

PRAHAAR

The final hit to UPSC Exam

Comprehensive, Integrated and Current Linked Notes for CSE Mains 2021

GS PAPER - I

GEOGRAPHY

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All you need:

1. Current + Static Comprehensive Coverage
2. Summary at last for Revision
3. Well researched multi-dimensions

POPULATION and Migration	7
Population	7
Parameters	7
Growth rate :	7
Distribution of Population and Density	8
Regional Variations in population growth in India :	9
Working Population	9
Issues in news :	10
Female Labour Force Participation In India	10
Impact of pandemic :	10
Literacy :	12
Digital literacy:	12
Financial Literacy :	12
Digital Divide :	13
Impact of Covid-19 pandemic :	13
Government Efforts :	14
Demographic Dividend :	15
How to convert human resources into demographic dividends ?	15
Human development :	16
Migration	18
Findings related India's migration :	19
Issues in News :	20
Migrant workers :	20
INDUSTRY AND EMPLOYMENT	23
Sectors of Economy	23
Primary Activities :	23
Hunting and gathering :	23
Pastoralism :	24
Commercial Livestock Rearing :	24
AGRICULTURE	24
Types of agriculture :	24
Indian dairy sector	26
Cooperative farming in India :	28
Horticulture sector in India	30
Indian Agriculture Sector	31
Major constraints in Indian agriculture are:	32
Future scope :	32
Changing trends in agriculture modernisation :	32
Agro based Industries and agro processing industry :	33
Impact of reverse migration during pandemic :	33
MINING Sector in India	34
Significance :	34
Government Initiative :	35
National Mineral Policy 2019 :	35
SECONDARY SECTOR :	36
Recent exit of General Motors , Harley Davidson , Ford :	41

Industrial Policy	42
Regulation over industries before 1991 :	42
Implications of policies before 1991 :	42
1991 policy of Liberalisation, Privatisation, Globalisation (LPG)	43
Positive:	44
Negative:	44
National Manufacturing policy(NMP) 2011 :	45
Industrial Corridors(IC)	46
Strategy of regional resource based manufacturing and management :	46
Agro-based Industries :	47
Textile Industries :	47
Government Initiatives	49
PLIS and Changing Scenario :	49
JUTE INDUSTRY :	49
Problems Associated :	50
Government Initiatives :	50
Sugar Industry :	50
Factors behind shifting location of Sugar Industry from North to South :	51
Tertiary Sector :	53
Significance of Indian Service Sector :	54
Impact of COVID19:	54
Quaternary sector / Knowledge Based Industries :	54
Significance :	55
Challenges :	55
Quinary Sector :	55
Significance :	55
Challenges :	56
Current trend :	56
MINERAL AND ENERGY RESOURCE	57
MINERALS	57
Distribution of Minerals in India:	58
Types of Mineral Resources:	58
Non-Ferrous Minerals:	58
National Mineral Policy, 2019	59
Energy	60
Conventional and Non-conventional Sources of Energy	60
Sources of Energy	60
Problems with India's power sector:	62
Initiatives taken:	62
Non-Conventional Sources of Energy	63
Solar power	63
India's Wind Power Project	64
Tidal Energy	65
Depletion of Natural Resources.	66
Causes of Depletion of Natural Resources:	66
Effects of Depletion of Natural Resources:	67
Solutions of Depletion of Natural Resources:	67
Decarbonising Transport	67
Significance/need:	68

Government Initiatives/way forward:	68
Alternative Fuels and Energy Resources	69
Hydrogen Based Energy	70
Hybrid Renewable Energy	71
Gas-Based Economy	72
New Emission Norms for Thermal Power Plants	73
Aerosol Nucleation	74
Fly Ash	75
Lithium reserves	76
Biofuel - Lessons from Brazil	77
National Offshore Wind Energy Policy,2015	77
Offshore Wind Energy: Benefits	78
Offshore Wind Energy Development in India: Recommendations	79
M-Sand Policy	79
Ratle Hydro Power Project	80
Vanadium in Arunachal	80
Floating Solar Power Plant	81
Land Use Pattern and Its Changing Trend	83
What's Land use Pattern?	83
Land use pattern in India	83
Why Planning Land Use is important?	84
Impact of Land Use Change	85
Changing Trends in land use pattern In India	86
Land Use classification	86
Increase and decrease in land use	87
Explanation to Declining Categories of Land Use	87
Land Utilization and Population Distribution	88
What's the link between Land Use Change and Climate Change?	90
WATER RESOURCE MANAGEMENT ISSUES AND CONCERNs IN INDIA	93
Issues with water resources	94
Water Pollution:	94
Other General issues:	95
Solutions for water resources management	95
Water Resource Management. (WRM)	96
Why water resource management is important?	96
What are the ways and means of water resource management?	97
Integrated Water Resource Management	97
Prevention of Pollution:	98
Micro-Water Shed Management and Development:	99
BENEFITS OF MICRO WATERSHED MANAGEMENT	100
Water use efficiency	100
Advantages of Micro Irrigation	101
Challenges in Adoption of Micro-Irrigation Technologies:	102
What should be the role of National Water Commission?	102
Government Interventions	103
Transport and Communication	106
Utility of transportation in improving industrial growth :	106
Railway transport system :	106
Objectives specified by Niti ayog :	107
Challenges of the Indian railways :	107

Government Initiatives :	107
Road Transport :	108
Objectives specified by Niti ayog :	108
Challenges :	108
Public Transportation system in Cities :	108
Civil Aviation :	109
Shipping and Inland waterways :	110
Interlinking of river :	110
Development of Pipeline transport :	111
Human settlements and associated issues	114
TYPES AND PATTERNS OF RURAL SETTLEMENTS	114
Urbanisation in India	115
Problems with India's Urbanisation	115
'Class Ghettoization' and Migration to Urban areas	115
Urban areas and Air Pollution	117
Urban areas and water Pollution	118
Significance of urban Water bodies	118
Impact of Urbanisation on climate change	119
Climate Smart Cities Assessment and its impact:	119
Smart City Mission: A remedy to India's unplanned Urbanisation	120
Success Stories in Smart Cities Mission	120
What does India need?	121
Geomorphology	122
Origin and evolution of earth	122
Big Bang theory	122
Nebular hypothesis	122
Planetesimal hypothesis	122
Gaseous Tidal hypothesis	123
Protoplanet Hypothesis	123
Age of the earth	123
Movements of earth	124
Polar Variation	124
Earth's magnetosphere	124
Internal structure of the earth	125
Distribution of Oceans and Continents	127
Convectional Current Theory	127
Plate Tectonic Theory	128
Volcanic landforms	133
Volcanoes and environment	134
Rock and Rock cycles	135
Depositional landforms	136
Landforms of glaciation	137
Depositional landforms	138
Oceanography	143
Factors Affecting Ocean Salinity	144
Atmospheric acidity impact oceanic ecology	145
Movement of Oceans	145
Climate change and Ocean Circulation	146
Impact of climate change on Ocean	146
Coral reefs and Climate change	147

Significance of Coral reefs for Ocean ecosystem _____	147
Ocean pollution _____	148
Impact of Ocean Pollution _____	148
Dead zone _____	148
Ocean microplastics _____	149
Impact of microplastics _____	149
Mitigation of Ocean Pollution: _____	149
Issues in News _____	150
ATLANTIC MERIDIONAL OVERTURNING CIRCULATION (AMOC) _____	150
Importance of AMOC _____	151
LA NIÑA _____	151
El Nino _____	152
Impact on Indian Climate _____	152
Madden Julian Oscillation (MJO) _____	152
Impact of MJO on Indian Monsoon _____	153
Deep Ocean Mission _____	153
DOM's Importance for India _____	154
Seabed 2030 _____	154
The Significance of Ocean Floor Research: _____	154
Climatology _____	157
Earth's Atmosphere _____	157
Climate change and Atmosphere _____	158
Solar Radiation, Heat Budget & Temperature _____	159
Climate and Earth's Energy Budget _____	159
Synergies between Urban Heat Island and Heat Waves _____	159
Climate Change & Shift in Earth's Axis _____	160
Finding of Study _____	160
Causes of this Shift _____	160
The South Atlantic Anomaly _____	161
Boreal Summer Intra-seasonal Oscillation _____	161
The Multidisciplinary Drifting Observatory for the Study of Arctic Climate (MOSAiC) _____	162
Glacial Lakes Outburst Floods _____	162
Impact of GLOFs _____	163
Ganga River Basin _____	163
The Atlas's Important Findings _____	163
Cryosphere and Climate change _____	164
Geographical perspective to disasters in India _____	166
Hazard and Disaster: _____	166
A : EARTHQUAKE _____	167
Impact of Earthquake _____	168
Earthquake swarm: _____	169
Current developments: _____	169
Earthquake in Manipur: _____	169
Earthquake in Gujarat: _____	169
Earthquake in Assam: _____	169
B : Cyclones _____	171
Recent Current development : _____	172
Super Cyclonic Storm Amphan : _____	172
Cyclone Tauktae : _____	172
Cyclone Nisarg _____	172
Cyclone Nirav : _____	173

C. Drought:	173
D. Landslides:	175
Landslide Vulnerability Zones	175
E. Heat wave	176
F: Forest fire :	178
Impact of forest fires:	178
Recent forest fires:	179
Floods :	179
Flood distribution in India	179
The causes of flood in India:	180
Impact of floods :	180
INDIAN CLIMATE	182
INDIAN MONSOON	184
Indian Ocean dipole:	185
Recent developments:	187
Indian Ocean dipole and Indian monsoon:	187
La Lina and Indian monsoon :	187
INDIAN CLIMATE –SEASONS	187
1. THE COLD WEATHER SEASON	187
Dropped in Delhi temperature:	188
2. THE HOT WEATHER SEASON	188
Recent development:	188
Rise in Indian temperature:	188
3. THE SOUTHWEST MONSOON SEASON	189
4. THE RETREATING MONSOON SEASONAL	189
Recent development:	190
Changing Rainfall Pattern in the Country	190
Monsoon and Economic life of India:	191
Monsoonal unity of India:	191
Recent development:	191
Monsoon Mission	191

POPULATION AND MIGRATION

PYQ

- COVID-19 pandemic accelerated class inequalities and poverty in India. Comment.
- Mention core strategies for the transformation of aspirational districts in India and explain the nature of convergence, collaboration and competition for its success.
- Critically examine whether growing population is the cause of poverty OR poverty is the main cause of population increase in India.
- Discuss the changes in the trends of labour migration within and outside India in the last four decades.

POPULATION

Introduction :

- Country's population makes up **the building blocks of the nation**. Human hands and human brain are the most effective instruments to shape the future of the nation. In 21st century India will bless with the **largest youngest population of the world**. To convert them into human capital would **be a great challenge and great opportunity** before policy makers.
- Having limited natural resources to support world's second largest population, it makes mandatory to study the population profile of India.
- According to Census 2011 the population of India was **1.21 billion**. India occupies **2.4 %** of the land area of the world but it is the home of **17.5%** of the world's population.
- These numbers are sufficient to indicate the immense pressure of the Indian population over its **scarce resource base**. It has been a challenge for policy makers to provide at least basic civic amenities and dignified life to every person living in India.

Importance of Population Study :

- To have a sustainable planet capable of **providing resources to the present population and upcoming generations**, **population study is must**.
- **Various attributes of population** like Growth rate , Demographic transition , Child population , Distribution and density , regional variations etc **helps policy makers to understand the present status of population composition and anticipate expected changes in the long term**.
- In its positive connotation population is considered as human resources rather than a burden over the state. Hence it is believed that **the real problem is not population explosion but what the population is doing**.
- **The role of the state is vital to convert human resources into human capital**. India since 2018 has entered into **the phase of demographic dividend which may last until 2055 as per UNFPA study**. This window can be best utilised if the state succeeded in providing them health, education and skills.

PARAMETERS

The following parameters are important to understand in order **to formulate next population policy to yield maximum output from our demography**.

Growth rate :

- Growth of population is **the change in population in the number of people living** in a particular area between two given points of the time. It includes both **natural growth and migratory growth**.

In India trend in population growth has been divided into four phases :

- **Period of Stagnant Population(1901-1921)** : High birth rate counterbalanced by high death rate. The Census of 1921 recorded a negative growth rate hence the year 1921 is called the **year of 'Demographic Divide'**.
- **Period of steady growth(1921-1951)** : The high birth rate continued. **The mortality rate started showing a downward trend due to improvement in health and sanitation conditions** along with a developed distribution system. Hence it was mortality induced growth.
- **Period of rapid high growth(1951-1981)** : There was a steep fall in the mortality rate but fertility rate remained high resulting in a very high rate of population growth. It is referred to as the **period of population explosion** which was the result of fertility induced growth.
- **Period of high growth with definite signs of slowing down(1981-2011)** : The highest ever growth rate of 22.2 % was recorded in 1971-1981 after the declining trend in population growth started. **The recent Census of 2021 reported an addition of less people than its previous decade**. This indicates a positive result of official efforts of birth control and people's enhanced awareness led to an inclination towards smaller families.
- **According to the National Commission on Population (NCP) ,**
 - **India would surpass China by 2031** and become the world's most populated country.
 - **India would reach its peak population in 2059.**
 - The key driver of above trends is Total fertility rate(TFR) which is expected to reach the replacement rate of **2.1** in coming years.

Distribution of Population and Density

- **Uneven distribution** is an important aspect of India's population. **High density pockets** have developed around **urbanised , developed areas and plains** regions. Backward areas and hilly , desert regions are **sparsely populated**.

Various reasons regarding unequal population distribution :

- **Terrain** : Plain areas witness higher density compared to hilly , desert regions due to productive agriculture , transportation , industries led development.
E.g. Ganges plain shows highest population density and Arunachal Pradesh shows lowest population density in India.
- **Climatic Conditions** : **Rainfall and temperature** play important roles in determining the population of an area. Extreme climate discourages population concentration.
E.g. Himalayas , Thar deserts. It is observed that the population map of India follows its rainfall map. As we move from Wet areas(Ganga delta) to dry areas (the Thar desert) population density decreases.
- **Mineral Resources** : Minerals are the basic raw material for industrial development. It attracts investment and creates employment opportunities. Mining sector comes under primary activities which is labour intensive in nature.
E.g. The Chota nagpur plateau of Jharkhand and adjoining areas of Odisha have higher population densities.
- **Fertile soil** : Fertile soil of the region attracts human settlements **due to productive agriculture and related livelihood securities**.
E.g. Ganga plains having alluvial soil have attracted dense population.
- **Urbanisation** : Due to high economic activities and employment opportunities population concentration is maximum in urbanised areas compared to rural areas.
E.g. Delhi , Mumbai , Kolkata , Bengaluru , Chennai are in top positions of population density.

Implications :

- **Resource allocation** : Dense pockets puts **high burden on natural resources and state administration** in providing basic amenities of water , food , electricity etc

- **Inflation** : General inflation is high in these regions due to high demand which results in high property rates and increase in living expenditure.
- **Impact of disasters** : Impact of flood , earthquake and pandemic like COVID-19 is very high which leads to high death toll and infrastructure destruction.
- **Migration** : Dense pockets acts like a magnet attracting more people due to available opportunities. This changes the demographic attributes of the region. It is generally observed that metropolitan cities shows poor sex ratio due male population immigration.
- **Climate change** : In Dense pockets requires per capita carbon footprint is higher. It causes immediate global warming effects like Heat islands and pollution led acid rains.

Regional Variations in population growth in India :

- The population growth and improvement in **demographic parameters in India is directly proportional to level of development in the state**. Health and Education facilities are primary pillars which decide the population pyramid of any region.
- **Southern VS Northern :**
 - In India southern developed states show improvement in population attributes compared to Northern states.
 - Southern states have entered into Stage 4 of the demographic transition model having low death and low birth rates leading to low growth rate. The Total fertility rate of these states is below replacement level of 2.1.
 - According to new census population projections , over one-third of the total increase in India's population between 2011 and 2036 will come from two states alone **Uttar Pradesh and Bihar** , while all of the southern Indian states will see their share in the population declining.
- **Urban VS Rural :**
 - As per world bank **urban population in India was 34% in 2017** and according to NCP **70% increase in population** is expected in urban areas by 2036.
 - **Urban women recorded a lower fertility rate** than women residing in rural areas across almost all states across time, but this gap has been shrinking, according to the first phase of NFHS-5, 2019-20.
 - At the same time, **India will move from being a very young country, to increasingly resembling something closer to a middle-aged country by 2036**.
- The Improvement in **TFR rate in populous states of UP , Bihar , Madhya Pradesh and Rajasthan states** would decide the population stabilisation India.

Working Population

Terminologies related to working population :

- **Labour force** : It refers to the number of people who are willing to work and able to work. It excludes those people who are not willing to work.
- **Working force** : It refers to the number of people who are actually engaged in any economic activity.
- Labour force participation rate : The proportion of the population working or seeking work.
- **worker-population ratio** : The proportion of the population that is working.
- **unemployment rate** : The proportion of the population in the labour force that is seeking but unable to find work.

Working Composition :

- The PLFS categorises the workforce into **self-employed , regular wage/salaried workers and casual labourers**.
- Following are the observations of third report of the Periodic Labour Force Survey (**PLFS**) , 2019-2020 :
 - Of all the worker categories, **only the proportion of unpaid family workers has gone up** significantly in the last three years.
 - Between 2018 and 2019, while **the workforce increased by 2.9%**, the proportion of all other employment categories in the workforce declined, except unpaid family helpers.

- Over the same period, almost the entire rise in the workforce was accommodated by agriculture. **Agriculture continues to absorb the workforce that cannot find remunerative employment elsewhere.**
- There is also a gendered dimension to the changing composition of the workforce. **The category of unpaid family workers is dominated by women**

ISSUES IN NEWS :

Female Labour Force Participation In India

- **Discrimination** : In India women are struggling to find equal opportunities in every sphere however their deprivation in economic spheres have deep implications on India's growth story.
- **According to World Bank estimates**, India has one of the lowest female labour force participation rates in the world.
- **As per the report of ILO**, during the last decade female labour force participation rate has fallen significantly with 95% women working in the unorganised sector or in unpaid work.
- **Different trend** : In India the trends in female participation rates are surprising because they do not follow a U-shaped curve which is usually observed in economies.
- **Female labour force participation initially declines with growth of the economy and then rises on account of structural shifts**. Despite experiencing these structural changes such as decline in fertility rates and expansion of women's education, Indian FLFPR is on a downward track.
- **Low skills** : Most employed women in India are in low-skilled work, such as farm and factory labour and domestic help.
- The average working Indian woman works a longer week than her developing country counterparts.
- **Unequal wages** : In rural areas a male salaried employee earned nearly 1.4 to 1.7 times a female salaried employee, while in urban area salaried men earned 1.2 to 1.3 times a salaried woman.

Impact of pandemic :

- **Decline in labour participation** : According to government report , due to impact of covid-19 pandemic female labour participation rate in India fell to 16.1% during last quarter of 2020 which is lowest among the major economies.
- **Job loss** : In urban areas due to social distancing and lockdown domestic workers lost their jobs and families are still reluctant to re-join them due to fear of third wave of covid-19 pandemic.
- Even they lost their jobs at construction sites , handicraft and retail units due business losses and shut down of enterprises.
- **Reverse migration** : Many families migrated back to their native place however with easing out of lockdown only male members have again come back for searching jobs leaving their wives at home unemployed.
- **Domestic care** : Women are bearing the majority of childcare with schools still closed due to the pandemic preventing them from going for work considering risk of covid-19 infection.
- **Urban women workforce have impacted more compared to rural women** because largely rural women works in own farms and others got their jobs easily.

Following reasons can be cited behind their low participation in the labour force :

- **Agriculture** : Defeminisation of agriculture is resulting due to increasing mechanisation for manual works which are generally performed by women.
E.g. Equipment like seed drills, threshers etc have reduced manual jobs that were mostly performed by women.

- **Manufacturing Sector** : Textile sector provides highest employment opportunities to women working force. However other industries failed to generate low skilled , manual jobs suitable for women. These industries either required skilled workers or have heavy works not suitable for women.
E.g. Service sector faired well in providing women employment opportunities compared to manufacturing sector.
- **Cultural norms** : The cultural norms that place the primary responsibility of routine domestic tasks on women, limit their ability to participate in the labour market. India's female-to-male share of housework is among the highest in the world.
E.g. Among women, Muslim women and Hindu women from forward caste have the lowest LFPR due restrictive patriarchal and conservative mindset.
- **Structural reforms** : However, in India, structural transformation led to a high share of the population working in the informal sector. These informal jobs and their lack of social security make people highly dependent on caste and kin networks for economic support in times of crisis and conform to society's traditional standards instead of challenging them. This acts as one of the main impediments to female participation.
- **Legal constraints** : Factory act 1948 , puts restriction on working hours of women between 6 am to 7 pm. Hence reducing their opportunity during night shifts.
- **Safety** : Increasing cases of sexual harassment at workplace and many unheard harassments of women in unorganised sector deters women from finding an employment.
- **Poor education and skill** : lack of education, access to quality education, digital divide, which limits them from gaining employable skill sets and entering the workforce or establishing an enterprise. While some of the fall in women's workforce participation is explained by higher rates of higher education enrolment.
- **Impact of Pandemic** : Pandemic impact has hit women disproportionately as they are caregivers at home and their job opportunities have diminished due to pandemic led restrictions.

Steps to be followed :

Economic survey 2021 have given following recommendations :

- **Child and elderly care** : Investment in institutional support to affordable and quality child care facilities and elderly care.
- **Work Culture** : Paid parental leave, family-friendly work environment and flexible working time.
- **Fair Treatment** : There is also a need to promote non-discriminatory practices at the workplace like pay and career progression, and improve work incentives.

Other steps :

- **Women entrepreneurship** : Women led entrepreneurship would fetch more women in the labour force. Start-up opportunities in child and elderly care can be reaped by women entrepreneurs.
- **Digital skills** : Digital literacy and adequate technical knowledge can help them enter formal sector jobs.
- **Vocational training** : Providing vocational training to adolescent girls and apprenticeship opportunities can build a strong linkage towards considering technology linked training and employment options.

Way Forward :

- There is a definite concern that arises from the advent of technology, digitisation and automation that women who are largely employed in low skills and low paying jobs will lose their place in the workforce.
- So providing education and skills to women is utmost important. Half of our demographic dividend should not be left behind due to restrictive social outlook and failure of policy makers to enhance female labour participation rate.

Literacy :

- **Definition :** According to the census of India , a person aged seven and above who can both read and write with understanding in any language is treated as literate.
- **Crude literacy rate :** It considers total population of India while **effective literacy rate** considers only population above 7 years.
- **According to census 2011 females outnumber males** in total literates added during last decade and total decrease in number of illiterates during last decade. This indicates the **gender gap in literacy is shrinking** in the country.
- Literacy is considered as a **step towards education** as one cannot become educated unless he/she is literate.
- **Literacy rate is directly proportional to the development of the state.** Literate populations tend to show better health indicators and they are easily accommodated into the labour force.
- **Kerala , Mizoram** have occupied top positions and **Bihar , Arunachal pradesh** have remained in bottom position with respect to literacy rate in India.

