe briefly the nature of energy resources.
3. Explain in detail distribution, production and utilization of coal in India,
4. Describe distribution and utilization of solar and wind energy in India.
5. Explain in detail various energy conservation measures implemented in India.

10.8 ANSWERS

Self-Assessment Questions (SAQ)

1. (i) Renewable, non-renewable; (ii) non-conventional; (iii) non-renewable; (iv) clean, green
2. a) (i) Tamil Nadu (ii) Mumbai High; (iii) Krishna-Godavari and Cauvery

- b) a - (ii); b - (iv); c - (i); d - (iii)
3. i - (d); (ii) - b; (iii) - c
4. (i) True; (ii) False; (iii) True

Terminal Questions

1. The conventional sources of energy such as coal, petroleum are non-renewable; they make use of old technologies for energy generation and cause environmental damage. Non-conventional sources of energy such as solar energy, energy from biomass, are based on renewable resources; they make use of comparatively recent technologies and cause minimum damage to the environment.
2. Nature of energy resources should highlight nature of availability, environmental impact and renewable sources of energy have lots of potential but have been less explored. Refer to section 10.2
3. Refer to Sub-Section 10.4.1 (i).
4. Refer to Sub-Section 10.4.2 (i) and (ii).
5. Improving efficiency of energy resources, prevention of Wastage, optimum utilization of energy resources, use of clean technologies and use of renewable sources of energy are the major energy conservation measures adopted in India. Refer to Section 10.5.

10.9 REFERENCES AND SUGGESTED FURTHER READING

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GLOSSARY

Afforestation	: It refers to the planting of trees in a clear piece of land which remained devoid of tree cover in the past due to geographical, climatic, edaphic, and other reasons. Its aim is to rejuvenate and transform the derelict and degraded agricultural and other lands into forests to augment the green cover for maintaining the healthy ecological balance.
Area under Non-Agricultural Use	: Land occupied by buildings, roads and railways or water bodies, e.g. rivers and canals and other lands are used other than agriculture.
Barren Land	: It is also known as unculturable Land which cannot be brought under cultivation. For example, mountains, deserts, etc.
CGWB	: Central Ground Water Board is a government organization which provides the scientific inputs for management, exploration, monitoring, assessment, augmentation, and regulation of groundwater resources in India. http://cgwb.gov.in/
Conservation	: It states that the bounties or precious gifts of natural environment like water, soil, minerals, forests and wildlife should be used in a judicious manner. This may help us to preserve and manage such precious resources which are very essential for the survival of both flora and fauna along with human beings on this solely inhabitable planet Earth.
Conventional Sources of Energy	: These are non-renewable by any natural process. Examples are coal, oil, and natural gas. These resources are available in a limited quantity.
Culturable Waste Land	: This includes lands available for cultivation, whether not taken up for cultivation or taken up for cultivation once but not cultivated during the current year and the last five years or more in succession for one reason or other. For example fallow or covered with shrubs and jungles.
Current Fallow	: It represents cropped areas that are kept fallow during the current year.
Damodar Valley Corporation (DVC)	: It is the first multipurpose river valley project in India, started in 1948 by the Indian Government along with the erstwhile Bihar and West Bengal states. Under which a total of 07 major dams on the rivers Damodar, Barakar, Konar, and Bokaro; and one barrage at the downstream end of the Konar River were suggested for construction for different purposes.
Deforestation	: It refers to cutting down and indiscriminate felling of trees for various purposes. It may include clearing of forest land for agriculture, urbanization, industrialization, transport and communication lines, dams and bridges etc.

Fallow Land	: The land was taken up for cultivation but is temporarily out of cultivation for a period of not less than one year and not more than five years.
Ferrous Minerals	: These minerals which have iron content in them.
Forest Land	: These are designated legally as forests or administered as forests, whether state owned or private, and whether wooded or maintained as potential forest land.
Forest Resources	: It refers to the array of services including timber, wood, fuel wood, etc., which it provides to the human societies in general and also helps to regulate the climate of any geographical region on the Earth.
FSI	: Forest Survey of India which deals with all the aspects related to forest resources, policies and guidelines, forest cover mapping and control etc. It is located at Dehradun in Uttarakhand state of India.
Green Energy	: It is also called clean energy. It refers to those energy which is mostly non-polluting and environment friendly.
Groundwater	: The surface water that seeps into the ground at certain depths is known as groundwater.
Gullies	: These are also called badlands or ravine lands. Gullies are formed by running water cuts as massive channels.
Hard Rock Formations	: These are consolidated formations which holds water, not at very deep levels.
Inorganic Minerals	: These are non-metallic minerals that do not contain any organic matter.
Land Cover	: It explains that the surface cover on the ground, for example, vegetation, buildings, etc.
Land Degradation	: It explains the deterioration in the quality and productivity of land.
Land Man Ratio	: It refers to the population density of any particular region.
Land Resource	: It includes the physical, biotic, environmental, infrastructural and socio-economic components of a natural land unit, including surface and near-surface freshwater resources.
Land Use	: It refers to the economic and cultural activities are carried out on a piece of land for human use.
Land Use Capability	: It is also called as land capability. It refers to the capacity of land to support a specific land use without incurring damage.
Metallic Minerals	: These are minerals which contain metal.
Mineral	: A naturally occurring substance with a definite chemical composition and recognisable physical properties.
Multipurpose River Valley	: A project which provides several benefits in irrigation, electricity generation, navigation, fishing, tourism, and the