Digital literacy:

- Digital literacy has become equally important in the digital era where **one is expected to perform basic functions related to web handling using a phone or computer.**
- **Significance of Digital literacy :**
 - It is helpful in **acquiring new skills** in modern technology.
 - It **increases accountability and transparency in governance** , ensures better public service delivery, increases people's participation in governance.
 - **Making online money has become easy** through Youtube etc. if a person has basic digital knowledge.
 - Digital processes transforms the work culture of enterprise and also widens its reach to increase its client base.
- **Challenges :**
 - **Digital divide** due to **poverty** and **lack of infrastructure**.
 - **Absence of Internet access** and **irregular electricity supply**.
 - **Poor effective literacy rate** is a major obstacle in making people digitally literate.

Financial Literacy :

- Financial literacy is the **ability** of a person to understand basics of economic transactions , awareness regarding banking processes , investment , savings and insurance etc. In digital era , understanding and operating of e-banking and mobile banking also forms important component of Financial Literacy.

Significance :

- **Financial inclusion and Inclusive growth:** Financial literacy is important for financial inclusion and financial inclusion is vital measure to achieve inclusive growth. Financial inclusion provides access to various financial instruments like fix deposit , recurring deposit , Life insurance , mutual funds etc.
- **Benefits from government schemes :** Various government schemes related to **marginal and deprived sections of the society fails to reach beneficiaries** due to their poor awareness and poor financial literacy.
 - E.g. Some beneficiaries fails to benefit from PMKISAN scheme and MGNREGA due to no bank account.
- **Women empowerment :** Financially literate women can handle their economic transactions and bank account independently thus increases their autonomy and say in domestic decision making. It also helps them to run a business through cheaper credit access and learning financial discipline.
- **Online Fraud :** Financial literacy helps in dealing with increasing financial frauds due digital penetration in economic sphere. Basic preventive knowledge of securing ATM pin, regularly changing password etc comes through financial literacy.

Challenges :

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- **Poor effective literacy rate and digital literacy** is a major obstacle in making people financially literate.
- **Poor penetration of banks in remote areas** compel people to remain outside of banking system.
- **Lack of land documents** prevents farmers and **failure to submit yearly returns** by small enterprises prevents them from accessing bank loans.
- **Patriarchy mindset prevents** women from engaging in any economic transaction or their accounts are only handled by their husbands.

Digital Divide :

Introduction :

- **Definition** : Digital divide refers to deprivation of accessibility , affordability , availability towards information and communications technologies across the demographics and regions.
- Digital access is **one of the parameters to assess societal development** of a country which depends upon penetration of information and communications technology (ICT) through the Internet , access to social media etc

Present scenario :

- India has the **second-largest internet user base with over 630 million subscribers** and electronic devices and data plans are becoming cheaper day by day.
- **Digital inequality has spread across all the parameters** : between Urban areas and rural areas; between different social groups; between male and female ; between rich and poor ; between the educated and uneducated population etc.
- **Regional divide** : Urban area has more than 100% digital penetration whereas rural areas have below 50% digital penetration. E-governance , E - transactions , E-banking etc are more prevalent in urban areas whereas rural areas due to digital illiteracy are deprived of these benefits.
- **Social divide** : Digital access has strengthened social grouping due to availability of virtual platforms , digital groups etc. Menace of fake news has further **deepened the social cleavages**.
- **Gender divide** : **Digital empowerment of women** would facilitate faster development of women as it can avail access to education , digital earning and awareness regarding the world.

Significance :

- **GDP increase** : According to a 2018 report by the Indian Council for Research on International Economic Relations every **10% increase in India's internet traffic delivers a 3.1% increase in per-capita gross domestic product.**
- **Economic growth** : Digital revolution has brought economic growth, job creation and human development at a faster rate. **While the Industrial Revolution was a marathon run, the digital revolution is turning out to be a sprint.**
- **Human Productivity** : ICT would boost the economy through **increasing productivity gains only if people having access to the technology also have the requisite skills** for making optimal use of it.
- Digital ecosystem can **improve productivity of farmers** by providing them with processed data on soil, weather, storage, logistics and digital land records that enable them to avail credit and access crop insurance.
- **Tele-services** : Improved digital ecosystems can help with the expansion of **telemedicine , tele-education** that can reduce the shortage of medical professionals in rural areas and smaller towns.
E.g. During Covid-19 pandemic, both telemedicine , tele-education played a huge role in advising patients online and online education.
- **SDG goals** : Access to ICT is essential to achieve **Sustainable Development Goals (SDGs) for 2030.**

Impact of Covid-19 pandemic :

- Those who are **digitally literate and digitally equipped found themselves at better place** compared to digitally illiterate persons because of following reasons :
 - **Awareness** : Digital access increased their **awareness regarding pandemic, preventive precautions to be taken.**

- **Digital transactions** : Digital transactions helped them to avoid direct contact and maintaining cash wasn't required during lockdown. Businesses also benefited through UPI payments.
- **Tele-medicines** : helped people in remote areas to save lives of people.
- **Tele-education** : Access to smartphones and internet **helped in maintaining continuity in studies** by attending online sessions.
- **Mental health** : Digital access **also helped to maintain healthy mental status**. Songs , online sessions by experts helped them to remain mentally fit. Even online teachings of **yoga and breathing practices** spread easily.
- **Business opportunities** : **Online coachings , sharemarket , home makers on Swiggy and Zomato** serviced during lockdown and related restrictions.

Challenges :

- **Lack of Infrastructure** : Vast population do not have smartphones , Schools are not equipped with computer labs , electricity supply is not regular , poor internet speed etc
E.g. Smartphone users in India are only 748 millions.
- **Illiteracy and poverty** : Due to **digital illiteracy** people are not capable of using devices in an optimum way. Smartphones are used only for calling purposes. **Poverty prevents people from regular access to internet subscriptions.**
E.g. **India has largest** population of illiterate adults in the world and it is estimated that covid-19 pandemic would cause **an overall increase in poverty by 15-20%**.
- The digital revolution has made **services more tradable and enabled India to grow at a faster rate** but this is now being restrained by the digital divide.
- **Industry 4.0** : **With advances in AI and ML digital divide is expected to worsen** in the future which would bring newer challenges. These critical technologies will be effectively utilised by skilled and educated persons only.
E.g. Effective use of Alexa and Google assistance can only be done by digitally skilled persons only.
- **Low share in GDP** : **India's digital sectors still account for less than 10% of GDP**, which is low compared to other emerging economies. Globally e-commerce revenue has grown exponentially. **In India its share is mere 5% of trade in India and more than 80% of all retail transactions are still made in cash.**
- **Digital colonialism** : Concerns have been raised that a few large corporations are beginning to dominate the digital field.
E.g. Dominance of Google ,Facebook , Instagram over digital space have raised the concerns regarding **manipulation of human opinion through digital advertising and funnelling effect**.
- **Regulation** : Issues related to **how data can be collected, stored and processed at national and global levels** is still at an early stage and **raises many societal and ethical questions**.

Government Efforts :

- **BharatNet project** was launched in 2011 to provide optical fibre connections to all village panchayats.
- **Digital India campaign** aimed at digitally empowered society and knowledge economy.
- **Pradhan Mantri gramin digital saksharta abhiyan** to spread digital literacy in 60 million rural households.
- **DIKSHA- digital infrastructure for knowledge sharing platform** would act as a national platform for school education for grades 1 to 12 under the notion of '**one nation one digital platform**'.

Way forward :

- Policymakers will need to ensure **electricity supply, digital labs in schools , digital awareness through gram sabhas** which will be the **key to a digital foundation**.
- Provision of **free public wifi in rural areas, cheaper data plan, subsidy to avail at least one smartphone for BPL families and improvement of digital data and ecosystem** would ease the way in which people can connect, collaborate, transact and share information.

- **Digital dividend and demographic dividend go together, hand in hand.**
- While increasing penetration of digital technology is necessary , it is also **essential to build up the complementary human capital for making optimal use of the technology.**
- India will benefit from establishing a **national digital institution to promote investments in digital infrastructure and build strategic partnerships** with the private sector, especially the Silicon Valley and European centres of excellence.

Demographic Dividend :

- According to UNFPA - United Nations Population fund , Demographic Dividend is **defined as, the economic growth potential that can result from change in population age structure where shares of the working age(15-64 years) population is greater than non-working age share.** **India would experience this phase between 2018 - 2055.** This phase will be available at different times in different states.
- A country with both an increasing number of young people and declining fertility has the potential to reap a demographic dividend.
- Increase in labour force leads to **increase in economic productivity** → increase in GDP → increase in living standard and **improvement in HDI score.**

Significance :

- **Cheap labour and demand** : The Indian demography will be the world's largest labour force and market for goods and services.
- **Growth** : It is believed that with the **right education and investment in human capital**, and an increase in foreign investment, India would expect even double-digit GDP growth.
- **Youngest nation** : India's median age is 28 years. This means that half of its population is under 28. Among the top 10 economies in the world, India has the youngest population. **By the end of 2021, two-thirds of India's population will be within the working age of 20 to 35 years.**
- During such a phase, **an economy's resources are freed up and invested in other areas** to accelerate a country's economic development.

How to convert human resources into demographic dividends ?

- **Food , Health , Education , skills and employment** are basic pillars to convert human resources into human capital.
- **Nutrition** : **The National Food Security Act (NFSA), 2013** aims to ensure food and nutritional security by providing availability , accessibility , affordability to adequate quantities of quality of food. Nutritional security of children and pregnant , lactating mothers is important to ensure adequate mental and physical health of children. Children suffering from Stunting and wasting are likely to perform poorer in future academic and sports.
- **Health** : **The National Health Policy of India**, which came out in 2017, envisaged that India spend at least **2.5 percent** of its Gross Domestic Product (GDP) on the health sector by 2025. It will reduce out of pocket expenditure and **enhance productive time per person.**
- **Education** : Education is the most important ingredient to reap the demographic dividend. **National Education Policy, 2020 (NEP)** reaffirms the recommendation of increasing public investment on education to **6% of GDP** Extension of RTE act 2009 up to secondary education and efficient working HEFA - higher education finance agency would be critical to revamp education sector.
- **Skill** : The mandate of NSDC - **National Skill Development Corporation is to provide skill training to 150 million people by 2022.** This would enable our labour force to adapt their skills as per the demand of the economy.
- **Reforms** : It is the right time **to implement the next generation of economic reforms** to deliver efficient public services, particularly focused on long-neglected social needs related to nutrition and health services, primary and secondary schooling, quality enhancement of tertiary education, water supply and sanitation, and urban development.

- **Employment Generation** : Jobless growth and impact of Covid pandemic have increased our unemployment rate. High investment in labour intensive sectors and promotion of entrepreneurship should be done to create employment at a faster rate.

Challenges :

- **Unemployment rate** : Even before the Covid-19 pandemic hit, unemployment levels in India had hit a 45-year high.
- **According to the Pratham survey report**: In 2020 enrolment rate in rural areas has reduced compared to 2018 and reading , maths solving abilities of students have impacted due to online schooling during the pandemic.
- **The Centre for Science and Environment** : It finds that an astounding 375 million children may suffer long-lasting impacts due to the pandemic including being underweight and stunted, which will lead to losses in education and economic productivity.
- **Demographic disaster** : The demographic dividend will only yield if they are productively engaged in high-wage employment which will allow them to buy goods and services. If India fails to capture its demographic dividend, a large number of young working-age people will be left unemployed or underemployed. Such overburden of dependent population on labour force would slowdown the growth rate.
- **Poor Investment** : Investments in human infrastructure have not kept up with its demographic transition. Women workers have been hit the hardest, with their labour force participation rate in India being one of the world's lowest.

Way Forward :

- India will have the highest population of young people in the world, and the quality of education they receive will dictate the future course of our country. The quality of its human capital would prove to be a 'dividend' or a 'disaster' over the coming decade.

Human development :

- The term Development indicates qualitative change which is value positive as against quantitative and value neutral change associated with the term Growth.
- **Definition** : Human development is a process of enlarging a range of people's choices , increasing their opportunities essential for their empowerment to live a dignified life including political freedom , guaranteed human rights and personal self-respect.
- Before 1990's a country's development was measured by its economic progress only. But this did not reflect the true nature of development because development includes improved quality of life , opportunities to enhance their capabilities and availability of choices with freedom to choose them.

Advantages of Human development ?

- It improves quality of life and ensures fair distribution of resources.
- It enhances productivity of human resources and helps to reap benefits of demographic dividend.
- It helps in sustainable development keeping our environment healthy .
- Human development is a barometer of effective democracy ensuring equality and social justice.

Lack of human development leads to concentration of wealth , inequality , and undermines social justice. It negatively impacts social , environmental and personal capabilities of deprived sections of the society.

Various Indices for measuring human development :

HDI and India :

- **HDI- Human development Index** :

- **Dr. Mehboob-ul-Haq and Dr. Amartya Sen** created the Human development Index in 1990. Which have given importance to following aspects of human development :
 - Leading a long and meaningful life, Ability to gain knowledge, Having means to live a decent and dignified life.
- **India's performance :**
 - Out of 189 countries, **India has ranked 131** on the Human Development Index 2020 prepared by the United Nations Development Programme (UNDP). **India dropped two ranks** compared to previous years ranking. However India has shown improvement in absolute HDI value.
 - When the **HDI is adjusted to planetary pressure** as newly introduced by the UNDP (Planetary Pressure Adjusted HDI), **its ranking improves by eight positions**. It includes two new elements: a country's material consumption and its carbon footprint and India's performance is much better in these compared to most countries having higher HDI values.
 - **The country fell in the medium human development category.** Since 1990, the HDI value of India has increased to 0.645 from 0.429, registering an increase of over 50%.
 - The United Nations Development Programme in 2020 report introduced a new metric **to reflect the impact caused by each country's per-capita carbon emissions and its material footprint.**
- **Health** : Life expectancy for Indians at birth was 69.7 years in 2019 which is **slightly lower than south Asian average**. India's life expectancy at birth **increased by 11.8 years between 1990 and 2019**.
- **Education** : **The expected years of schooling in India was 12.2 years** which is better compared to Bangladesh and Pakistan. The **mean years of schooling increased** by 3.5 years, and **expected years of schooling increased** by 4.5 years between 1990 and 2019.
- **Standard of living** : **India's Gross National Income (GNI) per capita is USD 6,681** which has **fallen** over the previous year.
- **Other findings of the report :**
 - **Climate change** : Climate change induced inequalities and disaster led loss of occupation are emerging causes behind poor improvement in human development.
 - India has slipped 1 position down in the gender inequality index indicating neglected efforts by the government for empowerment of women.
 - **Malnutrition** : Malnutrition induced stunting and wasting is a severe problem in Indian children.
 - **Financial security and ownership of land** : They have improved women's security and reduce the risk of gender-based violence which indicates that owning land can empower women.
 - **Patriarchy** : In India different responses in parent behaviour as well as some disinvestment in girls' health and education have led to higher malnutrition among girls than among boys as a consequence of shocks likely linked to climate change.
- **Conclusion :**
 - The report has not counted impact of Covid-19 in this report. It is expected that impact of covid-19 would have disproportionate negative impact on marginal and poor people. **So in coming year HDI for global world and India would decline drastically if urgent appropriate policy intervention and their proper implementation not taken by governments to restrict adverse impact.**

MIGRATION

Definition :

- Migration is a form of **spatial mobility of population** between one geographical location and another which involves both permanent and temporary migration.
- With increase in **transportation means and general acceptance of global outlook by society**, migration has become an important component of population change along with fertility and mortality.

Types of migration :

- Migration can be broadly classified as **international and internal migration**.

International migration :

- Movement of population from one country to another across the international borders. Which involves **emigration** of Indians to other countries and **Immigration** into India from other countries.

Out-migration :

Out Migration can be understood from several time periods involving various causes :

- **Ancient India** : During the reign of Ashoka many **preachers** migrated to southeast asia and east asian countries to spread Buddhism under the patronage of the king.
- **British India** : During the Colonial period many Indians and **convicts** were transported to sugarcane fields of **Mauritius and Caribbean islands**. It was **forced** migration under Britishers control.
- **Partition of the Indian Subcontinent** is a great event which resulted into large scale migration from India to Pakistan and vice versa.
- **Oil boom** : In 1970's attracted by the oil boom in West Asia, many skilled and semi-skilled people migrated to these countries for **economic purposes**.

- **During the 1980's and 1990's onwards** : Education and knowledge based Indian migration to USA , EU , Australia etc has proved world wide acceptance of India's human capital value.

Impact :

- **Opportunities** : Out migration is largely caused **by economic purposes** where people have migrated **to avail better economic opportunities**.
- **Remittances** : In return their **remittances to India** have helped **to improve the standard of living** of their families here. **India receives the largest remittances** which bolsters our foreign exchange reserves and helps to contain the current account deficit.
- **Brain drain** : On the contrary, **problems of brain drain** have transferred our expert human resources abroad which have impacted India's growth in technological research and development.
- **In the long term retaining talent would benefit in excelling Indian entrepreneurship culture** creating Indian unicorn startups making its global impact.

In-migration:

- Present day population of India consists of **descendants of people who migrated to this country at different prehistoric and historic times** from different parts of the country.
- During the **ancient and medieval period India** received many **scholars and skilled artisans** from foreign countries. However , **post independence India** has been struggling with **refugee influx** from Tibet , Bangladeshi, Chakma refugees , Rohingya muslims etc.

Internal Migration :

- **Migration within boundaries of a country** is considered as Internal Migration.
- With improvement in **mode of transport and availability of cheap transport** the rewards of better economic opportunities have overcome the cost of moving.
- The trends of migration for work and education has been **accompanied with structural transformation of economies and resulting remittances flow** helped in economic development of backward regions.

Findings related India's migration :

- **Less affluent states** see more people migrating out while **the most affluent states** are the largest receivers of migrants.
- **Disparities in economic development** seem to be the main cause of migration.
- While internal political boundaries impede the migration, **language does not seem to be a barrier in migration**. This indicates the increasing spread of common languages like Hindi and English.
- **Majority** of intrastate and interstate migrants **belong to rural areas**.
- **UP , Bihar and Rajasthan** are major areas from where out migration takes place. **Maharashtra , West Bengal and Punjab** are mostly in migrating states.

The most common pattern of migration in India is Rural - Urban Migration. However , **based on place of birth and place of remuneration** it is divided into 4 streams :

- **Rural to rural** : It includes **seasonal migration** of agriculture labourers and **marriage** led women migration.
- **Rural to urban** : It includes migration **pulled by education and employment opportunities**.
- **Urban to urban** : It includes **higher study and higher opportunity** led migration.
- **Urban to rural** : It includes **post retirement settlement back to native place**. Presently **work from home opportunities** helped people to migrate to their native rural place and work due to availability of 4G net connections.

Factors Of migration :

- **Pull factors** : When a destination centre attracts migrants for reasons like employment , modern facilities, security etc. These are known as Pull factors.
- **Push Factors** : When the source region fails to provide livelihood and aspirations of people in terms of education , health ,business etc people tend to push out to the region with better opportunities.These are known as Push factors.

Reasons of migration :

- **Work/Employment** : This is the **strongest reason** behind migration. **Males migrate more than their female counterparts** in search of a livelihood. People migrate from agriculture based rural areas to urban areas.
- **Marriage** : Marriage remains the **biggest reason behind migration of the females**.
- **Education** : Lack of educational facilities at rural areas and **aspiration of higher studies** push people to migrate to urban areas or metropolitan cities.
- **Health** : Lack of health facilities at rural areas and need of **critical health interventions** push people to migrate to urban areas or metropolitan cities.
- **Lack of security : Political disturbances and interethnic conflict** drive people away from their home. Large number of people migrated from Jammu & kashmir , Assam due to security reasons.

Consequences :

Migration affects both the area of origin and destination of the migrant population.

- **Demographic Consequences :**
 - Migration **brings about changes in the characteristics of the population** in both the regions e.g. age , sex , rate of growth of population. The proportion of old , children and females increases in source areas.
 - The migration is major cause of **less sex ratio in destination areas** because mostly youthful males are involved in migration.
- **Social Consequences :**
 - Migrants are **agents of social change**. It results in **intermixing of diverse cultures** and leads to the evolution of **composite culture**.
 - At the same time it may **foster regional sentiments ,protectionism , demand for opportunities only to 'sons of soil'** as seen in Assam , Maharashtra etc.
- **Economic consequences :**
 - The effects on **resource-population ratio** is one of the major economic consequences of the migration. It might render areas either underpopulated or overpopulated.
 - Hence it creates challenges to policy makers to devise a plan which would enable **migration from overpopulated regions to underpopulated regions by incentivising industrial concentration in these regions**.
- **Environmental Consequences :**
 - Large scale migration in urban areas leads to **overcrowding** and pressure on the infrastructure. Over exploitation of resources causes resource crunch , **water and air pollution and problem of sewage disposal** etc.

ISSUES IN NEWS :

Migrant workers :

- Migrant labourers from rural areas generally **belong to low economic groups** who work in the informal sector.
- Their migration is called **circular migration** as they visit their native place a few times in a year after earning adequate money.
- **It is largely a distress migration due to lack of employment at native places.**
- **COVID 19 pandemic** forced migrant labourers to visit their native place due to lockdown. These labourers are coming back to work again to ensure their livelihood security.

- These migrants again employed in agriculture activities which **provided cheap labour** and also **caused disguised unemployment**.

Case study :

- **Bonda tribe , a PVTG tribe of Malkangiri district of Odisha .** The COVID 19 pandemic led **distress** has forced them to leave their pristine hamlets **for low paid jobs** in distant towns of Andhra Pradesh , Telangana. **Even Bonda students who were studying in residential schools were also forced to migrate to ensure livelihood.**

Conclusion :

- Migration can't be completely stopped. However sustainable migration controlled through policy guidance is required. Policy should strive to **provide rural development through decentralised regional planning targeted towards rural employment generation** and extending urban amenities to rural areas.
- India needs horizontal development aimed at equitable distribution of resources, opportunities , investment and urban facilities.

INDUSTRY AND EMPLOYMENT

PYQ

1. Can the strategy of regional-resource based manufacturing help in promoting employment in India? 2020
2. Account for the present location of iron and steel industries away from the source of raw material, by giving examples. 2020
3. Discuss the factors for localization of agro-based food processing industries of North-West India. 2019
4. Define blue revolution, explain the problems and strategies for pisciculture development in India. 2019
5. What is the significance of Industrial Corridors in India? Identify industrial corridors, explain their main characteristics. 2018
6. Petroleum refineries are not necessarily located nearer to crude oil producing areas, particularly in many of the developing countries. Explain its implications. 2017
7. Whereas the British planters had developed tea gardens all along the Shivaliks and Lesser Himalayas from Assam to Himachal Pradesh, in effect they did not succeed beyond the Darjeeling area. Explain. 2014
8. Account for the change in the spatial pattern of the Iron and Steel industry in the world. 2013
9. Do you agree that there is a growing trend of opening new sugar mills in the Southern states of India? Discuss with justification 2013
10. Analyze the factors for highly decentralized cotton textile industry in India. 2013

Introduction :

Industrial sector is a part of economy concerned with the production of intermediate products (iron steel, machineries) and production of final products (vehicles, processed foods). The industrial sector constitute the part of secondary sector which together with primary sector and service sector form an interlocking chain of economic activities in a modern economy.

Manufacturing processes are the core part of industrial sector which transforms the natural material endowments into commodities of utility by processing, assembling and repairing. Manufacturing is an engine of economic growth which removes unemployment, poverty and transforms traditional society into a modern society.

SECTORS OF ECONOMY

Primary Activities :**Introduction :**

- Human activities which generate income are known as economic activities.
- Primary activities are **directly dependent on the environment** as these refer to utilisation of earth's resources such as land, water, vegetation, building materials and minerals.
- It includes : **hunting and gathering, pastoral activities, fishing, forestry, agriculture, and mining and quarrying.**

Hunting and gathering :

- This economic activity depends on their **immediate environment for their sustenance.**
- Hunters and gatherers subsist on:
 - Animals which they hunted.
 - The edible plants which they gathered from forests in the vicinity.
- **Geographical regions** : Tribal belt of Central India and Hilly regions of North East and Eastern India.
- In India largely tribal groups particularly PVTGs are engaged in hunting and gathering. E.g. Onges, Jarawas, Shompen of Andaman and Nicobar; Bondas of Odisha, Katkaris of Maharashtra.
- **Commercial opportunities** : In modern times some gathering is **market-oriented and has become commercial.** Gatherers collect valuable plants such as leaves, barks of trees and medicinal plants and after simple processing sell the products in the market for beverages, drugs, cosmetics, fibres etc
- **TRIFED** : the institution is working to provide remunerative prices for the products gathered by tribal.

Pastoralism :

- **Domestication for subsistence:** Pastoralism undertakes **domestication of animals** for subsistence. People living in different climatic conditions selected and domesticated animals found in those regions.
- **Status of practice:** Depending on the geographical factors, and technological development, animal rearing today is practised either at the subsistence or at the commercial level.
- **Nomadic herding or pastoral nomadism** is a primitive subsistence activity, in which the herders rely on animals for food, clothing, shelter, tools and transport .
- **Geographical regions :** In mountain regions, such as **Himalayas, Gujjars, Bakarwals, Gaddis and Bhotiyas** migrate from plains to the mountains in summers and to the plains from the high altitude pastures in winters. Such seasonal migration is known as **transhumance**.

Commercial Livestock Rearing :

- Commercial livestock rearing is **more organised and capital intensive**.
- Commercial livestock ranching is essentially **associated with western cultures** and is practised on permanent ranches.
- This is a specialised activity in which **only one type of animal is reared**.
- **Products :** Important animals include sheep, cattle, goats and horses. **Products such as meat, wool, hides and skin are processed and packed scientifically** and exported to different world markets.
- **Major countries :** **New Zealand, Australia, and the United States of America** are important countries where commercial livestock rearing is practised.
- In India commercial Livestock reading is in an **underdeveloped state** due to lack of expertise and lack of investment.

AGRICULTURE :**Introduction :**

- Agriculture includes raising of crops from the land , animal husbandry , agroforestry and pisciculture. Based on methods of farming, different types of crops are grown and livestock raised. The following are the main agricultural systems.

Types of agriculture :**1. Subsistence Agriculture:**

- Subsistence agriculture is one in which the farming areas consume all, or nearly so, of the products locally grown. It can be grouped in two categories — Primitive Subsistence Agriculture and Intensive Subsistence Agriculture.

A. Primitive Subsistence Agriculture:

- Primitive subsistence agriculture or shifting cultivation is widely practised by many tribes in the tropics, especially in Africa, south and central America and south east Asia.
- The cultivated patches are very small and cultivation is done with very primitive tools such as sticks and hoes.
- E.g. Jhuming in North eastern states of India, Milpa in central America and Mexico and Ladang in Indonesia and Malaysia.

B. Intensive Subsistence Agriculture :

- In India around 80% farmers **holds small and marginal lands. Hence the are engaged intensive subsistence agriculture.**
- This type of agriculture is **characterised by dominance of the rice crop**.

- **Land holdings are very small** due to the high density of population.
- Farmers work with the help of **family labour** leading to intensive use of land. **Use of machinery is limited** and most of the agricultural operations are done by manual labour. Farm yard manure is used to maintain the fertility of the soil.
- In this type of agriculture, **the yield per unit area is high but per labour productivity is low**.
- **Due to fragmented nature** of the land subsistence farming remains **devoid of mechanisation and benefits from economy of scale**.
- **Government efforts** : Indian government has launched **Intensive agriculture development program (IADP)**. Government is putting efforts to **transform subsistence farming into commercial farming** by forming **Farmer Produce Company** where land pooling by small farmers under the administration of expert professionals would bring them higher returns from the farming.

2. Plantation Agriculture

- **Plantation agriculture was introduced by the Europeans in colonies** situated in the tropics. Some of the important plantation crops are tea, coffee, cocoa, rubber, cotton, oil palm, sugarcane, bananas and pineapples.
- It is a type of commercial farming where monoculture is practiced having strong linkages with industries.
- **The characteristic features of this type of farming are** : Large estates or plantations, large capital investment, managerial and technical support, scientific methods of cultivation, single crop specialisation, cheap labour, and a good system of transportation which links the estates to the factories and markets for the export of the products.
- **Geographical areas** : They are largely **confined to tropical areas**. In India plantation agriculture has developed in hilly areas of **north east e.g. Tea plantation , Nilgiri , Annamalai , Baba Budan and Cardomam hills etc having plantation of coffee , rubber etc**.
- **Employment** : In Southern India **plantation crops generates employment to 13 lakh people** and tea , coffee , pepper grown here **have high demand overseas**.
- **Value addition** : **Value addition** is key to get sustainable benefits from plantations. **Processing** of coffee , tea enhances their value and helps to increase demand as well.
- **Government efforts for oil palm plantation** : Cabinet has decided to promote oil palm cultivation in 20 lakh acres in four years. **Centre is spending 70000 crore on import of edible oils every year as production of oil seed is very low in the country. Even Telangana government is planning to promote oil palm plantation in 20 lakh acres.**
- **Challenges of the sector :**
 - **Monoculture** has affected quality of soil and productivity has declined.
 - Sector is suffering from **distorted policies and lack of long term vision**. Government support through budgetary allocation and institutional support like formation FPO is must.
 - **Lack of mechanisation , high labour cost and lack of scientific interventions** causes inefficient cultivation.
 - **Impact of climate change , droughts and floods**. There is need to adapt resilient farming techniques.
 - **Lack of value addition** reduces its commercial potential and fails to compete in international market.
- **Way Forward :**
 - In India plantation provides higher income compared to **traditional farming**. **Comprehensive and integrated government policy is needed to doubling the farmer income**.
 - **Farm mechanisation , inter cropping , value addition , integrated farming activities** must be integrated with traditional plantation farming.

- **Insurance cover for farmers** and **climate resilient practices** must be adopted for sustainable development of the sector.

3. Mixed Farming:

- This form of agriculture is found in the highly developed parts of the world, e.g. **North-western Europe, Eastern North America, parts of Eurasia and the temperate latitudes of Southern continents.**
- Mixed farms are moderate in size and usually the crops associated with it are **wheat, barley, oats, rye, maize, fodder and root crops.**
- Fodder crops are an important component of mixed farming. **Crop rotation and intercropping play** an important role in maintaining soil fertility.
- Equal emphasis is laid on **crop cultivation and animal husbandry**. Animals like **cattle, sheep, pigs and poultry** provide the main income along with crops.
- In India due to **dependency of farming on monsoon**, animal husbandry is seen as a stable diversified income.
- In India **cattle rearing and poultry business** are largely practiced along with farming. **India has largest population of cattle and third largest producer of eggs.**
 - **Case study :** Farmers in **Hassan district** of Karnataka have taken up **dairy farming in their coconut farms** which have shown that tending to livestock also leads to **increase in revenue from coconut trees**. Availability of slurry in abundance and cultivation of a variety of fodder on the farm have helped strengthen the coconut palms.
- Dairy farming and livestock farming creates employment in rural areas and also increases income of farmers.

4. Dairy Farming :

- Dairy is the most advanced and efficient type of rearing of milch animals.
- It is highly capital intensive. Animal sheds, storage facilities for fodder, feeding and milking machines add to the cost of dairy farming. Special emphasis is laid on cattle breeding, health care and veterinary services.
- It is highly labour intensive as it involves rigorous care in feeding and milching. There is no off season during the year as in the case of crop raising.

Indian dairy sector

Introduction :

- India is **the largest producer of milk globally with 188 million MT production in 2019-20**. It produces over one-fifth of the global milk production.
- India's dairy sector provides **livelihood to about 70 million households**. A key feature of India's dairy sector is the predominance of small producers. Due to **Operation Flood** after the 1960s, India's contribution to world milk production rose from 5% in 1970 to 20% in 2018. Today, India is largely self-sufficient in milk production.
- **Milk cooperatives**, which played a major role during Operation Flood, are no more seen as engines of growth. Therefore, **policy has also favoured the entry of multinational dairy corporations** into the Indian dairy sector, through joint ventures, mergers and acquisitions. **For instance, the Swiss firm Nestlé was the largest private purchaser of milk in India in 2019.**
- **According to NITI Aayog in 2033**, India's milk production would rise to 330 MMT while its milk demand would be 292 MMT. Thus, India is likely to be a milk-surplus country by 2033.

Significance :

- **Diversification of income** : Dairy sector has augmented income of the farmers and during distress periods of drought and flood it has ensured livelihood security through steady income.
- **GVA contribution** : In the Gross Value Added (GVA) from agriculture, the livestock sector contributed 28 percent in 2019-20. Further, India witnesses a 6% growth rate in milk production every year.

- **Nutritional support :** Milk products are a vital part of diet to reduce malnutrition and undernutrition. Inclusion of milk products under the **mid-day meal scheme** would help to reduce stunting and wasting in children.
 - With increasing urbanisation and increasing per capita income in India demand for milk products is expected to boost in coming years.
- **Women empowerment :** It is a labour intensive sector in India and the female population comprises around **69% of the sector's workforce**. Hence , the dairy sector's development directly promotes women empowerment.

Challenges faced by the sector :

- **Fragmented supply chain :** Milk is a **highly perishable product** so it requires immediate disposal at customer end. This requires a **complex supply chain having cold storage infrastructure**.
 - Milk Cooperative societies are often **not equipped with modern storage infrastructure and efficient supply chain network**.
- **Unorganised sector:** Majority of milk producers are **unorganised thus fail to advocate their organised demands**. The sector is **not guaranteed with any MSP** unlike 24 agriculture commodities
- **Poor return to farmers :** The fat based pricing policy results in **20-30% less money to farmers** compared to market prices. Therefore , **cooperatives are not preferred by landless and small farmers**.
- **Cattle feed prices:** Due to the lack of sustained availability of cattle feed and its high prices, the profit margin of the business reduces.
- **Poor economy of scale:** In 2017 , the average herd size in a dairy farm was just **2** in India. So the output compared to efforts taken to run the business is very low. Therefore young generations are reluctant to venture their business in the dairy sector.

Govt Initiatives :

- **Rashtriya Gokul Mission** :It was launched in 2014 under a national programme for Bovine Breeding and Dairy development. For development of Indigenous breeds and to improve their genetic makeup.
- The government has launched a **Nationwide AI (artificial insemination) program**. It aimed at enhancing annual milk productivity upto 3000 kg/animal.
- **KCC** : The dairy farmers have been included in **the Kisan Credit Card (KCC) programme**. It ensures adequate and timely credit support for the farmers.
- **MGNREGA** : Dairying was brought under MGNREGA to compensate farmers for the income loss due to Covid-19.

Way forward :

- **Cooperatives should strengthen their voice by uniting together.** Government should provide basic needs of the sector i.e. availability of cheap cattle feed , upgradation of supply chain network and cold storages by boosting private investment under PPP model.
- **Use of ICT technologies and promotion of start-ups** assisted by government schemes would create new employment opportunities and retain new generations in this sector.
- **Milk processing industry is a sunrise industry** so cooperatives must venture into cheese , yoghurt , ice cream products to realise untapped demand and provide more return to the farmers.

5. Co-operative Farming:

- A group of farmers form a co-operative society by pooling in their resources voluntarily for more efficient and profitable farming.
- Individual farms remain intact and farming is a matter of cooperative initiative.
- Co-operative societies help farmers to procure all important inputs of farming, sell the products at the most favourable terms and help in processing of quality products at cheaper rates.

Cooperative farming in India :

- It is an organisation of farmers **where farming is done collectively** however each member remains the **owner of his land individually**. They share their **profit in the ratio of their land holdings**.
- Cooperative movement in India has started during British rule however it gained the strength due to reforms after independence and favourable policies.

Evolution :

- **Gandhian , socialist ideology** believed that cooperative farming would improve the status of Indian agriculture.
- **Land reforms** : Land reforms targeted towards abolition of Zamindari , removal of middle men tenancy reforms etc were aimed at increasing cooperation between farmers to increase the agriculture production.
- **Evolution of FPO's-** Farmers Producer Organisation are complementary to the progress of cooperative farming. FPO's are aggregation of small , marginal and landless farmers aimed at increasing economic strength of famers. Over 4,000 FPOs are supported by NABARD and SFAC.
- **FPC- Farmer Producer Company** these are registered under Companies Act. These are combination of cooperative sector and companies act.
- **State subject:** Constitution has included Cooperatives is a **state subject** giving ultimate rights to state to develop them depending upon local conditions.
- **Ministry of Cooperation:** Recently the Government of India constituted an **independent Union Ministry of Cooperation (MoC)**.The Ministry would work towards a cooperative based economy by providing ' **administrative, legal and policy framework' and 'Ease-of-doing-business for cooperatives.'**

Significance :

- It helps in extending benefits to small farmers which generally enjoyed by big farmers due large farm size.
- **According to the planning commission** , cooperatives represents institutionalization of the principle and mutual aid. It has the merit of combining freedom and opportunity for the small man with the benefit of large scale management and organisation.
- **Economies of scale** : In India 80% farmers are small and marginal. **Land pooling enables mechanisation of farming and precision irrigation** thus improves the overall productivity of land. This increases per capita output of the members.
- **Combination of inputs** : It provides platform where farmers can come together and **share efficient and scientific methodologies thus modern practices** can be implemented. Such complementary exchange of **ideas , capital , labour , livestock** would help to reap the maximum output from the farming.
- co-operative farming is likely to lead to **an increase in the quantum of marketable surplus** by making the collection of **surpluses easier than under individual farming**.
- **Access to credit** : Availability of credit to cooperatives is easy due to combined creditworthiness of the members.
- **Doubling farmers Income** : Effective organisation of cooperatives would help to realise doubling of small farmers income.

Case studies :

Maharashtra :

- The **rural development in Maharashtra revolved** around the cooperative movement for decades.

Success of cooperative farming lies in various reasons :

- Cooperatives did not remained restricted to farming activities only. Cooperative organisation in milk , sugar , banking etc formed **complementary institutions for development of each other**.

- **The rural politics in Maharashtra largely controlled by these cooperatives.** Hence political currency gained by cooperatives compelled state government to provide necessary support in the form of SAP- state advised prices for sugarcane.
- **Dedicated political parties like Shetkari Sanghatana** helped to maintain continuity in farmers welfare.

Way forward :

- **Success of cooperative movement has restricted** to few states like Maharashtra and Gujarat. At all India level cooperatives have failed put their positive impact. Due to political control and corruption in the cooperative institutions.
- **FPC :**
 - It is a **hybrid between cooperatives and private limited company registered under companies act.** It would **plug the structural vulnerabilities of agriculture sector.**
 - It organise farmers into collective group to **improve their bargaining strength.**
 - They are owned and governed by shareholder farmers and **administered by professional managers.**
 - It combines **good principles of cooperatives and efficient practices of companies.**
 - FPC's would increase farmers control over company under statutory provisions thus removes flaws of cooperative organisation.
 - Success story of largest FPC – **Sahyadri farms** can be replicated throughout the country.
- **Dedicated ministry and success of FPC model** can rejuvenate the agriculture sector and can play vital role in realising goal of doubling the farmers income.

6. Collective Farming:

- The basic principle behind this type of farming is based on **social ownership of the means of production and collective labour.**
- **Collective farming or the model of Kolkhoz** was introduced in the erstwhile Soviet Union to improve upon the inefficiency of the previous methods of agriculture and to boost agricultural production for self-sufficiency.
- The farmers used to pool in all their resources **like land, livestock and labour.** However, they were allowed to retain very small plots to grow crops in order to meet their daily requirements.
- **Benefits :**
 - **Economy of scale** : Pooling of land and means of production helps in realising **fruits of economy of scale.**
 - **Fair distribution** : Distribution of output as per individual inputs.
 - **Social harmony** : It helps in **social harmony** as farmers belongs to **different cast and creed come together** and practice farming.
 - **Women empowerment** : It helps in efficient utilisation of land , water management and women empowerment as large number of rural women are engaged in farming.

7. Mediterranean Agriculture :

- Mediterranean agriculture is highly specialised commercial agriculture. It is practised in the countries on either side of the Mediterranean
- Viticulture or grape cultivation is a speciality of the Mediterranean region.
- Best quality wines in the world with distinctive flavours are produced from high quality grapes in various countries of this region.

8. Market Gardening and Horticulture :

- Market gardening and horticulture specialise in the cultivation of high value crops such as vegetables, fruits and flowers, solely for the urban markets.

- Farms are small and are located where there are good transportation links with the urban centre where a high income group of consumers is located.
- This type of agriculture is well developed in densely populated industrial districts of north west Europe, north eastern United States of America and the Mediterranean regions.
- The regions where farmers specialise in vegetables only, the farming is known as truck farming. The distance of truck farms from the market is governed by the distance that a truck can cover overnight, hence the name truck farming.

Horticulture sector in India

Introduction :

- Horticulture is a subtype of agriculture which deals with **cultivation of fruits , vegetables , flowers , aromatic plants and medicinal herbs**.
- Share of horticulture is **more than 33% in agriculture**. Fruits and vegetables account **for 90% of total horticulture production in India**.
- India is **second largest** producer of fruits and vegetables.
- **As per Third Advanced Estimates(2018-19)** of Area and production of various Horticulture Crops , the total horticulture production of various horticulture crops is estimated to be slightly higher than horticulture production of 2017-18.

Significance :

- **Low input cost** : Horticulture crops requires less amount of inputs , pesticides ,water etc compared to food grains and plantation crops.
- **Diversification of income** : Horticulture sector is a prominent driver of agriculture growth to realise doubling income of farmers. Horticulture is important in fragmented nature of Indian agriculture which augments the income of small farmers.

E.g. Vegetables provides seasonal additional income to farmers.

- **Employment** : Horticulture sector has strong linkages with food processing industries thus creates wide range from employment in forward and backward linkages , ware houses and value addition etc.
- **Exports potential** : includes variety of cultivation, Fruits and Nuts(Pomology) , Vegetables(Olericulture) , Flowers(Floriculture) etc. These wide variety of products holds huge potential of exports after processing.

E.g. Huge demand for Alphonso mangos in European market.

- **Food processing** : It is a sunrise industry directly depends upon horticulture for its raw material.

E.g. Jam , Ketchup , jelly , chips etc

- **Urbanisation** : With increasing per capita income demand of healthy diet including green vegetables and fruits would increase in coming years.
- **The production of horticulture has overcome the production of food grains** in India.
- **Agro-climatic diversity** : Diverse agro-climatic conditions and diverse soil helps to grow wide variety of horticulture crops. E.g. root and tuber crops , ornamental crops , medicinal and aromatic plants etc

Challenges :

- **Monsoon dependency** : Dependency over monsoon and lack of irrigation makes it risky venture for farmers.
- **No MSP** : Horticulture products are not covered under MSP regime hence **no guarantee of minimum returns**.
- **Supply chain networks** : Poor supply chain networks and lack of cold chain storage **compels distress sales** for farmers due to its perishable nature. It **causes huge wastage** of horticulture crops.
- **Lack of mechanisation** : Due to traditional farming , less mechanisation and modernisation **productivity is less and input costs are higher**.

- **Fluctuation in prices** : Seasonal production and supply and demand mismatch causes high fluctuations in prices.
- **Poor commodity market** : Commodity market in India is not developed in India which prevents farmers from realising remunerative prices.
- **Lack of awareness regarding market intelligence**, foreign demand and failure to clear international standards for sanitary measures prevents farmers from tapping export potential of crops.

Government Initiatives :

- **Mission For Integrated Development Of Agriculture(MIDH)** to promote holistic growth of horticulture sector. It encouraged formation of farmers FPO's to enhance horticulture production and augment farmers income.
- **Pradhan Mantri Kisan Sampada Yojana(PMKSY)** : It is an umbrella scheme for creation of modern infrastructure with efficient supply chain management from harvesting to counter sale.
- **Operation Greens** : It was announced in 201-19 budget for enhancing value realisation of Tomato , Onion and Potato. Under the scheme Indo-Israel cooperation was envisaged for transfer of new technologies and capacity building of farmers.

Way forward :

- The sector holds strong prospectus to spur agriculture growth , doubling diversification , employment creation and stimulate food industry.
- Government policy should directed towards sufficient budgetary allocation , infrastructure development , strong forward and backward linkages , technological upgradation and R&D.

INDIAN AGRICULTURE SECTOR

Introduction:

- Agriculture is a **primary economic activity mostly dependent upon unskilled workers**.
- It is the **largest employment provider** in India. The agriculture sector employs **over 52% of the workforce**.
- According to the **Economic Survey 2020-2021**, agriculture constitutes **19.9% of the gross domestic product (GDP)**, up from 17.8% in 2019-20
- From a meagre 55 million tonnes, production of food-grains has increased to a record **308.65 million tonnes last season (July 2020-June 2021)**.
- **The Green revolution** which made the country self-sufficient in food grains. India stands among the top 10 agricultural products exporters.
- Government of India aimed to achieve **doubling of farmers income by 2022**. To achieve this NITI ayog has identified three strategies : **Modernizing agriculture , Policy and governance reforms and creation of value chain and rural infrastructure**.

Increase in share of agriculture employment :

- **The latest PLFS report** : It shows a sharp increase in employment in agriculture from 42.5 per cent of the total employment in 2018-19 to 45.6 per cent in 2019-20. According to the PLFS, manufacturing, construction and transport, storage and communication are the top losers of employment.
- **Safety net** : Agriculture provides a low wage safety net for labour during times of distress in India. It is a sign of distress in the labour market where non-agricultural sectors are unable to provide employment and labour is forced to shift to agriculture.
- However the biggest increase in employment in 2019-20 was in agriculture and within agriculture the increase was largely among women.
- Agriculture has emerged as a bright spot even during the pandemic, which has absorbed migrated workers from cities.

- Thus agriculture with right intervention by government **would evolve as a major employment creator when other sectors are failing to create them.**

These interventions could be :

- **Startups** :Promotion of agri processing industries by **incentivising private investment and new startups in the sector.**
- **FPO** : **Formation Farmer produce companies** are emerging to increase remuneration from agriculture sector and also retaining youth generation in the agriculture.
- **Forward and backward linkages** : **Development of Forward and backward linkages** in the rural areas would create new forms of employment in packaging, storage, processing, logistics, food preparation, restaurants etc
- **Technology** : **Use ICT technologies** to increase agriculture labour productivity.