Project	supply of water for water deficit regions are named as multipurpose project.
Net Area Sown	: It represents the total area sown with crops and orchards.
Non- Metallic Minerals	: These are minerals which do not contain any metal in it.
Non-Conventional Sources of Energy	: These are renewable and eco-friendly in nature. These resources are available in an unlimited quantity and considered as clean fuel. For example solar, wind, bio-fuel, bio-mass, tidal, ocean energy.
Non-Ferrous Metallic Minerals	: These are metallic minerals having no iron content.
Non-Perennial or Ephemeral Waterbody	: The water is available for only part of the year in a waterbody.
Non-Renewable Sources of Energy	: Non-renewable resource has a limited supply. These resources are finite in nature. Examples are coal, oil and natural gas.
Operational Holdings	: These are categorized as marginal land holdings (< 1 hectare), small (between 1 and 2 hectares, semi-medium (2-4 ha), medium (4-10 ha), and (v) large holdings (10 hectares or more).
Organic Minerals	: These are non-metallic minerals which contain organic matter.
Perennial Waterbody	: The water is available throughout the year in a waterbody.
Permanent Pastures	: All grazing lands such as permanent pastures, meadows, village common grazing lands, etc.
Renewable Source of Energy	: These energy resources can replenish themselves at the rate those resources are used. Examples are include wind, solar, tidal and geo-thermal.
River Basin	: It is the area of land over which all the surface water flows by a river and all of its tributaries. In India, twenty important river basins/group of river basins are recognized.
Salinization	: It refers to all types of soil degradation caused by a rise in salt levels in the soils.
Soft Rock Formations	: These are also porous rock formations. These include unconsolidated formations and semi-consolidated formations.
Surface Water	: It refers to the water bodies covering on the surface of the Earth, for example, rivers, streams, lakes, seas and oceans.
Unconsolidated Formations	: The sediments comprising newer alluvium, older alluvium and coastal alluvium are categorized under unconsolidated formations. These are composed of clays, sand, gravel and boulders, ferruginous nodules, kankar, etc.

UNESCO

: Full form is United Nations Educational, Scientific and Cultural Organization was formed on 16 November 1945. Its headquarters located at Paris, France.

UNFC

: It abbreviates United Nations Framework Classification.



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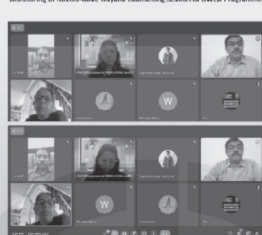
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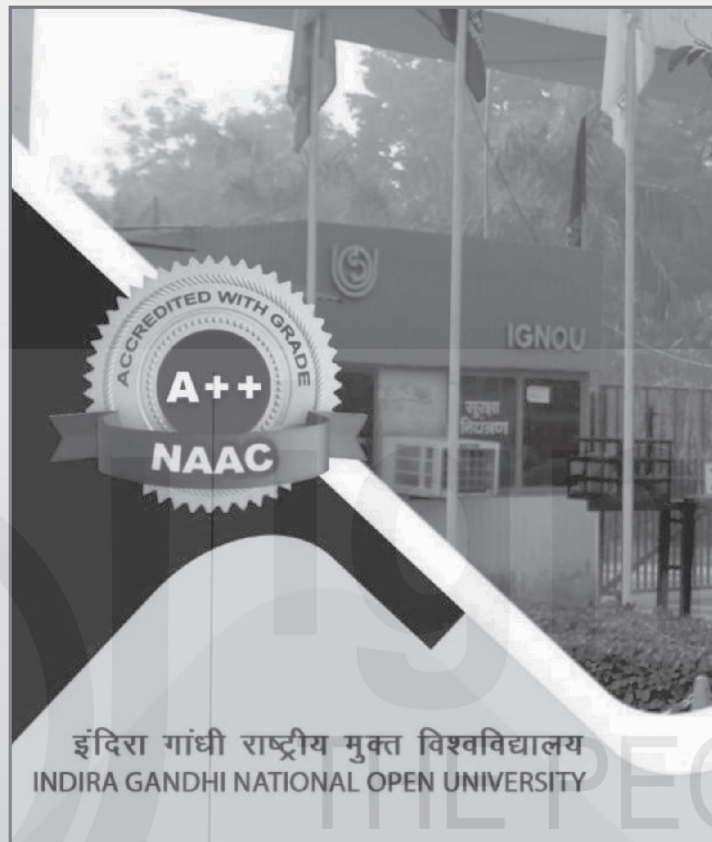
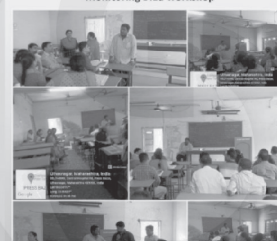
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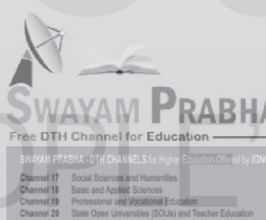
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