Major constraints in Indian agriculture are:

- **Operational holdings** : According to the 2010-11 Agriculture Census, **an average operational holdings size of Indian farmers is 1.15 hectares and 85 per cent are in marginal and small farm categories of less than 2 ha.**
- **Subsistence agriculture** : Indian agriculture is **largely subsistence oriented** which deprives benefits of economy of scale due to small holdings and inability to practice mechanised farming.
- **Lack of credit** : **Poor access of credit and farmers trapped under the clutches of unorganised creditors** forces them distress sale with low remuneration.
- **Forward and backward linkages** : **Due to lack of forward linkages value addition and primary processing to farm products is very low** as compared to developed countries.
- **Lack of irrigation** : **Poor infrastructure , Lack of irrigation and erratic monsoon** makes farming unsecured which pushes the young generation with their vigour and entrepreneurship away from the sector.
- **The key challenges of agriculture in India** : small holdings of farmers, primary and secondary processing, supply chain, infrastructure supporting the efficient use of resources and marketing, reducing intermediaries in the market.
- There is a need for work on **cost-effective technologies with environmental protection** and on conserving our natural resources.

Future scope :

- **Diverse climatic zones** : India has **large arable land with 15 agro-climatic zones** as defined by ICAR. Such diverse fertile conditions are capable of growing a variety of crops.
- **Precise practices** : With the evolution of **new concepts like 'precision agriculture', 'farm to fork' and 'farming as a service', technology** is playing a decisive role in this sector by increasing its economic outputs.
- **Urbanisation** : Increasing population, urbanisation , increasing average income and globalisation effects in India will increase **demand for quantity, quality and nutritious food, and variety of food**. Capturing these demands by enhancing processing and value addition capabilities would make the agriculture sector one of the sunrise industries in coming years.
- **Industry 4.0** : Apart from this, **intervention of Information Technology , IoT , AI and ML in agriculture, private investments on research and development, government efforts** to rejuvenate the cooperative movement to address the problems of small holdings and small produce etc are changing the face of agriculture in India.
- **Many start-ups in agriculture by professionals** : It indicates admiration of the high potential of putting money and effort into this sector. Cumulative effects of technology and required investment in the sector will be the key drivers in the days to come.

Changing trends in agriculture modernisation :

- Protected cultivation of **green and other vegetables.**

- Innovations in the field of **innovative products , better seeds , fertilisers , customised farm machinery for increasing productivity.**
- **Use of biotechnology** for creation of eco-friendly , climate resilient and nutritious crop varieties.
- **Artificial intelligence** led automation for precise application of inputs using sensors and drones.
- Use of **nano technology** to minimise nutrient losses in fertilisation and pest management.
- India has improved remarkably in **digital connectivity** and market access has become very easy.

To gain maximum out of these trends for employment generation and increasing productivity **skill impartation to farmers is need of the hour.**

Agro based Industries and agro processing industry :

- **Inputs** : Agro Based industries involve **supplying of farm and agriculture inputs and processing and value addition of the agriculture produce** for the intermediate and final consumption. These industries mainly **depends upon raw material provided by the agriculture.**

E.g. **Cotton for cotton textile industry , sugarcane for sugar industry , milk for dairy products etc.**

- **Employment generation** : The agro and food processing industry are labour-intensive which has potential to create vast employment opportunities in the rural areas. Local employment opportunities would help to restrict urban migration and would create urban facilities in rural areas.
- The Agro-based industries are the **major avenue to accomplish the goal of doubling the farmers income.**
- **They absorb the surplus rural labour** and address the problem of large-scale unemployment in rural areas.
- **Sunrise industry** : NITI ayog has identified Food processing industries as sunrise industry having huge domestic demand which has ability to uplift the unorganised sector.
- The food processing sector contribution in India's **GDP is less than 2%**. Thus need private investment and new start-ups to exploit its true potential.

Significance :

- **Income diversification** : These industries also provide profitable diversification in the rural areas which ensures an all-round industrial growth in the rural areas.
- **Income composition** : The contribution of cropping and animal husbandry in the total income of the farm households is only 35 per cent while wages and service contribute to more than 50 per cent in the average monthly income.
- **Employment** : The Annual Industrial Survey, 2016-17 showed that the agro-industries contribute about 36 per cent of the industrial employment. Substantial employment is generated in production agriculture and supply chain.
- **Forward and Backward linkages** : Development of these linkages in post-harvest management ,warehouses , cold storages , logistics facilities etc would shift surplus labour from the farming sector to more productive industrial activities.
- **Restrict migration** : Agro-based employment in rural areas would restrict the urban migration and potential well earning customer base in rural area will attract urban facilities as well.

Impact of reverse migration during pandemic :

- **Utilisation of their skills** : Pandemic led reverse migration of labourers and closure of workspaces in urban areas could have a **positive impact on the rural agricultural sector**
- Migrants that returned home and are **now involved in farm work**. Use of **their skills and knowledge can boost livelihoods and quality of life in India's villages.**
- One of the major challenges of Indian agriculture is ineffective outreach of extension efforts. If messages/technical details on **improved agriculture practices and information** related to the weather and markets could be **passed on**

- to the villages in local languages via the migrant workers, using social media, it would boost the agriculture sector in huge way.
- It may lead to enhanced or diversified production, fewer losses due to the vagaries of weather, and better price realisation.
 - Agro-processing at a small level :** It can contribute in a large way in enhancing farm income. Migrant workers, many of whom have technical skills, can be groomed as entrepreneurs/operators.
 - This would be a source of sustainable livelihood for them,** and at the same time, the availability of agro processing right in the neighbourhood would help farmers to realise better prices.

Way forward :

- India is going to become the world's most populous country in the next decade and providing food for them will be a prime concern before policy makers.
- Farmers are still not able to earn respectable earnings.
- To solve these problems , agriculture and food processing GDP contribution has to rise around 20% while surplus labour needs to be deployed in manufacturing and food processing.
- Following reforms** can be considered to direct future of agriculture sector :
 - Impetus should be given on sustainable yield improvements through scientific farming practices.
 - Enhance agriculture marketing framework to increase farmers' price realisation through policy changes. Direct marketing through farmer producer organisations can be promoted.
 - Formulate an Integrated Agriculture Export Mission to scale up food processing and exports by increasing value addition from 10% to 50%.

MINING Sector in India

Introduction :

- The Mining industry in India is one of the core industries of the economy. It provides basic raw materials to many important industries.
- The rise in infrastructure development and automotive production is driving the growth of the metals and mining industry in India.
- Minerals like manganese, lead, copper, alumina are expected to witness double-digit growth in the years ahead. There is a significant scope for new mining capacities in iron ore, bauxite, and coal.
- Objectives :**
 - Double the area explored from 10% of obvious geological potential(OGP) area to 20%.
 - Increase the employment contribution to 15 million in 2022-23.

Significance :

- Growth :** According to the government's own assessment, one percentage point growth in mining pushes up the growth rate of industrial production by 1.2-1.4 percentage points.
- Employment :** One direct job in the sector creates 10 indirect jobs.
- It is a labour intensive industry** which provides employment opportunities largely to unskilled labourers.
- Production :** India is the world's second-largest coal producer and being the 5th largest country in terms of coal deposits. It is a net exporter of finished steel and has the potential to become a champion in certain grades of steel.
- Gross Value Addition :** The mining and quarrying industry's contribution (at current prices) to GVA accounted for about 2.38% for the first quarter of the year 2018-19.
- As per 2019 data , the mineral sector's contribution to the GDP is 1.75 percent.
- National Mineral policy 2019 :** It directs to increase the domestic mineral production and reduce trade deficits in the mineral sector in the next 7 years.

Government Initiative :

- **FDI up to 100%** under the automatic route is allowed with certain clauses.
- **PLI scheme** : GOI has given approval to introduce **the Production-Linked Incentive (PLI) Scheme** in Specialty Steel for Enhancing India's Manufacturing Capabilities and Enhancing Exports.
- The Government has amended the **Mines and Minerals Development and Regulation Act 1957 (MMDR Act)** and **National Mineral Exploration Policy 2019** have brought further transparency, better regulation and enforcement, balanced social and economic growth as well as sustainable mining practices.
- **The NMP 2019 aims to attract private investment** through incentives while the efforts would be made to maintain a database of mineral resources and tenements under the mining tenement system.
- **Mission Purvodaya** : It emphasized to unlock the potential of the eastern India region to fuel the next wave of national growth.
- **The mining surveillance system** has been operating to curb illegal mining activities.
- **District Mineral Foundation Fund** has been established for the wellbeing of mining affected people.
- **KABIL** initiative to ensure supply of critical and strategic minerals to Indian industries.

National Mineral Policy 2019 :**Key proposals of the National Mineral Policy 2019 :**

- **Production** : It envisages to increase the production of major minerals by 200 percent and reduce trade deficit in the mineral sector by 50 per cent in seven years.
- **Revenue sharing model** : It adopted a revenue sharing model to encourage the private sector in exploration.
- **Private investment** : Policy aims to attract private investment through concessions like financial package, right of first refusal at the time of auction etc.
- The policy has provision for transfer of mining leases and creation of dedicated mineral corridors to boost private sector mining areas.
- **Export-Import policy** : It provides emphasis on a long term export-import policy for the mineral sector to give stability for investing in large scale commercial mining activity.
- **Exclusive Mining Zones** : Policy has introduced the concept of 'Exclusive Mining Zones' which will come with in-principle statutory clearances for grant of mining lease.
- **Easy clearance** : Policy would simplify the process of clearance and would make it a time-bound process for mineral development and commencement of mining operations.
- Certain areas would be declared as **no-go areas or inviolate areas** considering fragility of the ecosystem.
- **District Mineral Fund** : Policy emphasises on proper utilisation of District Mineral Fund to ensure welfare of mining-affected people by providing rehabilitation and resettlement to affected people.
- Policy has introduced the concept of **Intergenerational Equity** in mineral resource exploitation.

Challenges :

- **Issue of displacement and rehabilitation:** Acquisition of land for mining causes displacement of tribal groupings which creates discontent against the government due to poor rehabilitation of affected people.
 - These conditions are fertile to grow Left Wing Extremism in mineral rich areas of Jharkhand , Chhattisgarh , Odisha.
- **Environmental issues:** Mining causes loss of vegetation cover and loss of biodiversity. Pollution of Damodar river and Kopili river provides evidence for water pollution. Baseline pollution monitoring data in most of the mining areas is very poor.
 - Limitless mining activities in western ghats have intensified flood conditions in kerala.
- **Rat hole mining :** This illegal mining has caused death to mining workers in Meghalaya. Though it was banned since 2015 poor people get engaged in such activities and lose their lives.

- **The sector is affected by legalities** which has restricted the scope of mining operations and raised costs.
- **Lack of skills** : Inadequate infrastructure resulting in **evacuation problems** and poor workforce productivity due to **disconnect between training institutions and industry**.

Way forward :

- **Effective implementation of National mineral policy 2019** and transparency in mineral block allocation must be maintained.
- **Single window and time bound environment , forest clearance** will be key to timely allocation of blocks and meeting the demands of industrial sectors.
- Effective conduct of **Environment Impact Assessment(EIA) and Social Impact Assessment(SIA)** must be ensure before allocation of any project.
- **NGT guidelines** must also be followed for protection of ecological sensitive areas. E.g. Recently NGT has ordered UP govt to take remedial actions to curb illegal sand mining.
- **Proper rehabilitation of mining project affected displaced persons** and utilisation of district mineral fund for their welfare is mandatory to gain trust of these people. It **will restrict them from supporting Left wing extremism activities**.
- Practising **global safety standards to avoid occupational hazards** is required and strong actions must be taken to stop illegal rat hole mining.

Conclusion :

- India has **huge mineral potential but explored area is very minimal** compared to actual potential which has caused huge minerals import bill.
- Sustainable and regular supply of minerals is **key to uninterrupted functioning of industrial sector which is growth engine of any economy**.
- India has no room to miss its mineral sector objectives hence effective functioning providing expected output is **must maintain growth rate of 8-9% per year**.

SECONDARY SECTOR :

Introduction :

- Secondary sector includes industrial sector which **processes natural raw material and converts them into finished products**.
- Secondary sector is the backbone of economy which **provides employment to people who moved from primary sector and have gathered certain skills**.
- In India secondary sector has not achieved its true potential and service sector has emerged as largest sector in economy.
- Presently secondary sector **contributes 16-17% of GDP** and **rate of employment is declining over the last 5 years**.
- Sector includes **Agrobased industries , automobile industry , iron-steel industry etc**.

Importance of industrial sector in Indian context :

- **Backbone of economy** : Manufacturing sector is considered as **the backbone of development of any nation**.
- **Transition** : With development share of primary sector in economy decreases and generally replaced by industrial sector.
- However unfortunately in Indian case **economy transformed from primary sector to tertiary sector without realising true potential of industrial sector**.
- **Employment** : Industries allows mechanisation of primary sector such as agriculture , mining and provides job opportunities in industries to people who were earlier engaged in primary activities.
- **Poverty alleviation** : This sectoral transformation to industrial sector is **precondition for eradication of unemployment and poverty**.

- Before corona pandemic contribution of manufacturing sector was mere **16% of GDP** which is very low compared to **south Asian economies where industrial share is around 30%**.
- Also sector is **not creating employment opportunities** as per growing demands.
- In India **manufacturing has never been the leading sector** in the economy other than during the Second and Third Plan periods.
- Hence **increasing its share up to 25% in GDP** and creation of **new 100million jobs** are the aims of industrial policy.

Significance :

- **Demographic dividend** : India is going to witness largest demographic dividend in coming decade. Manufacturing sector is vital as it can create labour-intensive jobs and can promote an improved standard of living for the future generation.
 - E.g. **Textile , Automobile sectors** have huge demand and potential to create new jobs.
- **Cheap labour** : The **labour cost is low** compared other economies.
 - E.g. Due to cheap and skilled labour availability global value and supply chains are moving towards to India.
 - It is the right time to **implement new generation economic and structural reforms to integrate these global chains within Indian economy.**
- **Advanced manufacturing sector** and **skilled human capital** would help India to gain maximum benefit from Global supply and value chains.
- **Enhancement in Exports** : **Export of manufactured goods expands** trade and commerce, and brings in much needed foreign exchange.

E.g. **Promotion of SEZs , NIMZs** provided with wide concessions have potential to raise Indian share in global exports.

- **Equitable growth** : It was also aimed at **bringing down regional disparities** by establishing industries in tribal and backward areas.

E.g. **Promotion industries In backward areas** have helped in distributing fruits of development in remote areas as well. Development of **Vidarbha region of Maharashtra**.

Types Industries :

Manufacturing Industries can be classified based on various grounds. The following are some basic classifications of the industries :

On the basis of raw material:

- **Agro based Industries** : These industries obtain their raw material from agriculture. E.g. Cotton and Jute textile.
- **Mineral based Industries** : These industries receive their raw material mainly from minerals such as iron and steel , aluminium etc.
- **Chemical based Industries** : Such industries use natural chemical minerals e.g. mineral oil is used in the petro-chemical industry , Synthetic fibers , plastic etc
- **Forest based Industries** : These industries receive their raw material from forest. Basket industries , paper card-board , lac , resin based industries.

On the basis of Finished good :

- **Heavy Industries** : These industries use bulky raw material and produce bulky raw materials. E.g. Iron steel Industry
- **Light Industries** : The finished products are light in weight. E.g. electric fans ,sewing machines etc.

Miscellaneous Industries :

- **Cottage Industries** : These are set up by artisans who work with wood , cane , brass etc. Handloom , khadi , leather work falls in this category.

- **Ancillary Industries** : The industries which manufacture parts and components to be used by big industries are called ancillary industries.
- **Capital Intensive Industries** : The industries which require huge investment are called capital intensive industries. E.g. Iron and steel industry.
- **Labour Intensive Industries** : They require a huge labour force for running them. E.g. Shoe making industry.

Concept of high technology Industry :

- These are the latest generation of manufacturing activities which includes **application of intensive research and development (R and D) efforts** leading to the manufacture of products of an advanced scientific and engineering character.
- **Professionals and highly skilled workers** make up a large share of the total workforce.
 - E.g. Robotics on the assembly line, computer -aided design (CAD) and manufacturing, electronic controls of smelting and refining processes, and the constant development of new chemical and pharmaceutical products are notable examples of a high-tech industry.
- Planned business parks for high-tech start-ups have become **part of regional and local development schemes**.
- High-tech industries which are regionally concentrated, self-sustained and highly specialised are called **technopolis**. The **Silicon Valley near San Francisco and Silicon Forest near Seattle** are examples of technopoles.

Factors influencing the location of Industries :

There are range of factors influencing the location of the industry which can be divided into two broad categories ,

- Geographical factors.
- Non-geographical factors.

Geographical Factors

1. Raw Materials :

- Raw material has been the **most fundamental** deciding factor of industrial location. The optimum location would be where the transportation cost is minimum. **Transportation cost is calculated on the basis of the distance and weight of goods**.
- According to **Alfred Weber's industrial location theory**,
 - **Case-1:** when the **raw material is ubiquitous** in nature then industry location will be in-market to save transportation cost.
 - **Case-2:** When the **raw material is localized** in nature and pure raw material then industrial locations will be anywhere between the source of raw material and the market.
 - **Case-3:** When the **raw material is impure**, then the industry will be near to raw material locations to save transportation costs.
- **Footloose industries :**
 - Footloose industries have more freedom to choose their locations. They do not have critical dependency over any particular raw material.
 - The final product is always high value and lighter in weight thus can be transported easily.
 - Such industries are often located with no reference to raw materials and are referred to as '**footloose industries**'.
 - These includes watch making , diamond cutting , mobile assembly etc.
 - E.g. **Apple has established its mobile assembly plant in Bengaluru**.

2. Power :

- Regular supply of power is **prerequisite for continuous industrial production**.
- Most of the large and heavy industries tend to concentrate at the source of power.

E.g. Iron and steel industry mainly depends upon coking coal as a source of power hence are located near coal fields.

- **The industries moved to southern states only when hydropower could be developed** in these coal deficient areas. Thus a cheap and regular supply of power is a vital factor while selecting an industrial location.

E.g. Cotton industries moved to south due to availability of cheap power from Pykara dam.

3. Labour :

- The location of any industrial unit is determined after **balancing all the relevant factors**.
- However , **light consumer goods and agro-based industries are labour intensive** hence tend to locate where a cheap labour force is available.
- The large MNCs have their production and assembly units dispersed across the world depending upon the expertise and cost of labourers.
- **The global value chain is largely controlled by skills and cost of labourers.**

E.g. Apple designs and sells the iPhone, it doesn't manufacture its components. Various components of Apple products are manufactured across the world and finally assembled in China and India.

- **Impact of Industry 4.0 on labourers :**

- The intervention of robotics , AI and ML have **changed the role of labourers in their functioning**. Industries are **moving towards automation** reducing manual labour employment.
- This has created new employment opportunities for skilled labourers who **would control and regulate these automated processes**.
- Hence there is increasing **demand for upgradation of labour skills** to remain relevant as per changing demand of the industry.
- With more penetration of these technologies **threat of unemployment is inevitable**. Therefore early intervention for skilling the labourers **to make them skilled to be accepted at global scale is much needed**.

4. Market :

- Nearness of market is essential for **quick disposal of manufactured goods**.
- It decreases the transport cost and **makes products cheaper**. Automobile industries are largely located near metro regions due to the availability of a huge market.
 - E.g. Mumbai-Pune , Chennai , Kolkata are chief centres of automobile production.

Impact of Online Shopping :

- Due to increasing share of online shopping range of clients has widened to all India level. This aspect has **reduced the importance of being nearer to specific market**.
- Now industries are **tend to establish their warehouses at central location** having efficient transportation and logistics facilities thereby ensuring delivery of products within few days.
- Share of online shopping in **textile and electronics sector** has increased manifolds reducing the urge to establish plants near to particular market.
- E.g. Centralised locations like **Bengaluru in south India , Noida in North India** have been preferable choices to establish warehouses having industrial location based upon other suitable factors.

5. Transport :

- It is an essential factor **for assembly and marketing of the product**.
- Development of **railways** and connecting the hinterland with the **port cities** have determined the location of many industries **around Kolkata , Mumbai and Chennai**.
- Cluster of industries developed along **the Delhi-Mumbai Industrial corridor** exhibits the significance of the transport in industrial development.

- Interior connectivity through road networks **has boosted logistics sector** which is in high demand due to **online order and home delivery of merchandise.**

6. Water :

- Industries like **textile , chemical and iron- steel** require huge amounts of water for their functioning hence proximity to water resources is beneficial for these industries.
- E.g. Jute industry in Bengal is benefited due to closeness of Hugli river.

7. Climate :

- **Extreme climate obstructs industrial development** e.g. North west India.
- **Cotton textile industries require a humid climate** because thread breaks in dry climate. Hence , cotton industries have flourished in coastal areas of Maharashtra and Gujarat.
- **Sugar industries** have migrated to southern India due to climatic conditions helps to increase sucrose content of sugarcane and retains for longer time compared to continental climate.

Non Geographical factors :

1. Capital :

- Establishment of an Industrial unit **requires huge investment.**

- Easy availability of **capital and government subsidies** can determine the location of industry in any particular state or near a financial hub.
- **Capital Intensive Industries** like Telecom industry , Automobile industry etc requires huge capital to kick off the business.
- Compared to primary and tertiary sector , secondary/industrial sector requires larger capital.
- **Strong banking sector and cheaper interest rates along with subsidies** conferred by states can attract industries to particular location.
- Due to **increasing cost of labourers and complexity of labour laws** industries are moving towards automation which requires capital investment.
- Indian economy has been revived **from twin balance sheet syndrome and pandemic led recession** demands high investment in the industrial sector to expand their businesses.
- Government should align **industrial credit demands with monetary policy of RBI** to extend greater credit to industrial sector with special emphasis on MSME sector.

2. Government Policies :

- The influence of **India's Five year plans on industrial location** can determine the vitality of this factor.
- **Second Industrial policy of 1956** was influenced by socialist ideology which resulted into establishment of industries like **BHEL , Durgapur and Bhilai steel plant controlled under public sector enterprises**.
- Under **competitive federalism** different state policies are attracting industries with their incentives to set up in their states. E.g. **Gujarat's industrial policy has attracted Nano plant of TATA** from west Bengal due to favourable government policies and incentives.
- **National manufacturing policy and make in India have relaxed FDI limits** to boost foreign investment in India. This has enabled hi-tech giants GE , Toshiba either setup their plants or proliferate their business in India.
- **India's Production Linked Incentive (PLI) scheme has attracted Foxconn , Pegatron companies to set up in India.**
- **Case study of IT revolution :**
 - The government invested to create **high speed internet connectivity** which helped in integration of Indian IT industry and US market.
 - High speed connectivity enabled **faster data flow and easy communication**.
 - Later government allowed IT industry **to duty free import of hardware and software**.
 - IT industry were established under the **Shops and Establishment Act** which require less compliances.
 - Government boost to higher education specially engineering colleges provided **skilled labourers at low cost** which attracted investment and MNCs in India.

Recent exit of General Motors , Harley Davidson , Ford :

- These global giants have closed their plants India in recent years **due various reasons like low demand ,business losses etc.**
- Their withdrawal is big worry for India's manufacturing sector. The government efforts to retain these giants have failed absolutely.
- There is a need to revamp the government policies to **cater the needs of MNCs** which may fail to gather domestic market. These companies **must be given concessions to export from India to other countries**.
- **So that their business remain in profits and they could survive in Indian market** striving to increase footprint in local market.
- **Also promotion of joint ventures with Indian players** could help them to increase their market share e.g. success story of Maruti-suzuki

3. Access to agglomeration Economies :

- Many industries **benefit from nearness to a leader-industry and other industries.**
- Benefits are derived from the linkages which exist between different industries.
- Functionally dependent industries tend to cluster together where **the final product of one industry may act as a raw material for another**

4. Industrial Inertia

- Industries tend to develop at the place of their **original establishment due to inertia of the region**. E.g. Lock Industry at Aligarh.

5. Historical Factors:

- **Mumbai, Kolkata and Chennai locations** are greatly influenced by our colonial past. Manufacturing activities in these regions received great impetus provided by the European traders. These locations enjoyed the benefits of early start.
E.g. Colonial legacy helped **initial growth of Cotton industry in Mumbai and western Maharashtra**.
E.g. Historical trade with South East Asian countries helped growth of southern ports like **Chennai, Kochin etc** and associated **ship building industries**.

INDUSTRIAL POLICY

Introduction :

- Industrial policy is a **broad concept** which **controls and regulates industrial development and shapes the patterns of industrialisation**.
- It **incorporates fiscal and monetary policies, tariff policies, labour policies and other policies** which may influence industrial growth of the country.
- Post-independence evolution of industrial policies took place in various stages. **It began with 1948 Industrial policy followed by 1956, 1977, 1980 and Industrial policy of 1991**.
- The industrial policy of 1991 accompanied with LPG reforms brought major changes in the industrial outlook of the country.
- There is a need to understand the two different regimes of industrial control and regulations post and before 1991 policy.

Regulation over industries before 1991 :

- **The 1948 policy envisaged a mixed economy** in which both public and private sectors were involved.
 - It classified industries into **4 types** where,
 - **strategic industries** (Arms, Atomic and Railway) were **under government monopoly**,
 - **Key industries** were to be set by the central government allowing continuation of the existing private sector under government control.
 - **Important and other industries** were allowed to be set up by the private sector having ultimate control of the government.
- **The 1956 policy** contemplated development of **heavy industries under the public sector** for self-reliance and employment generation.
 - It encouraged **village and small scale enterprises**.
 - It further **reduced the scope for private sector** in industrial development by regulating them under license raj and quota system.

Implications of policies before 1991 :

- **Corruption and red tapism** : Until 1991 the **private sector was required to obtain a license** to start any industrial activity. The system was marred with **corruption, red tapism etc**.

- **Less competition** : The **big corporations were barred from entering into sectors reserved for small scale industries.**
- **Less employment** : The overall system showed **sluggish growth and poor employment generation** due to lack of competition , lack of innovation.
- **Protectionism** : The economic outlook of the government was **inward looking guided by import substitution policy and protectionism.**
- **Lack of R&D** : Mere protectionism **did not help Indian industries to excel because government monopoly and control prevented competition from private players** and lack of R&D work by the enterprises.

1991 policy of Liberalisation, Privatisation, Globalisation (LPG)

Introduction :

- The new Industrial Policy was announced in 1991.
- The policy has three main dimensions: **liberalisation, privatisation and globalisation.**
- It was envisaged **to unshackle the Indian industrial economy from bureaucratic control.**
- **Policy of nationalization was stopped** and encouragement for disinvestment was given.
- **India joined the WTO regime** and was obliged to reduce its tariff and non tariff barriers.

Objectives : The major objectives of this policy were to build on the gains already made, correct the distortions or weaknesses of the existing system ,maintain a sustained growth in productivity and gainful employment and attain international competitiveness.

Liberalisation : It implies loosening of control and regulations by the government and enhancing scope of the private sector.

- The industrial policy has been **liberalised to attract private investors both domestic and multinationals.**
- Following **measures** have initiated under this policy : Abolition of industrial licensing, free entry to foreign technology, foreign investment policy, access to capital market, open trade, abolition of phased manufacturing programme, liberalised industrial location programme.

Privatisation : It implies **deregulation of the market , inclusion of the private players** in the industrial sectors where they were earlier denied. **Decreasing government sharing in PSUs** and increasing private share through disinvestment.

- **New sectors** like mining, telecommunications, highway construction and management have been **thrown open to private companies.**
- **The industrial licensing system has been abolished** for all except six industries related to security, strategic or environmental concerns.
- At the same time, the number of **industries reserved for the public sector** since 1956 have been **reduced** from 17 to 4.
- Only Industries related to **atomic energy and Railways have remained under the public sector.**
- The government also has decided to offer a part of the shareholdings in the public enterprises to financial institutions, general public and workers.
- **The threshold limits of assets have been scrapped and no industry requires prior approval** for investing in the delicensed sector.
- **foreign investment has been liberalised** and the government has permitted access to an automatic route for Foreign Direct Investment. FDI would bring technological upgradation, access to global managerial skills and practices, optimum use of natural and human resources, etc.

Globalisation : It means **integrating the economy of the country with the world economy**. Under this process, goods and services along with capital, labour and resources can move freely from one nation to another.

- The thrust of globalisation has been **to increase domestic and external competition** through extensive application of market mechanisms and facilitating dynamic relationships with the foreign investors and suppliers of technology.
- In Indian context, this implies:
 - **opening of the economy to foreign direct investment** by providing facilities to foreign companies to invest in different fields of economies activity in India.
 - removing restrictions and obstacles to the **entry of multi-national companies in India**.
 - **allowing Indian companies to enter into foreign collaboration** in India and also encouraging them to set up joint ventures abroad.
 - **carrying out massive import liberalisation programmes** by switching over from quantitative restrictions to tariffs in the first place, and then bringing down the level of import duties considerably.
 - Instead of a set of export incentives, opting for exchange rate adjustments for promoting export.

Implications :

Positive:

- **Immediate impact of LPG reform** : It helped us to deal with Balance of Payment crisis where foreign **reserves were left only to finance imports of 15 days**. It also helped to control **inflation during the period which was spiking up to 16%**.
- **Increase in GDP growth rate** : Post 1991 reforms India achieved 6-7% average GDP growth rate and now India is among the world's fastest-growing major economy with **GDP growth of around 8-9%**.
- **Increase in employment** : Reforms created many job opportunities in the private sector which in turn resulted in increased Per Capita Income. Unemployment rate was also reduced after the reforms.
- **Increase in per capita income** : Per capita income in India in 2019-20 was estimated **to be 1,35,050 rupees**.
- **Increase in Foreign Direct Investment (FDI)** : Upon opening up of the market many MNCs started investing in India which led to increase in FDI and foreign reserves.
- **Technology transfer** : LPG reforms facilitated transfer of technology and triggered **ICT revolution in India**.

Negative:

- **Low growth in the agriculture sector** : LPG reforms hardly helped the agriculture sector to progress. Private players and FDI invested outside the agriculture sector therefore the sector remained aloof from new technology.
E.g. Agriculture sector is struggling to achieve even **targeted 4% growth**.
- **Increase in income disparity** : Globalisation has widened the income gaps in the country. It has disproportionately favoured rich and educated professionals compared to poor and unskilled workers.
E.g. **Top 10% of Indian population holds 77% of total national wealth**.
- **Adverse impact on environment** : New industries and infrastructure development resulted in clearing of vegetation cover. Industry led pollution and vehicular pollution increased drastically raising pollution level to higher margins.
E.g. Due to increasing level of pollution frequency of extreme events like Cyclone(Eastern coast) , Flash floods (Hyderabad , Mumbai) has increased. **22 out of the world's 30 most polluted cities are in India**.
- **Regional imbalance** : The gap between developed and developing states has become wider. Major share of both domestic investment as well as foreign direct investment went to already developed states. seven north-eastern states could get less than 1 per cent of the proposed investment.
E.g. Growth favoured only few states within which only few regions. In **Maharashtra Mumbai-Pune-Nasik region , In south Bengaluru-Hyderabad-Chennai belt etc.**

National Manufacturing policy(NMP) 2011 :

- Economic reforms unveiled in 1991 have brought about **a structural shift enabling the private sector to assume a much larger role in the economy.** GDP growth has largely been enabled by growth of the services sector. The worry is that **India's manufacturing sector has stagnated at about 16 percent of GDP**, with India's share in global manufacturing at only 1.8 per cent.
- **The NMP-2011 has following objectives :**
 - To increase the share of manufacturing in **GDP to 25% by 2022 and create 100 million jobs**. Policy has envisaged formation of NIMZ- National Investment and Manufacturing Zones.
 - **NIMZ is an industrial township including Special Economic Zones , Industrial Parks , Export Oriented Units etc.** NIMZ will be given concessions in Tax , relaxed FDI norms , relaxed labour laws , faster connectivity etc. NIMZ will be governed as a self-governing body under article 243Q(c).
 - **Increase depth in manufacturing** with focus on domestic value addition and to address the national strategic requirements.
 - **Enhance global competitiveness** of Indian manufacturing through appropriate policy support.
 - **Ensure sustainable development** by enhancing industrial output using environmental friendly technologies.
- Government initiatives like '**Make in India**' , '**Digital India**' and '**Skill India**' and **relaxed foreign investment policy are aligned with NMP-2011.**
- The NMP-2011 has contemplated following thrust areas to grow Indian manufacturing :
 - **Improving the business regulatory framework** : Government will timely clearances by decreasing red tapism and provide exemptions from rules and regulations related to labour , environment etc.
 - **Focus Sectors** : Employment-intensive industries , Capital goods industries , Strategically significant industries are focused sectors under NMP policy.
 - **Human asset development** : Encouragement to entrepreneurship which will bring new ideas and startups. Skilling and training labourers to increase their productivity.
 - **Improving technology and value addition in manufacturing**: Policy intends to introduce green technologies. A technology acquisition and development fund has been proposed for acquisition of appropriate technologies.
 - **Developing effective clusters for growth of SMEs (small and medium enterprises)**: to revamp the SME sector policy intends to provide easier access to bank finance. Policy contemplates liberalization of RBI norms for banks investing in venture capital funds with focus on SMEs and liberalization of IRDA guidelines to provide for investment by insurance companies.
 - **National Investment and Manufacturing Zones (NIMZs)** : These are conceived as industrial greenfield townships to promote world class manufacturing activities.

Assessment of Policy :

- The major parameters to assess the industrial policy are : increase in foreign investment, its contribution in GDP growth and employment generation.
- **Foreign investment** : Since its inception the foreign investment did not accrue as per expectation. The Gross Fixed Capital formation(GFCP) , a measure of investment in economy has declined from 2011 to 2020.
- **Industrial contribution** : Sector yet to achieve its stated target i.e. increasing share of manufacturing sector to 25% of GDP. Presently the sector contributes 16-17% of GDP.
- **Employment Generation** : In last 5 years , the sector has seen decline in employment share from employing 51 million Indians in 2016-17 to reach 27.3 million in 2020-21
- Though policy yet to achieve its said aims , the government initiatives like **Make In India , Assemble In India , Digital India are rays of hope in coming years.**
- The real challenge lies ahead is to again gain the momentum after lockdown **by increasing demand and increasing investment through PPP mode.**

Following suggestions must be kept in mind to shape industrial policy in coming years :

- **Electronic Manufacturing** : Promotion of electronics manufacturing must be promoted.
- **Over Competition** : Centre and state efforts must be coordinated to disallow over competition in particular sector like Telcom, Aviation.
- **Reforming Labour laws and reducing logistics cost** : It would trigger the industrial sector in short term.

Industrial Corridors(IC)

- **Objectives** : These are envisaged along the main transport routes giving special thrust for industrial development. It involves multiple projects targeted towards increase in exports, employment generation , environment management etc.
- IC would create a global manufacturing and investment destination endowed with smart industrial cities which would compete with the best international manufacturing and industrial regions.
- The project efforts would complement the NMP-2011 by creating employment and increasing output and exports.
- **Investment regions(IRs) and Industrial Areas(IAs)** : The project will be developed on the concept of node-based development including **Investment regions(IRs)** and **Industrial Areas(IAs)**. These are proposed as self sustaining industrial townships with world class infrastructure.
- **Following are proposed Industrial corridors to be developed** : Delhi-Mumbai Industrial Corridor (DMIC), Amritsar-Kolkata Industrial Corridor (AKIC), Chennai-Bengaluru Industrial Corridor (CBIC), Bengaluru-Mumbai Economic Corridor (BMEC), East Coast Economic Corridor (ECEC)
- **Facilities to be developed under this project** : High speed road and rail transportation network, Modern airports and Ports with world class cargo handling facilities, Smart industrial townships, Logistic parks, Financial hubs.

Significance :

- **Economic growth** : Industrial corridors are meant to provide **world class transportation** facilities connecting industrial clusters. **High capacity dedicated freight corridor** would act as a backbone for creating a global manufacturing and investment destination.
- **Logistic improvement** : IC will help to facilitate multi-modal movement of cargo on par with global logistics standards. It will decrease the cost of logistics improving competitiveness of Indian goods. It includes 4 key components : **Transport , Warehousing , Forwarding and Value added logistics**.
- **Ease of doing business** : IC would facilitate faster **clearance to starting business , dealing with construction permits , registering property**. It will attract more business and investment.
- **Employment creation** : IC provides both forward and backward linkages to the industries hence have wide potential to create employment across logistics sector , warehousing sector. It would boost infrastructure development creating jobs in associated sectors.

Strategy of regional resource based manufacturing and management :

Introduction :

- Industries which are located near raw material utilises local inputs and transforms them into final material.
- This also helps in **creation of employment and overall regional development**.
- This strategy helps in **backward area development** and promotion of equitable development.
- It **promotes local products and artefacts and try to convert them into national and Global brands**.
- Under this strategy industries are attracted based on availability of natural resources and **provided with other facilities like transportation , electricity etc.**

Government initiatives to harness regional potential :

- **One District , One Product Scheme of UP government** strives to promote regional traditional industries.
- **North East Industrial development scheme** incentivises industries to set up in north east region.

- Strategy complements the 'vocal for local' initiative under Atmanirbhar Bharat as advocated by prime minister of India.

Challenges :

- Lack of infrastructure** : Resource rich regions like Jharkhand , Chhattisgarh , north east region fails to attract industries due lack of complementary infrastructure.
- Lack of skills and modernisation** : Local craftsman fails to modify local artefacts as per global demands due to lack of modern equipment.
- Lack of vision in policy formulation** : Due to poor development of local skills and poor marketing regional products have failed to transform into recognised brands.

AGRO-BASED INDUSTRIES :

Textile Industries :

Introduction :

- The term Textile includes **cotton , jute , wool , silk and synthetic fibre textiles**.
- The Indian textile industry is **the second largest manufacturer and exporter in the world**.
- This sector is the **second biggest employer after agriculture**. The share of women employment in textile industries is higher than other sectors making it an agent of social upliftment of women.
- Backward linkages of the sector to the rural economy** has the potential to uplift the lives of farmers ,artisans and handloom manufacturers.
- Thus the sector is contributing to **Make In India , Skill India , Women empowerment and rural development**.

Cotton Textile Industry :

Introduction :

- At present it is the largest organised modern industry of India.
- Power looms account for the largest share(around 80%)** in cotton textile production followed by handlooms and mills. It is an agro based industry depending upon pure raw material.
- India is the **largest producer of cotton and a second largest producer of textiles and garment**.

Locational factors :

- Cotton industries are established balancing the several factors like **raw material , power , market ,transport etc**.
- The cotton does not lose much of the weight** after processing hence industry tends to be located at **centres which have favourable transport facilities** with respect to market and proximity to cotton growing tracts.
- Post-independence ,the industry also tended to **shift from areas of high labour cost to those with low labour cost**. The labour cost factor played a crucial role in establishing this industry at Madurai, Tirunelveli, and Coimbatore.

Important centres : Mumbai , Ahmedabad ,Coimbatore , Indore , kanpur etc.

Distribution:

Maharashtra :

- It has maintained its **top position** in the cotton textile industry however its **share in production has declined over a period** due to decentralisation and spread of industry across the country.

Since independence Mumbai has been placed at dominant position because ,

- Humid climate** is useful to remain thread strong.
- Good connectivity** through port , land and railways.

OnlyIAS Nothing Else

- Proximity to cotton producing belt.
- Cheap labor from backward Marathwada , Kokan and Gujarat region.

However it is losing its share due to various reasons :

- Ahmedabad emerged as a counter magnet region having similar benefits as that of Mumbai and advantage of cheap land .
- Labour strikes in mills created unstable conditions to run business.
- Industry shifted from areas of high labour cost to those with low labour cost, establishing industry at Madurai, Tirunelveli, and Coimbatore.

Gujarat :

- It is a second largest producer of cotton textile having Ahmedabad as its largest centre.
- Textile industry in Gujarat also enjoys similar benefits as that of the Maharashtra region.

Tamilnadu :

- The state got prominence as it excels all other states in the production of yarn and accounts for over 44% of yarn production in India. Coimbatore is a prominent centre.

Geographical location :

Decentralised nature of cotton textile industries :

- **Early 20th century** : Cotton textile industry evolved in western states of India namely Maharashtra and Gujarat. Mumbai , Surat , Ahmedabad developed into main centres due to proximity to cotton producing tract , cheap labour , available capital and market.
- **Impact of Railway lines** : Development of railway lines helped cotton industry to penetrate into peninsular region. New centres of industries emerged at Solapur , Nagpur , Indore , Jaipur , Kanpur etc. Railway transport helped in moving raw cotton and finished goods to high demand market. These centres developed near coal regions (Nagpur) , near port cities (Kolkata) .
- **Southward movement** : Southern India lacked cheap and regular energy supply due to lack of coal reserves. Hence industries spread in southern part only after development of Hydroelectricity. Development of Pykara dam helped cotton industry to shift in southern part and new centres like Coimbatore , Madurai , Tirunelveli emerged.
- **Powerloom and handloom sector** : These sectors due to their lower capital required and patronage given by government under schemes like TUFS – Technology upgraded fund scheme and INSITU upgradation of power looms helped this sector to develop in decentralised way with emergence of new centres across the country.
- **Government policies** : Today under the direction of ease of doing business state governments are providing various incentives through electricity subsidy , cluster developments etc are attracting textile entrepreneurs to relocate or expand their business.

Problems :

- **Quality of raw cotton** : most of the long staple cotton growing areas went to Pakistan. So there is a scarcity of long staple cotton in India.
- **Obsolete Machinery** : Most of the mills are old with obsolete machinery which results in low productivity and inferior quality.
- The sector is dominated by the unorganised sector and small and medium industries. Hence advantages of economy of scale.



- **Productivity of Indian labour is low** compared to advanced countries due to lack of automation and advanced technology.
- **Labour laws** : Indian labour laws are complex and difficult to comply with. The Industrial Disputes Act, 1947 put limitations on firm size limiting its growth. Hence benefits of economy of scale did not accrue to the industry.
- **Lack of foreign investment in the sector** is a major reason behind the use of outdated machinery and technology which is increasing the cost of Indian products making them uncompetitive.

Government Initiatives

- **ATUFS - Amended Technology Upgradation Fund Scheme** : It was launched in 2015 for technology upgradation of the textile industry.
- **SITP - Scheme for Integrated Textile Parks** : To provide world class state of art infrastructure facilities to small and medium units with cluster approach.
- **SAMARTH- Scheme for Capacity Building In Textile Sector** : The scheme is aimed at addressing the shortage of skilled labours in the textile sector.
- **National Technical Textile Mission** : To position the country as a global leader in technical textiles and increase the use of technical textiles in the domestic market. It strives to enhance R&D and export promotion in technical textiles.
- **PLIS - Production Linked Incentive scheme** : The scheme is aimed at promoting industries that invest in the production of man-made fibre apparel , man-made fibre fabrics and technical textile segments.

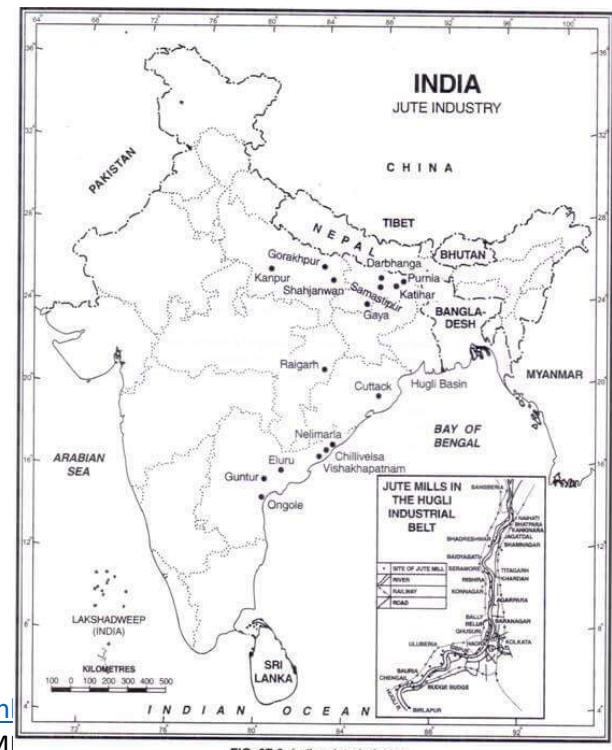
PLIS and Changing Scenario :

- **Current Situation** : Indian production and export of textile and clothing products are **largely cotton-based**. Of the total global fibre manufacturing and consumption, **70% is man-made fibre-related**, while in India it is just about 35%.
- **Stagnant growth** : Annual textile and clothing exports have remained largely stagnant over the last seven years.
- **Man made fiber** : Countries including **Bangladesh and Vietnam** have gained a sizable share in the man-made fibre segment of the global textile trade.
- India met its demand for man made fibre through imports which are jumping higher every year.
- According to the available data , **during 2018-19, the import of man-made fibre garments jumped 39% from the previous year**.
 - PLIS would provide policy support to make man-made fibre segment internationally competitive.
- **Domestic procurement** : With launch of Production Linked Incentive scheme in the textile sector Global retail brands, which are present in India are likely to start **sourcing man made fibre from India** once the garments become available at internationally competitive prices.
- **Investment and employment** : The government has said the scheme will help attract ₹19,000 crore of fresh investments and generate 7.5 lakh jobs.

JUTE INDUSTRY :

Introduction :

- This is the **second important textile industry** in India after the cotton textile industry.
- Jute production is a **labour intensive industry**.



- India is a **largest producer of Jute products**. West Bengal has the largest concentration(80%) of jute industry in India followed by Andhra pradesh.

Hooghly basin has high concentration of jute mills because following reasons :

- **Raw Material** : Ganga-Brahmaputra delta grows about three fourth of India's jute.
- **Power** : Coal is obtained from Raniganj fields.
- **Cheap water transportation** and abundant water available for processing and washing.
- **Humid climate** is beneficial for spinning and weaving.
- **Connectivity** through Kolkata port has established easy export.
- **High density** populations have provided cheap labour.
- **Big capitalist , Banking and Insurance facilities** are available near Kolkata region.

Geographical Distribution :

Problems Associated :

- **Raw material** : Most of the jute producing areas went to Bangladesh resulting in acute shortage of raw material. Hence the availability of quality raw jute and shrinking acreage
- **Obsolete Machinery** : Most of the mills are old with obsolete machinery which results in low productivity and inferior quality and insufficient efforts of modernising technology.
- Newly established jute mills with **advanced technology in Bangladesh** produce better quality jute products at a cheaper rate compared to India jute products.
- **Competition** : Competition from synthetic packing materials has shrunk the market for jute goods.
- **Obsolete processing technology** and the **lack of product diversification** have limited the jute products only to handicraft and packaging.
- **Infrastructural bottlenecks** : Power, transportation and capital also pose several threats to the sustainability of the Jute industry.

Government Initiatives :

- **Jute SMART** : It provides a platform for procurement of jute products and promotes transparency in the jute sector.
- **Jute ICARE** : It helps farmers by providing them certified seeds , nail weeders for periodic weeding , seed drills to facilitate line sowing.
- **The Jute Packaging Materials (Compulsory Use in Packing Commodities) Act** was enacted in 1987 to protect the jute sector from the plastic packaging segment.
- **Government has put a ban against plastic bags and single-use plastic packaging** holds potential for the jute sector.
- Government has made mandatory packaging of **100% foodgrains and 20% sugar in jute bags**.
- **MSP** : Jute is included into the **MSP regime** to incentivise farmers for jute cultivation.

Significance :

- **The jute packaging is environment friendly** thus holds strong potential in future to increase its share in the packaging industry replacing plastic bags.
- A recent initiative called '**The Jute Foundation**' (TJF) is trying to address many issues pertaining to the environment-friendly product.

Sugar Industry :

Introduction :

- Sugar can be produced from any crop having sugar content , in India Sugarcane is the main source of sugar.
- It is the **second largest agro based industry Of India** after cotton textile industry.
- India is the **second largest producer of sugar after Brazil**.

- Modern sugar industry was introduced by British Indigo planters when demand for indigo ceased to exist.

Location of Industries :

- It is based on raw material **sugarcane** which is heavy , low value , weight losing and perishable. Sugarcane can not be stored for long as it loses its sucrose content. Therefore sugar industries are established **near areas of sugarcane cultivation.**

Distribution :

Factors behind shifting location of Sugar Industry from North to South :

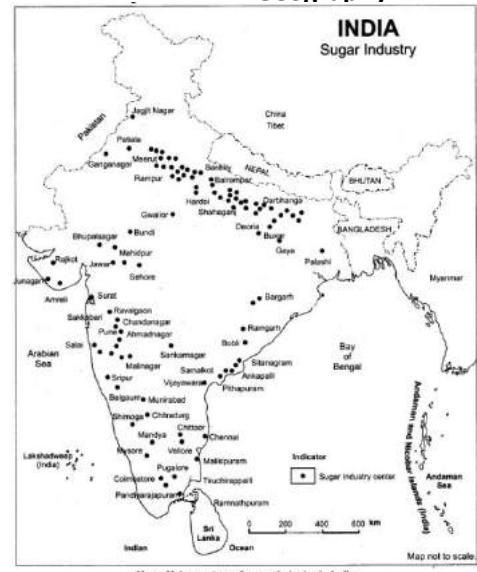
Previously North India used to produce 90% of India's sugar which is reduced to 35-40% now because following reasons:

- **Suitable climate** : Tropical climate of peninsular region gives higher yield per unit area as compared to north India.
 - **Sucrose content** is higher in tropical varieties of sugarcane.
 - **Crushing season** of South India is longer (7-8 months) compared to north India's 4 month.
 - **Cooperative Movement** in Peninsular India is more successful than northern India. Cooperative sugar mills are better managed in South India.
 - **Politicisation of cooperative movement** helped farmers to put their demands effectively to get higher prices for sugarcane **through FRP- Fair and remunerative prices and SAP – State advised prices**.
 - Most of the mills in the south are new and equipped with **modern machinery having high productivity**.

Geographical Distribution :

Problems and challenges :

- **Low yield** : India has the largest area under sugarcane cultivation but the **yield per hectare is very low**. This has led to low production and **short supply of sugarcane to mills**.
 - **Short crushing seasons** : Sugar manufacturing is **a seasonal phenomenon varying from 4-7 months in a year**. The mills and workers remain idle during the remaining period of the year. It has created financial problems for industry. **Sowing and harvesting at different intervals** would help in continuous supply of sugarcane and increase in crushing period.
 - **High cost of production** : The production **cost of sugarcane is one of the highest in the world because of the high cost of sugarcane , inefficient technology , uneconomic process of production and heavy excise duty etc**. The production cost can be reduced by utilising by-products like bagasse and Molasses.
 - **Old and Obsolete machinery** : Particularly north Indian mills use **old machinery having poor productivity**. It has led to poor productivity of mills and reduced production.
 - **Government policies :**



- Sector is suffering from **the government's control and populist policies**. Unviable sugarcane pricing caused the sugar cycle to oscillate between surplus and severe shortage.
- The government grappled with **large cane arrears** while the industry survived on periodic government funded **bail-outs and subsidies**.

Present scenario :

- **Partial decontrol** : In 2013 the government chose to **decontrol the sector**. The decontrol focussed on **the sugar side of the business only**. It set sugar mills free to sell whatever quantity and price of their choice. Supply of sugar through PDS also ended.
- However, **the control on the sugarcane side remained and it continues even today**. This includes the issue of the government fixing the price of sugarcane. It has caused high prices of sugarcane making Indian cost of sugar production higher than competitors.
- **WTO issue** : Hence , **without subsidies Indian exports are not viable** as the cost of producing sugar is way above the international sugar price. **At the WTO , India has been allowed to continue with the export subsidies till December 2023**.
- Without subsidies our export will decline and **the issue of managing surplus sugar would surface again**.

Solution :

The ethanol option :

- If the ethanol option- 'blending ethanol with petrol for use as auto fuel' is implemented properly, it will offer required cash flow to sugar mills, ensure better prices for farmers , enhance India's energy security and reduce pollution.

The Rangarajan Committee has suggested a formula :

- Sugarcane prices are fixed by the government under populist pressure. This inflicts huge losses on the mills and causes cane arrears to build.
- The Rangarajan Committee has suggested a formula to **fix cane price factoring in the price of sugar and other by-products**.
- In case the formula based cane price drops below what the government considers as a reasonable payment then the government can **bridge the gap by making a dedicated fund through cess levies**.

Conclusion :

- Government has **aimed to double the growth rate of manufacturing sector by 2022** which requires foreign investment , promotion of latest technologies like '**Industry 4.0**' and effective implementation of government schemes : **Make In India , Ease Of Doing Business and Digital India**.
- Industrial sector in India has **yet to achieve its true potential in terms of GDP contribution and employment generation**.
- India is bestowed with **potential demographic dividend**. Structural reforms in economy and infrastructure development accompanied with **skilled human capital** would form the win-win situation to accomplish goal of **Atmanirbhar Bharat**.

TERTIARY SECTOR :

Introduction :

- Tertiary activities come under the service sector. The most important component of the tertiary sector is human capital. These are also called **white collar jobs**.
- Tertiary activities include both **production and exchange**. The production involves the 'provision' of services that are 'consumed'. Exchange involves trade, transport and communication facilities that are used to overcome distance.
- The tertiary sector of economy involves **the provision of services to business as well as final consumers**.
- Tertiary activities are dependent upon specialised skills, experience and knowledge of the workers e.g. Teacher, Doctor , Lawyer ; whereas secondary activities depend upon production techniques, machinery and factory processes.

Significance :

- India is the **fifteenth largest country** in the world in terms of services' output.
- **Employment** : This sector provides **employment to 23% of the workforce** and is the fastest growing sector, with a **growth rate of 7.5% in 1991–2000**.
- **GDP share** : It has **the largest share in the GDP**, accounting for 53.8% in 2005 up from 15% in 1950.
- Tertiary sector depends on scientific research and innovative developments to increase productivity .**Developed countries employ more than 80% of the services sector**.
- **Communication** : Emerging Edtech companies like BYJUs , Unacademy benefited from revolution in communication services are seen as sunrise industries
- **Transport** : Ola , Uber companies urban transport and logistics facilities provided by URL , Delhivery to online sellers shows increasing contribution in GDP and employment generation.

- **Services** : Zomato IPO sale , increasing subscriptions to OTT platforms indicates their future potential to grow.

Significance of Indian Service Sector :

- Service sector accounts for around **60%** of the total size of the economy , about **38% of total exports** and **two-thirds of the total FDI inflows into India**.
- **Robust demand** : India has emerged as an export hub for software services. The Indian software industry is **expected to reach US \$1 trillion by 2030**. **Foreign exchange earned** through exports of services has helped to raise all time high foreign reserves.
- **Global exports** : Share of Indian service sector **in global services exports** is expected to increase from **3.3% to 4.2% for 2022**.
- **Employment** : It provides **employment opportunities to 25% labour force** of India. **Tourism , healthcare , education** , business processing sector are among the top employment provider.
E.g. **Healthcare Tourism and Yoga Tourism** are attracting global tourists due to increased recognition of **Ayurveda ,Hatha yoga, Vipassana etc**
- **Competitive advantage** : India's has highly skilled manpower and demographic dividend available at low cost has attracted **BPO , KPO , Business processing industries India**.
- **Policy support** : Government **efforts on focussing Make In India , Digital India initiatives** and expanding India's entrepreneurship across all service sectors.
- **Urbanisation** : **Increasing population, urbanisation , increasing average income and globalisation effects** in India will increase demand for quality and variety of services. Capturing these demands by **creating new startups and enterprises would further boost the Indian economy**.
E.g. New startups like **bla-bla cars , Dunzo , Zomato** are increasing their market share day by day.

Impact of COVID19:

- Global COVID19 restrictions , particularly travel bans, have **restricted international demand** for Indian services like , **Tourism , Healthcare services Education etc.**
- **Export businesses declined sharply , debt over businesses increased , banking and insurance sector** also impacted due to failure to pay EMI and premium on timely basis.
- Due to **subdued demand , liquidity concerns new hiring came to halt** thus rate of employment generation rate reduced.
- **The GDP had contracted by a record 23.9%** in the first quarter of 2021 fiscal year.

QUATERNARY SECTOR / KNOWLEDGE BASED INDUSTRIES :

- **Definition** : Knowledge economy makes **use of knowledge and information to create goods and services**. It requires skilled workers with sound **analytical abilities** and command on their subjects that can manipulate information and are **research and innovation driven**.
- The advancement in information technology has had a profound influence on the country's economy. The Information Technology (IT) revolution opened up new possibilities of economic and social transformation.
- With the advent of the **Digital India program**, India declared its vision to quickly transform itself into a **digitally empowered society and a knowledge based economy**.
- The Indian software industry has emerged as one of the fastest growing sectors in the economy. The software industry has surpassed electronic hardware production.

Significance :

- **IT sector** : India with the onset of globalization, **having a youth population and massive growth in the IT sector** makes it a strong candidate to usher in knowledge based industry. It will help in creating new better paying jobs, good infrastructure and technology upgrade.
- **Innovation** : The knowledge based industry **uses modern Information & Communication Technologies principles, innovation and research**, specialized skills to create, disseminate and apply knowledge. It works towards **reducing poverty through inclusive economic growth**.
- **Industry 4.0** : With the advent of newer and advanced technologies like Artificial Intelligence (AI), Machine Learning (ML) and Internet of Things (IOT), **conventional manual jobs would easily get replaced**. Newer jobs requiring **specialized skills will be created**. Therefore, **the Knowledge industry is the way ahead for India as well as the globe**.
- **Enhancing income** : With increase of knowledge based industry share in the economy India is likely to **rise over the problems of middle income trap and income inequality**.

Challenges :

- The Indian economy is still **a labour intensive economy**. India has a **huge amount of unskilled laborers and untrained workers**. The knowledge industries will need education and skill impartation to the majority of people.
- Due to discrepancies in the Indian education system, **the knowledge industry doesn't have the right amount of highly skilled professionals** mainly because of lack of skill based training and academics focused on rote learning rather than thinking abilities and innovation.
- Knowledge based industries are **likely to cause problems like unemployment** as it would only create high skilled jobs.

Way forward :

- The Industrial Revolution didn't end agriculture as people still have to eat. Similarly, the Knowledge Revolution cannot undermine the importance of industries as people still need physical goods. Thus, **the Knowledge Economy in India must be paired up with sound agricultural and sustainable industrial growth**, only then it can benefit India all round.

QUINARY SECTOR :**Introduction :**

- **The quinary activities** : It includes creation , re-arrangement and interpretation of ideas , data interpretation , business analysis , critical thinking , evaluation and upgradation of new technologies.
- This sector represents another **subdivision of the tertiary sector** and is referred to as **Gold Collar professions**.
- **Professionals** : Sector includes Senior business personnel , CEO's , MD's , Scientist , Higher government officials , Financial and legal experts etc.

Significance :

- **High share in GDP** : The sector provides employment to highly skilled professionals thus **share in employment generation is very low** at the same time **contribution to GDP is very high** due to high value and specialized services provided by them.
- **Employment** : Though share of employment in Quinary sector is low but **growth of this sector ensures employment generation in other sectors which are skilled , semiskilled or unskilled**.
 - E.g. Growth of Entrepreneurs would create **more enterprises creating new jobs**.
- The sector ensures the pace of technological advancement which directs the economic growth of the nation.
- In developed countries quinary sector is highly evolved engaged in research and innovation.

E.g. Design and development of **electric cars**.

- **Knowledge house** : The sector includes highly qualified and intellectual professionals. Their **guidance and knowledge sharing helps to reap dividend from newer generations**.

E.g. Knowledge transfer from veteran doctors helps their juniors to bring out best doctors out of them.

Challenges :

- **Poor education** : The quality of education in country decides the quality of quinary sector in country. Best universities bring out the best talent in the world.
- Poor quality of higher education in India compels much of the **talent visiting foreign universities**. They carry their research works outside India. Such **export of Indian talent** must be retained in the country. E.g. Many MNCs in the world have Indian CEO's. **Sundar Pichai is CEO of Alphabet Inc.**
- **Poor innovation** : Research and development ecosystem in India is very poor and quality of innovation is secondary to global innovations. The basic motto behind education is finding a job and through theoretical learning.
- **Entrepreneurship efforts** : In India Entrepreneurship efforts are only concentrated in **ITES sector**. Agriculture , Automobile , Electronics sector are not explored by new entrepreneurs. These sectors are lagging behind from achieving their real potential.
- **Policy absence** : Government efforts are not targeted to boost this sector. **The national policy to promote quinary sector has not been formulated yet.**

Way forward :

- Increasing budgetary allocation to education system. There is a need to bring **change in attitude of students**. They must be inspired to create jobs rather than finding a job.
- Promotion of innovation culture since early education. Promotion of PhD and R&D by providing stipends and provision of advanced laboratories and world class instruments.
- Diversification of entrepreneurship through incentives to other areas : Agriculture , Electronics etc.

Current trend :

- **New trends** in quinary services include **knowledge processing outsourcing (KPO)** and '**home shoring**', the latter as an alternative to outsourcing. The KPO industry is distinct from Business Process Outsourcing (BPO) as it involves highly skilled workers. It is information driven knowledge outsourcing.
- **Examples of KPOs** include research and development (R and D) activities, e-learning, business research, intellectual property (IP) research, legal profession and the banking sector.
- **COVID 19** pandemic created many opportunities for **startups in healthcare sectors** especially in meeting **oxygen demand** and research in vaccines development and allopathic medicines.
- **Tele-medicine , Tele- education , Tele -Law** are emerging trends which are attracting investment and talent across the world.
- **Industry 4.0 AI and ML , IoT etc** have received largest attraction from government , professionals and MNCs.
- **Also innovations to curb climate change, sustainable use of natural resources and reducing carbon footprint** has been devoted with investment and talent by many companies.

MINERAL AND ENERGY RESOURCE

PYQ

1. India has immense potential of solar energy though there are regional variations in its developments. Elaborate 2020
2. Why is India taking keen interest in resources of Arctic Region? 2018
3. How does India see its place in the economic space of rising natural resource rich Africa? 2015
4. With growing scarcity of fossil fuels, the atomic energy is gaining more and more significance in India. Discuss the availability of raw material required for the generation of atomic energy in India and in the world. 2013
5. It is said the India has substantial reserves of shale oil and gas, which can feed the needs of country for quarter century. However, tapping of the resources doesn't appear to be high on the agenda. Discuss critically the availability and issues involved. 2013

MINERALS

- The mineral resources provide the country with the necessary base for industrial development. For the development of industrialized society requires quality and economical industrial minerals in such industries as smelting of copper and iron, manufacturing of cement, manufacturing ceramic materials, etc.
- Because of high transportation cost, most of the industrial minerals are not imported due to this a country or region must have a good raw material source. Varied geological structure has endowed India a rich variety of mineral resources.

Distribution of Minerals in India:

Mining sector is one of the important sectors of the Indian economy. India is endowed with huge resources of many metallic and non-metallic minerals. At present, India produces near about 95 minerals including 4 fuel, 10 metallic, 23 non-metallic, 3 atomic and 55 minor minerals.

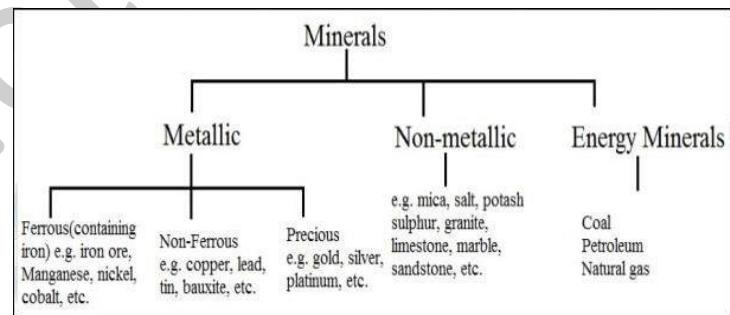
Minerals are generally concentrated in **three broad belts** in India. These belts are :

- **The North-Eastern Plateau:** It is endowed with the minerals like iron ore coal, manganese, bauxite, mica.
- **The South-Western Plateau Region:** This belt covers Karnataka, Goa and contiguous Tamil Nadu uplands and Kerala. This belt is rich in ferrous metals , bauxite and contains high grade iron ore, manganese and limestone ,etc. Kerala has deposits of monazite and thorium, bauxite clay.
- **The North-Western Region** This belt extends to regions of Aravali in Rajasthan and part of Gujarat and minerals are associated with Dharwar system of rocks. Copper, zinc have been major minerals. Rajasthan is rich in building stones i.e. sandstone, granite, marble, Dolomite and limestone. Gujarat is well known for its petroleum deposits.
- **The Himalayan belt** witnesses the copper, lead, zinc, cobalt and tungsten etc. They occur on both the eastern and western parts. Assam valley has mineral oil deposits. Oil resources are also found in off-shore-areas near Mumbai Coast (Mumbai High).

Types of Mineral Resources:

Ferrous Mineral: Ferrous minerals such as iron ore, manganese, chromite, etc., are essential to provide a strong base for the development of metallurgical industries. India is well-placed in respect of ferrous minerals both in terms of reserves and production.

- **Iron Ore:** India has endowed with the largest reserve of iron ore in Asia. The haematite and magnetite are two main types of ore found in the country. About 95 per cent of total reserves of iron ore is located in the States of Odisha, Jharkhand, Chhattisgarh, Karnataka, Goa, etc. The value of metallic minerals in 2019-20 was Rs.66,084 crores , it increased by 3.19% over the previous year.



- **Manganese:** Manganese is used as a raw material for smelting of iron ore and also used for manufacturing ferro alloys. Manganese deposits are found in almost all geological formations, it is mainly associated with Dharwar system. Leading producer of Manganese are Odisha ,Karnataka Telangana, Goa, and Jharkhand. The production value of Manganese was Rs.1,942 crore in 2019-20.

Non-Ferrous Minerals:

India is poorly endowed with non-ferrous metallic minerals except bauxite.

- **Bauxite :**Bauxite is the ore which is used in manufacturing of aluminium. Bauxite is found mainly in tertiary deposits and is associated with laterite rocks. Leading producer of Bauxite are Odisha, Jharkhand, Gujarat, Chhattisgarh etc. The Production of Bauxite at 21,824 thousand ton during 2019-20 registered a decrease of 7.87% as compared to the previous year.
 - **Bauxite reserves:** India ranks fourth in the world in terms of bauxite reserves. The country has high quality metallurgical grade bauxite deposits with close to four billion tonne reserves.

- **Import of Bauxite:** The country continues to heavily import bauxite for its industrial needs causing an estimated forex loss of over \$571 million in the last six years alone.
- **The per capita consumption** of aluminium in India is quite low at about 2.5 kg, compared to the world average of about 11 kg and China's 24 kg, while many developing countries have already reached 8 kg. Ambition of the country for economic growth would increase this to 7-8 kg in line with other developing nations.
- This is critically required for proposed infrastructure development, power transmission, manufacturing, transport and defence.
- As per the **Paris Convention**, aluminium is a critical metal, essentially required for achieving low-carbon footprint and renewable energy generation.
- **Copper:** Copper is an essential metal in the electrical industry for manufacturing wires, electric motors, transformers and generators. Its properties are alloyable, malleable and ductile. It is also mixed with gold to provide strength to jewellery. The Copper deposits mainly occur in Jharkhand, Madhya Pradesh and Rajasthan. The production of copper ore in 2019- 20 at 3,952 thousand tonnes decreased by 4.41% as compared to that in the previous year.

Non-metallic Minerals :

mica is one of the important non-metallic minerals. In addition to mica, other important non-metallic minerals are limestone, dolomite and phosphate. The value of production of non-metallic minerals was Rs.8,882 crores during 2019-2020 .It decreased by 3.62% as compared to the 2018-2019 year.

- **Mica :** Mica is used in the electrical and electronic industries. It is malleable ,tough and flexible. Mica in India is found in Jharkhand, Andhra Pradesh, Telangana ,etc.

Conclusion: The mining is the science, technique, and business of mineral discovery and extraction .It will be one of the most politically and environmentally sensitive areas of the global economy for decades to come. It means **there is increased impetus for circular economy models for metals.**

National Mineral Policy, 2019

- **The objective of National Mineral Policy 2019** is to have a more effective, meaningful and implementable policy that brings in further transparency, better regulation and enforcement, balanced social and economic growth and sustainable mining practices.

Details:

The National Mineral Policy, 2019 includes provisions which will give boost to mining sector such as:

- **Introduction of Right of First Refusal** for RP/PL holders;
- **Encouraging the private sector** to take up exploration;
- **Auctioning in virgin areas** for composite RP cum PL cum ML on revenue share basis;
- **Encouragement of merger and acquisition** of mining entities;
- **Transfer of mining leases and creation of dedicated mineral corridors** to boost private sector mining areas;
- **Proposes to grant status of industry** to mining activity to boost financing of mining for private sector and for

Benefits:

- **The NMP 2019 ensures more effective regulation.** It will help in sustainable mining sector development in future while addressing the issues of project affected persons those residing in tribal areas.
- **Reduction in transportation cost** due to Dedicated Mineral Corridors.
- **Easy finance:** As soon as mining industry gets an industrial status, it will be easy for entrepreneurs to get finance from banks and other institutions.

- acquisitions of mineral assets in other countries by private sector;
- **Proposes to auction mineral blocks** with pre-embedded clearances to give fillip to auction process;
 - **Proposes to make efforts to harmonize taxes, levies & royalty** with world benchmarks to help private sector

- **Policy is in sync with objectives of ease of doing business.**
- **Private Sector** will be able to generate output from those reserved areas which have yet not been utilized by the PSUs

Conclusion:

- India is well endowed with natural resources, particularly minerals. They serve as raw material for many industries, paving a path for rapid industrialisation and infrastructural development. It, in turn, will facilitate the economy's growth to a path of sustained growth and a five trillion-dollar economy. It ensures the sustainable growth of the economy.

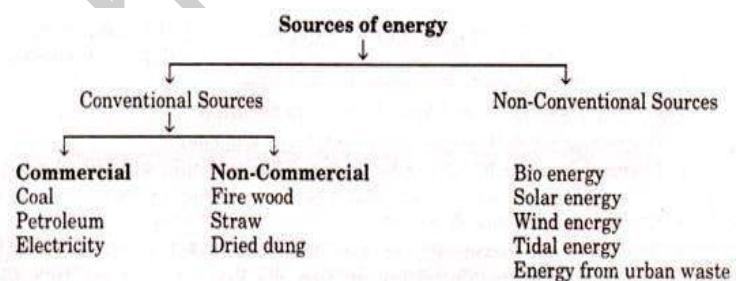
ENERGY

Energy is one of the important factors of the economic infrastructure. It provides the basic input needed to sustain economic growth. There exists a strong relationship between economic development and energy consumption. SDG - 7 aims of sustainable energy for all.SDG-7 targets:-

- Target 7.1: By 2030,to ensure universal access to affordable, reliable and modern energy services.
- Target 7.2: By 2030, to increase substantially the share of renewable energy in the global energy mix.
- Target 7.3: By 2030, to double the global rate of improvement in energy efficiency.

The more developed is a country, the higher is the per capita of energy consumption and vice-versa. Human civilization relies on different sources of energy.

The two major sources of energy can be classified under:



Conventional and Non-conventional Sources of Energy

Conventional sources of energy

- Eg:-Fossil fuel, CNG, coal, oil, natural gas
- The conventional sources of energy are non-renewable by any natural process
- These resources are available in a limited quantity
- Conventional energy sources contributes to pollution.

Non-conventional sources of energy

- Eg:-Solar Energy, Wind Energy, Bio Energy, Hydro Energy, Tidal Energy, Ocean Energy
- Non-conventional energy resources are renewable
- They are unlimited in terms of quantity. Non-conventional energy sources are eco-friendly in nature
- Non-conventional energy sources do not increase pollution

Sources of Energy

- India ranks the third-largest energy consuming country in the world. Energy demand has doubled since 2000, the 80% of energy demand is still being met by coal, oil and solid biomass. On a per capita basis, India's energy use and emissions are less than half the world average.
- **Scope for further growth in energy demand:** As India recovers from a Covid-19 induced slump in 2020,it is re-entering in to a very dynamic period in its energy development. According to International Energy Agency:-

- Before the global pandemic, India's energy demand was likely to increase by almost 50% between 2019 and 2030, but growth over this period is now closer to 35% in the Stated Policies Scenario(STEPS), and 25% in the Delayed Recovery Scenario.
 - An expanding economy, urbanisation and industrialisation mean that India witnesses the highest growth in energy demand of any country, across all of the sectors to 2040.
 - To meet growth in electricity demand over the next twenty years, India will need to add a power system to the size of that of the European Union.
- a) Coal is one of the most important sources of energy. There are near about 150000 coal deposits in India. India is the fourth-largest coal-producing country. The deposits are mostly found in Bihar, Orissa, Madhya Pradesh, Jharkhand and Bengal.
- Electricity consumption: Coal-fired generation witnessed a dip in electricity consumption in 2020.
 - Loosing hold: Coal's prominence in India's power sector is loosening.
 - The share of coal in the overall energy basket of the country steadily declines in the STEPS, from 44% in 2019 to 34% in 2040.
 - No net growth: Once the under construction coal-fired power plants are completed over the next few years, there is no net growth at all in India's coal fleet.
- b) Oil is considered as one of the crucial sources of energy in India and the world. Oil is mostly used in planes, automobiles, trains and ships. In India it is mainly found in Assam, Gujarat and Mumbai. In the STEPS, India's oil demand rises by almost 4 million barrels per day (mb/d) to reach 8.7 mb/d in 2040, the largest increase of any country.
- 25 million trucks are likely travel on India's roads by 2040 as road freight activity triples. The total of 300 million vehicles of all types are likely to add to India's fleet between now and then.
 - India is likely to witness huge expansion of transportation infrastructure – from highways, railways and metro lines to airports and ports.
- c) Natural Gas: India's current energy mix comprises 6 % of share of natural gas. It is among the lowest in the world:
- Gas based economy: Natural gas can also acts as a replacement to the coal in power generation, helping India's aspiration of a "gas-based economy" to come to reality.
 - Affordability issue is dear to consumers, especially when the additional charges and tariffs that, on average, doubled the cost of wholesale gas by the time it reached end-users in 2019.
 - Multiple uses: Natural gas can be used in multiple ways in India's energy system, including to help meet air quality and near-term emissions goals.
 - Sustainable Development demands that a long-term vision for gas needs to incorporate a growing role for biogases and low-carbon hydrogen, for which India has large potential.
- d) Electric power: Electricity is used for domestic and commercial purpose. The national electric grid in India has an installed capacity of 383.37 GW as of 31 May 2021.
- The major sources of power generation are mentioned below:
- Thermal Power: It is generated with the help of oil and coal. It is an important source of electric energy. In India electric energy comprises 72% coal generated electricity. For utility power generation, India consumed 622.22 million tons of coal during 2019-20 which is less by 1% compared to 628.94 million tons during 2018-19.
 - Waste of resources: According to The Centre for Science and Environment, Indian coal-based power sector is a one of the most resource-wasteful and polluting sectors in the world. In part due to the high ash content in India's coal.

- **Low ash content coal:** The Ministry of Environment and Forests has mandated to use the coals whose ash content has been reduced to 34% (or lower) in power plants in urban, ecologically sensitive and other critically polluted areas.
- **Inefficient power plants:** Thermal power plants of India are inefficient. It is necessary to replace them with cheaper renewable technologies offers significant potential for greenhouse gas (CO₂) emission reduction.
- **Hydroelectric Power:** Hydroelectric energy is a form of renewable energy. It uses the power of moving water to generate electricity.
 - India's potential for hydro power is near about 125,000 MW at 60% load factor.
 - **Underutilised potential:** Globally India is ranked fourth in terms of underutilized hydro power potential.
 - **No additional cost:** Hydroelectric power plants produce secondary /seasonal power at no additional cost when rivers are flooding with excess water.
 - **Alternative system of storage:** Storing electricity with the help of alternative systems such as batteries, compressed air storage systems, etc. is more costly than electricity production by stand by generator.
- **Nuclear Power:**
 - In India the Nuclear power is the fifth-largest source of electricity after coal, gas, hydro-electricity and wind power.
 - **Installed capacity:** As of 31 March 2019, India had 6.78 GW of installed nuclear power generation capacity or nearly 2% of total installed utility power generation capacity. Nuclear plants generated 37,812 million kWh at 63.67% PLF in 2018-19.

Problems with India's power sector:

- **Inadequate last mile connectivity:** Despite having the adequate generation and transmission capacity to meet the full consumer demand, both temporally and spatially.
- **Unequal electricity distribution:** Almost all households have access to electricity but the supply is intermittent and unreliable.
- **Erratic power pricing:** Industrial and commercial consumers subsidize domestic and agricultural consumers.
- **Lack of adequate coal supply:** Despite abundant reserves of coal, power plants are witnessed the under-supply of coal.
- **Poor gas pipeline connectivity and infrastructure:** India has endowed high coal bed methane and natural gas. A giant new offshore natural gas field has delivered far less gas than claimed, causing a shortage of natural gas.
- **Transmission, distribution and consumer-level losses** are more than 30%, including the auxiliary power consumption of thermal power stations and fictitious electricity generation by wind generators, solar power plants, etc.

Initiatives taken:

- **National Infrastructure Pipeline:** The Government of India has allocated Rs. 111 lakh crore (US\$ 1.4 trillion) under the National Infrastructure Pipeline for FY 2019-25. The energy sector is likely to account for 24% capital expenditure over FY 2019-25.
- **Automatic approval of Foreign Direct Investment:** Automatic approval for 100% foreign equity is permitted by the government of India in generation, transmission and distribution, and trading in the power sector without any upper limit on the investment.

- Signing of Fuel Supply Agreements:** The Cabinet Committee on Economic Affairs (CCEA) has issued a directive to the Ministry of Coal/Coal India Limited to sign fuel supply agreements (FSAs) for a total capacity of 78,000 MW, including tapering linkage, which are likely to be commissioned by March, 2015.
- Pass-Through mechanism:** Pass-through mechanism for the concluded Power Purchase Agreements (PPAs) has been approved by the CCEA.
- Deen Dayal Upadhyaya Gram Jyoti Yojana:** Deen Dayal Upadhyaya Gram Jyoti Yojana for electricity feeder separation and strengthening sub-transmission and distribution systems in rural areas has been launched.
- Ultra Mega Solar Power:** Ultra Mega Solar Power projects in Rajasthan, Gujarat, Tamil Nadu, and Laddakh in J&K have been announced.
- Ujwal Discoms Assurance Yojana (UDAY)** was launched by the Government to encourage operational and financial turnaround of State-owned Power Distribution Companies (DISCOMS) with an aim to reduce Aggregate Technical & Commercial (AT&C) losses to 15% by FY19.

Way forward:

- The Indian government has released its **227 GW renewable energy roadmap** (including 114 GW of solar power and 67 GW of wind power) by 2022. The Indian Union Government is **preparing a 'roof rental' policy** to fund the goal of generating 40 gigawatts (GW) of energy through solar roof top projects by 2022.
- India's coal-fired power generation, currently standing at 199.5 GW, is **expected to achieve a total power output of 47.86 GW by 2022.**

Conclusion: Power is among the most critical component of infrastructure. It is a crucial for the economic growth and welfare of nations. Adequate infrastructure is essential for sustained growth of the Indian economy. Electricity demand in the country has increased rapidly and is expected to rise further in the years to come. In order to meet the increasing demand for electricity in the country, massive addition to the installed generating capacity is needed.

Non-Conventional Sources of Energy

What are Non-Conventional Sources of Energy?

- Non-Conventional Sources of Energy (Renewable energy) is produced from renewable resources, which are naturally replenished on a human timescale, including carbon neutral sources like sunlight, wind, rain, tides, waves, and geothermal heat. Examples include solar energy, bioenergy, tidal energy and wind energy, etc. **India is running the world's largest clean energy programme to achieve 175 GW of renewable capacity, including 100 GW of solar power by 2022.**

Solar power

Why in news?

- Recently, **India ranked at 5th position in the world in solar power deployment**. India's solar power capacity has increased by more than 11 times in the last five years from 2.6 GW in March, 2014 to 30 GW in July, 2019. At present, solar tariff in India has achieved grid parity.

Advantages of Solar Power?

- It is a **clean and renewable energy** source. Causes **no pollution**.
- Solar energy **can be produced free of charge** once a solar panel is installed.
- Solar energy **will last forever**. It is estimated that the world's oil reserves will last for 30 to 40 years.

Disadvantages of Solar Power?

- High installation cost** of Solar panels resulting in a time-lag of many years for savings on energy bills to match initial investments.
- Electricity generation **depends entirely on a country's exposure to sunlight**; this could be limited by a country's climate.

- Solar cells make **no noise**. The giant machines utilized for pumping oil are extremely noisy and therefore very impractical.
- **Less maintenance cost** is needed to keep solar cells running. There are no moving parts in a solar cell which makes it impossible to really damage them.
- In the long term, there can be a **high return on investment** due to the amount of free energy a solar panel can produce. It is estimated that the average household will see 50% of their energy coming in from solar panels.

Way forward:

- **Finance:** There is a need to improve investment in the solar supply chain within India.
- **Policy:** Chinese success in the solar sector can be a guiding star for us.
- **Demand-side approach:** The solar demand in India is still low due to its cost-effectiveness and only a few metro cities can heavily implement rooftop solar projects. In this scenario, the government with its ubiquitous presence, can be the largest consumer of solar energy through rooftop solar projects over government buildings.
- **Hybrid energy model:** The solar-wind hybrid energy model is an emerging model that works on deficiencies of both the sectors and provides a more reliable source of power generation.
- **Solar Federalism:** Electricity is under concurrent list under the seventh schedule requiring both states and centre to have a policy say.

Conclusion: As the PM said in 2015 that India has to think in GW as against MW in the past. This intent along with consequent thrust on solar energy nationally and internationally showcases India's seriousness about making solar energy a prime mover in the energy sector. The pandemic itself is a critical opportunity for India to plan its own green deal on the lines of the European Union. Solar energy sector is a solution to most of pressing issues of the country such as equitable and sustainable development, social sector, employment generation, etc. It forms an important component of the quest for **Atmanirbhar Bharat**.

India's Wind Power Project

Why in news:

Till the end of February 2021, the total installed wind power capacity of the country was 38.789 GW. India has the **fourth largest installed wind power capacity in the world**. Wind power capacity is mainly spread across the Southern, Western and Northern regions.

Advantages of Wind Power:

- **Wind power is cost-effective** as it is one of the lowest-priced energy sources available today.
- **It's a clean fuel source.** Because it doesn't pollute the air like power plants that rely on combustion of fossil fuels.
- **It's sustainable** form energy with the solar energy. Winds are generated as the result of by the heating of the atmosphere by the

CHALLENGES OF WIND POWER:

- **Good land-based wind sites are often located in remote locations**, far from cities where the electricity is needed.
- **High cost of land utilization.** Land suitable for wind-turbine installation must compete with alternative uses for the land.

- sun, the rotation of the Earth, and the Earth's surface irregularities.
- **Wind turbines can be built on existing farms or ranches.** This greatly benefits the economy in rural areas, where most of the best wind sites are found.
 - Wind enables industrial growth and employment generation

Conclusion: Wind is an intermittent and site-specific resource of energy and therefore, an extensive Wind Resource Assessment is essential for the selection of potential sites. The expansion of the wind industry has resulted in a strong ecosystem that will help India to chase her Commitment to Paris agreement.

Tidal Energy

- As per the Indian Institute of Technology, Chennai in December 2014, the tidal power potential was estimated at around 12,455 MW.
- The potential areas with low/medium tidal wave strength are in the Gulf of Khambat, Gulf of Kutch & southern regions in Gujarat, Palk Bay- Mannar Channel in Tamil Nadu, and Hoogly river, South Haldia & Sunderbans in West Bengal.
- Tidal energy is still in Research & Development (R&D) phase and has not been implemented on a commercial scale in India. The earlier efforts for harnessing tidal power were not successful due to high capital cost ranging from Rs. 30 crore to Rs. 60 crore per MW.

Advantages:

- **Clean And Renewable:** No pollution and doesn't take up much physical space when compared to other renewable energy systems.
- **Predictable And Reliable:** Most areas experience two high tides and two low tides per day. This cycle is easily predicted and isn't subject to unexpected changes unlike many other renewable resources.
- **Long-Lasting Equipment:** The average estimate for most tidal systems is 75-100 years of working use. In comparison, a solar panel usually degrades after an average of 25-30 years.
- **Effective at Low Speeds:** Tidal energy systems can produce energy even when the water passing over or through them is moving relatively slowly. Water is 1,000 times denser than air, which means it can power a turbine even when moving a snail's pace.

Disadvantages:

- **Environmental impact:** The systems require turbulent water to power them, a large foundation needs to be built. This type of underwater construction can result in habitat destruction.
- **High construction Costs:** Building structures strong enough to withstand the turbulent, corrosive nature of sea water is by no means a cheap undertaking
- **Scarcity of suitable locations:** Not every seashore near a shore is suitable for a tidal energy facility. They require a very specific set of factors in order to operate effectively and efficiently. For example, the height of the sea during low and high tide
- **It can be very inconsistent:** Engineering flaws and technical errors like excessive turbine failure rates, failures in generating electricity during low water conditions, and strong currents are preventing turbines from operating properly. It is also an inconsistent because it relies on the tide

Conclusion: Globally, tidal energy is not cost-competitive and is still at a nascent development stage. Combine efforts of government and private sector is necessary to set up tidal power projects in India by overcoming the financial, technological, environmental and other risks.

What is the importance of the non-conventional source of energy?

- **Clean Energy source:** Non-conventional sources of energy are considered to be important as they are renewable, pollution-free, availability of them is in abundance, and they are environmentally friendly.
- **The government is aiming** to achieve 227 GW of renewable energy capacity (including 114 GW of solar capacity addition and 67 GW of wind power capacity) by 2022, more than its 175 GW target as per the Paris Agreement.
- **Readily available energy source:** Non-conventional/renewable energy is an indigenous source available in considerable quantities to all developing nations and capable, in principle of having a significant local, regional or national economic impact.
- **There is a great scope of research and development** in non-conventional/renewable energy sectors regarding its future development and scientific utilization.
- **Less operational cost:** The power plants based on renewable do not have any fuel cost and hence negligible running cost.
- **Environmental friendly source of energy:** Renewable have low energy density and more or less there is no pollution or ecological balance problem. Provide energy in environmentally benign manner.
- **Economic benefits:** The use of non-conventional/renewable energy could help to conserve foreign exchange and generate local employment if conservation technologies are designed, manufactured, assembled and installed locally.
- **Short gestation period and low investment.**

CONCLUSION: The sustainable economic development and growth of any country are closely related to the development and security of its energy sectors. Concerning the finite and limited reserves of conventional energy sources and their impact on environment, a great emphasis should be given to the development of non- conventional energy sectors and their proper utilization for the benefit and betterment of mankind. countries. In India, there is great scope for the development of non-conventional and renewable energy sectors.

Depletion of Natural Resources.

- The depletion of natural resources occurs when resources are consumed at a faster rate than that of its replacement. Natural resources are either be renewable or non-renewable. In the context of natural resource depletion, it is referred to depletion in water usage, farming, fossil fuel consumption, fishing, and mining. Natural resource depletion is defined on the premise that the value of a resource is measured in terms of its availability in nature.

Causes of Depletion of Natural Resources:

- **Overpopulation** is a critical factor in accelerating the depletion of natural resources. An increase in the populace expands the need for resources and conditions necessary to sustain it.
- **Poor Farming Practices**, Poor soil management practices, unsustainable irrigation practices and the use of heavy machinery and farming equipment also destroy the soil structure making it unsuitable for plant growth.
- **Overconsumption of Natural Resources** due to advancements in technology and research in the contemporary era; exploitation of minerals has become easier. The increased exploitation of different minerals has led to some of them entering into decline of a production .
- **Pollution:** The soil, air, lakes, and seas are being contaminated with sewage, radioactive, materials, and toxic chemicals among other pollutants.

- **Industrial and Technological Development:** Growth in industries that release toxins and chemical by-products which are eventually deposited in lakes, soils, and lands causing toxic materials to enter into and alter natural habitats such as aquatic systems and wildlife.

Effects of Depletion of Natural Resources:

- **Water shortages:** Poor farming practices, deforestation, and pollution are causing the water resource depletion due to contamination, wastage, and the destruction of natural water catchment areas.
- **Oil depletion:** According to EIA's **International Energy Outlook**, due to the high rate of oil exploitation, the amount of oil remaining would last for only 25 years.
- **Loss of forest cover:** Studies indicate that globally an increase in deforestation in the past three decades has resulted in a 12% to 17% rise in greenhouse gases.
- **Depletion of minerals:** Increase in the exploitation of minerals such as phosphorus, gasoline, copper, and zinc among others to sustain the seven billion people on earth may cause that the earth could run out of phosphorus – an essential element for plant growth, in the next 50 to 100 years.
- **Extinction of Species:** As a result of resource overexploitation and habitat degradation, some species may go extinct.

Solutions of Depletion of Natural Resources:

- **Controlling Deforestation:** Programs like the REDD (Reducing Emissions from Deforestation and Forest Degradation) created by the World Bank, the New York Declaration on Forests, and the United Nations are initiatives that could help reduce the depletion of natural resources.
- **Reducing oil, mineral, and material consumption:** Oil-rich countries together with the World Bank, state, and consumables' regulatory bodies should join hands towards a common international objective of discussing how oil and mineral consumption, as well as exploitation, can be reduced.
- **Re-use and recycle:** Manufacturers can, for instance, be trained on lean manufacturing (recycling, re-use, and reducing wastage) while consumers sensitized on how to adopt re-use, reducing wastage, and recycling techniques.
- **More exploration and use of renewable sources of energy:** Renewable energy sources like solar and wind power can be explored more and utilized to reduce the dependency on fossil fuel.
- **Protecting wetlands and coastal ecosystems:** The coastal and wetland ecosystems are thus vital in sustaining the food chain as they replenish water sources and avail minerals and nutrients for primary producers (green and flowering plants), essential for maintaining plant and animal biodiversity. Also when coastal ecosystems are protected, they aid in controlling marine overfishing and protect coral reefs.
- **Sensitization and awareness creation:** People need to be educated on how their daily practices put a strain on the scarce natural resources and their individual contributions to the depletion of natural resources.

Conclusion:

- According to the study, natural resource exploitation has caused irreparable distortion on the environment and the livelihood of the people in the affected communities. The purpose of natural resource exploitation is generally to trigger economic growth and development. There is a need to consider green accounting system to achieve sustainable growth.

Decarbonising Transport

Why in news?

- 'Forum for Decarbonizing Transport' in India as part of the NDC-Transport Initiative for Asia (NDC-TIA) project launched on 23 August, 2021 by NITI Aayog and World Resources Institute (WRI).

Definition:

- According to ITF ,Decarbonising Transport initiative promotes carbon-neutral mobility to help stop climate change. It provides decision makers with tools to select CO₂ mitigation measures that deliver on their climate commitment.

Significance/need:

- The COVID-19 pandemic has posed a number of challenges** for the transport sector, one of which is the shift of citizens from public to private and personal modes of transport. It is likely to increase co2 emissions.
- Increasing GHG in near future:** The transport sector of India is the third most greenhouse gas (GHG) emitting sector and accounted for 14 per cent of our energy-related CO₂ emissions. In the coming future with increasing population the GHG is going to increase.
- To achieve India's NDC :**India is one of the few countries on track to achieve its Nationally Determined Contributions under the Paris Agreement, having already achieved 21 per cent of its pledge to reduce emissions intensity of GDP by 33-35 per cent by 2030. It is only 2 % short of the 2030 target of 40 per cent of installed non-fossil fuel electricity capacity.
- Sustainable growth** needs to continue to bolster efforts in this direction to reduce oil import bills and to usher cleaner mobility.
- Employment generation:** The emergence of newer business models, advanced research, greater employment opportunities and an overall multiplier effect on the economy.
- With increasing URBANISATION**, the fleet size i.e. the **NUMBER OF SALES OF VEHICLES IS INCREASING RAPIDLY**. It is projected that the **TOTAL NUMBER OF VEHICLES WILL BE DOUBLED BY 2030**.
- TRANSITION TO A DECARBONISATION PATH** for the transport sector in India is essential to achieving the goals of the PARIS CLIMATE AGREEMENT FOR 2050.
- Climate change cannot be stopped without decarbonising transport.** Transport emits around 23% of the energy-related CO₂ that feeds global warming. Without immediate action, its share could reach 40% by 2030.

Challenges :

- Low expenditure (<1% of GDP) on R&D** may restrict environment friendly innovations.
- Adversely affect on automobile industry:** Use of disrupting technology like Hydrogen fuel cell, electric vehicles ,BS VI etc., may adversely affect on automobile industry.
- High cost of Decarbonising transport** may not be attractive for price sensitive middle class families.
- Lack of facilitative infrastructure** for Decarbonising transport. Eg. Lack of charging stations for electrical vehicles, poor quality of roads that can sustain delicate electric vehicles.

Government Initiatives/way forward:

- The FAME II scheme** (the subsidy as part of which was recently increased, further bringing down the cost differential between EVs and ICE vehicles) is providing an impetus to clean mobility.
- Production Linked Incentive (PLI)** scheme for Advanced Cell Chemistry (ACC) battery storage will further accelerate EV adoption.
- The Railways** has pledged to become a net-zero emitter by 2030 and the operationalisation of dedicated freight corridors will cut emissions by almost 450 million tonnes in the first 30 years.
- Metro rails** are rapidly expanding across the country as is the concept of high speed regional mobility — the Delhi-Meerut Regional Rapid Transit System and the Kerala Semi-High Speed Rail are both transformational projects, which will provide quick and seamless inter-city linkage and take millions of vehicles off the road.

- **Ropeways**, for Overhead Mass Rapid Transit (OMRTS) along the lines of the highly successful La Paz Ropeway in Bolivia, are already being explored in Northern and North-eastern states.

Conclusion:

As a developing country, it is important for India to balance the aspirations of citizens and intended economic growth with environment and sustainability. Decarbonising Transport would provide highly efficient and impactful transport ecosystem in the country.

Alternative Fuels and Energy Resources

Why in News?

The Union Budget for FY 2021-22 presented by the Union Minister of India, has exclusively focussed on Green Energy initiatives.

Definition: Alternative fuels, known as non-conventional and advanced fuels, are any materials or substances that can be used as fuels, other than conventional fuels like; fossil fuels (petroleum (oil), coal, and natural gas), as well as nuclear materials such as uranium and thorium, as well as artificial radioisotope fuels that are made in nuclear reactors.

Eg: Alternative fuel comprise bio-diesel, bio-alcohol (methanol, ethanol,), refuse-derived fuel, chemically stored electricity (batteries and fuel cells), hydrogen, non-fossil methane, non-fossil natural gas, vegetable oil, propane and etc.

Why Alternative Fuels and Energy Resources?

- **Power sector**, being primarily dependent on fossil fuels, is one of prime sources of air pollution.
- **Sustainable**: Alternative fuels generated energy will be cleaner , greener and more sustainable.
- **Power supply**: It can help in providing 24*7 power supply to 100% of the households.
- **Employment opportunities**: New technology inclusion means more employment opportunities for the working population of the country.
- **Market assurance**: From the economy point of view, alternative fuels and energy resources provide more market and revenue assurance as compare to any other resources.

Challenges with Renewable Energy:

- **24*7 Power Supply**: Sustainable and uninterrupted power supply along with the storage system is one of the biggest challenges ahead.
- **Cost factor**: Conventional sources are comparatively cheaper as compared to alternative fuels and energy resources.
- **Integration with the Main Grid**: India needs to work upon the integration of the alternative fuels and energy resources with the main grid.
- The **storage and battery solutions** is needed in large quantities to accelerate the uptake of alternative fuels and energy resources,

Initiatives Taken:

- **Budget 2021-22** talks about **PLI scheme in Solar Manufacturing, Vehicle Scrappage Policy and the Hydrogen Energy Mission**.
- **The National Hydrogen Energy Mission** intends to reduce petroleum use, greenhouse gas emissions, and air pollution. It also aims to contribute to more diverse and efficient energy infrastructure.
- **Solar energy**: The Jawaharlal Nehru National Solar Mission (JNNSM) aimed to achieve 20 GW solar capacity by the year 2022.

- Agricultural Sector:** The agricultural sector is one of the energy intensive sectors. There is a challenge to provide sufficient power and energy to every household and to the agricultural sector as well.

- Renewable energy:** The Government of India had set a target of 175 GW renewable power installed capacity by the end of 2022

Way Forward:

- Hydrogen fuel cell based vehicles and Electric vehicles:** These are the most suitable options when it comes to shifting towards renewable sources of energy, that's where we need to work upon
- Exploration:** More storage solutions need to be explored on the line of lithium ion battery.
- Agriculture subsidy:** Agricultural subsidy should be rectified in order to ensure that only the required amount of energy is consumed.
- Incentivise and promotion of pro **bio fuel cropping pattern.**

Conclusion: India needs to focus on diversified energy mix. Solar and wind have a great potential, Hydrogen could be a game changer in Indian energy transition journey. **Energy Vision 2035** of NITI Aayog will help in achieving India's clean energy goals.

Hydrogen Based Energy

Why in News?

Budget 2021 has proposed the launch of the Hydrogen Energy Mission in this fiscal year.

Hydrogen Energy Mission:

- The National Hydrogen Energy Mission **aims to reduce petroleum use, greenhouse gas emissions, and air pollution**, and contribute to more diverse and efficient energy infrastructure.
- It is now proposed to launch a **Hydrogen Energy Mission in 2021-22** for generating hydrogen from green power sources.
- Green Hydrogen Mission** is not only essential to de-carbonise heavy industries like steel and cement, it also holds the key to clean electric mobility that doesn't depend on rare minerals.

What is Hydrogen based energy?

Hydrogen energy involves the use of hydrogen and/or hydrogen-containing compounds to generate energy to be supplied to all practical uses needed with high energy efficiency, overwhelming environmental and social benefits, as well as economic competitiveness.

Pros:

- The energy of 2.2 pounds (1 kilogram) of hydrogen gas contains the same amount of the energy in 6.2 pounds(1 gallon 2.8 kilograms) of gasoline.**
- Clean fuel:** Hydrogen fuel produces only water as a by-product.
- Hydrogen fuel is a renewable source of energy so that it can be used along with electric power to run electric vehicles.

Challenges:

- High production cost:** The technology used in production and use of hydrogen like Carbon Capture and Storage (CCS) and hydrogen fuel cell technology are at initial stage of development and are expensive. This increases the cost of production of hydrogen.
- It is difficult to store** due to its very hard to move property.
- High maintenance costs** of fuel cells post-completion of a plant.

- **Efficient:** Hydrogen fuel + electric energy is more efficient and cleaner as compare to internal combustion engine.
- Hydrogen can be used as a **fuel for internal combustion engines.**
- **Need huge investment** in R&D of such technology and infrastructure for production, storage, transportation and demand creation for hydrogen.
- **It is dependent on fossil fuels:** Although hydrogen energy is renewable and has minimal environmental impact, other non-renewable sources such as coal, oil and natural gas are needed to separate it from oxygen.

Way Forward: A calibrated approach can help India to get unique position for herself to take advantage with increasing investment in R&D, capacity building, compatible legislation, and the opportunity for creation of demand among its vast population. These initiatives can propel India to become the most favoured nation by exporting hydrogen to its neighbours and beyond.

Hybrid Renewable Energy

Why in news?

Prime Minister laid the foundation stone of **The Hybrid Renewable Energy Park** near Vighakot village in the district of Kutch in Gujarat in December 2020. It will be the country's largest renewable energy generation park. It will generate 30 GW of renewable energy. The park will have a dedicated hybrid park zone for wind and solar energy storage, as well as exclusive zone for wind park activities.

Advantages:

- **Continuous power supply:** The hybrid renewable systems provide power continuously, without any interruption, as the seasonality of solar energy can be compensated by wind power generation.
- **Utilize the renewable sources in best way:** As the batteries are connected to the system to store the energy, there is no waste of the excess energy generated on bright sunny days and days of high wind speed.
- **Low maintenance cost** – The maintenance cost of the hybrid renewable energy systems is low as compared to the traditional generators which use diesel as fuel.
- **High efficiency** – The hybrid solar energy systems work more efficiently than traditional generators which waste the fuel under certain conditions.
- **Load management** – Unlike traditional generators, which provide high power as soon as they turned on, most of hybrid renewable power systems manage load accordingly.

Disadvantages:

- **Complicated controlling process :** With different types of energy sources in use, the systems require some knowledge. The operation of different energy sources, their interaction and co-ordination must be controlled and it can become complicated.
- **High installation cost:** The maintenance cost is low, but the initial investment for the installation of the systems is high as compared to a solar systems.
- **Less battery life :** The batteries connected to the system may have a lower life as they are often exposed to natural elements like heat, rain, etc.
- **The number of instruments connectable is limited :** The number of devices can be connect to a hybrid solar energy system is limited .

Conclusion:

- Hybrid Renewable Energy can become a viable solution to meeting future power requirements of the country, that too all at zero carbon emissions and future cost-inflation proof. Indian corporates are also showing active interest in increasing usage of clean power if round-the-clock solutions are provided.

Gas-Based Economy

why in news?

Prime Minister, in early February 2020, inaugurated several oil and gas-related infrastructure projects in Haldia, including GAIL's 348-km Dobhi-Durgapur natural gas pipeline and an LPG import terminal.

What is gas-based economy?

Gas-based economy means the gas as the main commercial energy source in the energy basket of an economy. The reforms are intended to provide a standard procedure for the sale of natural gas in a transparent and competitive manner. It aims to discover market price by issuing guidelines for sale by the contractor through e-bidding.

Why Natural Gas?

- Natural gas **can be easily found and is abundant** as it is available from nature.
- Natural gas is **highly flammable** due to high level of methane.
- Natural gas is **colourless, tasteless, and odourless**.
- The **density of natural gas is lower than that of the density of the air** which makes it lighter than air. As in case of leakage, it can easily dissipate into the air.
- Natural gas is less corrosive due to high methane and low carbon composition.

Advantages of Natural Gas:

- Natural Gas is Environmentally Clean** because unlike other gases, natural gas emits very less by-products into the atmosphere as pollutants. This keeps the air cleaner.
- It is Economical:** It is not as expensive as other burning fuels.
- It is Convenient** for cooking or electric purposes, it can be directly connected to the consumer's house with the help of pipelines. This eliminates the long process of collecting, processing, packing, and delivering the end product to the customers.
- Natural Gas is Safe to Use:** One of the biggest fears while using LPG cylinders or any other type of fuel is the possibility of leakage. Natural gas is lighter than air. In case of a leakage, it dissipates quickly into the air avoiding fire.

Disadvantages of Natural Gas

- Limited Quantities:** India does not have vast reserves of natural gas. Most of the natural gas that is consumed by the country has to be imported from other countries. This constant purchases can turn into a rather expensive proposition over time.
- Natural Gas is Highly Combustible:** As natural gas is odourless, it is difficult to detect a leakage as well.
- Natural Gas is a Non-Renewable Source of Energy:** Experts state that natural gas will be depleted in the future and we will have to import it from other nations.
- Natural Gas Emits Carbon Dioxide:** It emits carbon dioxide which is bad for our atmosphere. Constant introduction of carbon dioxide into the atmosphere will lead to climate change and also global warming.
- Long Processing Process:** As natural gas has other components that have to be removed before using it

- **It is Available Abundantly:** As per study, amount of natural gas available is more than crude oil or other such products.
- **It is More Efficient:** When compared to things like propane gas, natural gas provides more energy when it burns, which makes it much more efficient.
- **Natural Gas is Easy to Deliver:** Considering the current mode of delivery of gas to homes in India, a lot of metal cylinders changing hands. To deliver natural gas there is a need of network of pipes.

for residential or commercial purposes, it takes a lot of time and manpower to process it.

- **Leakage:** Even though it is lighter than air and can disperse easily, a big danger with natural gas is that since it is colorless, odorless and tasteless, should it start leaking, detection of the leak is very hard.
- **Storage:** Its volume happens to be four times that of petrol which makes it more expensive to store since more needs to be spent on additional storage.

Conclusion:

Despite all these disadvantages, natural gas is one of the cheapest and easily available fossil fuels in this world. It can be considered that natural gas can serve as a viable alternative to other fossil fuels till such time as something more efficient can be found.

New Emission Norms for Thermal Power Plants

Why in news?

The Environment Ministry has amended rules allowing the thermal power plants within 10 kilometres of the National Capital Region (NCR) and in cities with more than 10 lakh population to comply with new emission norms by the end of 2022.

Gist of New Emission norms:

- A task force will be constituted by the **Central Pollution Control Board (CPCB)** to "categorise thermal power plants (TPPs) in three categories on the basis of their location".
- **TPP units in "non-attainment cities"** and those within 10 kilometres of critically polluted areas are required to meet the emission norms by December 31, 2023.
- **Coal-fired power plants** in the rest of the areas have to comply with the new standards by December 31, 2024, according to the notification.
- TPPs declared that **TPPs retiring before December 31, 2025**, are not required to meet the specified norms in this case such plants to submit an undertaking to the CPCB and the CEA (Central Electricity Authority) for exemption on ground of retirement.

Need of New Emission Norms:

- **Pollution:** Major pollutants from coal-fired power plants are oxides of nitrogen (NOx), sulphur dioxide (SO2) and particulate matter (PM).

Eg:-According to the Centre for Science and Environment (CSE), TPPs account for more than 60 per cent of total industrial emissions of particulate matter; 45 per cent of SO₂ ,etc.

- **Water overuse:** These are also responsible for 70 per cent of the total freshwater withdrawal by all industries, according to an analysis by the green think tank.

- Negligence in following emission norms:** A recent compliance report by CSE showed that out of the 12 power plants located around Delhi, SO₂ control technology was available only in two plants.

Conclusion:

Energy sector causes over 40% of India's greenhouse gas emissions. It comes from heavy dependence on coal. It becomes necessary to strictly adhere to New Emission Norms for thermal power plants to ensure cleaner and greener environment.

Aerosol Nucleation

Why in news?

- In early June 2020, Scientists from the University of Hyderabad measured neutral sub-3nm particles for the first time at an urban location in India. This has critical importance as a major fraction of these newly formed particles can reach to sizes of cloud condensation nuclei where they have climatic impacts.

Aerosol nucleation means?

- Aerosols, which are **suspensions of fine solid particles** or liquid droplets in a gas. The formation of small molecular clusters of sub-3nm size is technically called aerosol nucleation, and subsequent growth of these newly formed clusters to the large sizes is called **atmospheric new particle formation (NPF)**.
- NPF occurs everywhere in the terrestrial troposphere, and therefore it is a large source of aerosol numbers to the atmosphere. All atmospheric aerosols scatter incoming solar radiation, and a few aerosol types can also absorb solar radiation.

Impacts

Positive Impacts:

- Cooling effect on environment:** Aerosols that mainly scatter solar radiation have a cooling effect, by enhancing the total reflected solar radiation from the Earth.
- Cloud formation:** Aerosols are vital for cloud formation because a subset of them may serve as cloud condensation nuclei (CCN) and ice nuclei (IN). An increased amount of aerosols may increase the CCN number concentration and lead to more, but smaller, cloud droplets for fixed liquid water content.
- Increases the albedo:** This cloud formation increases the albedo of the cloud, resulting in enhanced reflection and a cooling effect, termed the cloud albedo effect.
- Life cycles of clouds** are controlled by an intimate interplay between meteorology and aerosol-and-cloud microphysics, including complex feedback

Negative impacts:

- Warming effect :** Strongly absorbing aerosols have a warming effect.
- Diminishes the potential for cloud formation:** Absorbing aerosols also have the potential heating the air surrounding them while reducing the amount of solar radiation reaching the ground, which stabilizes the atmosphere and diminishes the convection and thus the potential for cloud formation.
- Increasing the atmospheric temperature:** Absorbing aerosols also have the potential increasing the atmospheric temperature, which reduces the relative humidity, inhibits cloud formation, and enhances evaporation of existing clouds. This is collectively termed the semi-direct aerosol effect.
- Poor air quality:** the presence of aerosols in the atmosphere was common but their presence in urban areas means, over a period of time, the city may have

processes, and it has proven difficult to identify the traditional lifetime effect

to face haze and air quality may also get affected in the process.

Conclusion: The study of aerosols is not prolific in India and a lot of research using state-of-the-art instrumentation is needed to understand the mechanisms driving NPF in diverse environments across India. It needs to be done before coming to a total conclusion on these aerosols affecting the urban atmosphere badly.

Fly Ash

Fly ash or flue ash, coal ash, pulverised fuel ash or coal combustion residuals (CCRs), is a coal combustion product that is composed of the particulates (fine particles of burned fuel) that are driven out of coal-fired boilers together with the flue gases.

The **components of fly ash** vary considerably, but all fly ash includes substantial amounts of silicon dioxide (SiO_2) (both amorphous and crystalline), aluminium oxide (Al_2O_3) and calcium oxide (CaO).

Uses:

Coal ash uses include (approximately in order of decreasing importance):

- It helps in **concrete production**, as a substitute material for Portland cement, sand.
- It can be used as a **corrosion control measure** in RC structures. Fly-ash pellets **can replace normal aggregate** in concrete mixture.
- It can be **used for making embankments** and other structural fills (usually for road construction).
- It helps in **waste stabilization** and solidification. It acts as a solution for mine reclamation. Acts as a stabilizer for soft soils.
- Acts as aggregate substitute material (e.g. for brick production).

Advantage:

- **In terms of usability in Concrete and Cement:** It provides higher ultimate strength, increased durability, improved workability etc.
- **In terms of usage as fly ash bricks:** It reduces excavation of clay ,Low cost of brick as compared to clay brick of same quality, etc.
- **Other benefits of using fly ash:**
 - Reduces soil erosion by replacing top soil as ingredients for most construction mixes.
 - Reduces pollution measure by re-use of wastes.
 - Reduces the amount of greenhouse gases being added to the atmosphere.
 - Hydrophobic nature helps in proper draining off of water from roads and structures.

Environmental problems:

- **Groundwater contamination:** Fly ash obtained after combustion of coal that resulted in to enhance concentrations of elements(such as arsenic, barium, beryllium, etc.) .They are main cause of the ash to cause groundwater pollution .
- **Ecology:** Fly ash dust can be deposited on topsoil increasing the pH and affecting the plants and animals in the surrounding ecosystem.
- **Spills of bulk storage:** Where generally fly ash is stored in bulk in wet rather than dry to minimize fugitive dust. The resulting ponds are typically large and stable for long periods, but any breach of their dams or bunding is rapid and on a massive scale.
- **Contaminants:** Fly ash contains trace concentrations of heavy metals (such as cadmium, barium, chromium, copper, lead, mercury etc.)are detrimental to health .

- **Impediments in its full-scale utilization in India:** Imperfections typical of quasi-markets, such as information asymmetry and high transaction costs, vested interests, technical and technological limitations, and the lack of regulatory oversight and political will etc.

Initiatives: Maharashtra has become the **first state** in the country to adopt the **Fly Ash Utilization Policy**. The policy paves way for prosperity by generating wealth from waste and environment protection.

Conclusion: Policy frame work and national strategy can make it possible to utilize all fly ashes in gainful manner. It would mitigate the environmental threat, generate employment and industrial wealth, conserve mineral resources, provide sustainable construction and agriculture including forestry and cleaner environment.

Lithium reserves

Why in news?

- According to the researchers at the Atomic Minerals Directorate for Exploration and Research (AMD), Department of Atomic Energy, Government of India, potential lithium reserves have found in the Mandya district, Karnataka, about 100 km from Bengaluru.
- Their research has shown the presence of 1,600 tonnes of lithium resources in the igneous rocks of the Marlagalla-Allapatna region of Karnataka's Mandya district.
- The discovery is significant since the reserve is being touted as the country's single largest source of lithium, an element that is increasingly finding applications in battery technology used in electric vehicles.

Lithium reserves in India.

Exploration activities to extract lithium from brine pools in Rajasthan and Gujarat, and mica belts of Odisha and Chhattisgarh is in "preliminary and reconnaissance" stage.

About Lithium

- Lithium is a **soft, silver-white metal** within the alkali metal group on the periodic table.
- In nature, lithium **occurs only in compounds** due to its high reactivity.
- **Chile has the largest lithium reserves worldwide** by a large margin. Chile had an estimated 9.2 million metric tons of lithium reserves in 2020. **Australia came in second**, with reserves estimated at 4.7 million metric tons that year.

Potential benefits:

- **To strengthen country's nuclear programme:** Due to thermonuclear properties of Lithium ,it is among the elements which are required to support the country's nuclear programme.
- **Help to promote Electric Vehicles:** The demand for lithium is growing to demand in the near future due to its use in Li-Ion battery.
- **Economic benefit:** At present India's demand of Lithium is met by imported Lithium from Bolivia, Chile etc. Lithium reserves may reduce import dependence of country.
- **Atmanirbhar Bharat:** It may help India to be self-reliant in terms of lithium requirement.

Challenges:

- The DAE made it clear that unless a proper technology or method is available to profitably extract lithium from its ore, the real benefit of exploration may not be there .
- The actual economic benefits of the over four-decade-old exploration efforts cannot be estimated at this stage.
- Out of this lithium ore, only small quantity of lithium metal can be extracted.

Conclusion: Lithium reserves can be utilised cost effectively by inventing cutting edge technologies and taking help of Lithium producing countries.

Biofuel - Lessons from Brazil

Why in news?

Recently, the government announced an ambitious plan to roll out vehicles running on 20% ethanol blended petrol by 2025, against the current level of blending of 5-6%. To achieve this target there is a need of paradigm shift in production and distribution of ethanol, the lessons for which could be taken from Brazil.

Progress of Brazil in bio fuel:

- Brazil is the **world's second largest producer of ethanol fuel**.
- Brazil is considered to have the **world's first "sustainable" biofuels economy** and the biofuel industry leader, and its sugarcane ethanol is "the most successful alternative fuel to date".
- Biofuels are central to Brazil's low carbon emission strategy.
- It can act as a policy model for other countries.

How did Brazil achieve this?

- Focus on new variety of sugar cane is known as **energy cane**, which is low in sucrose but high in biomass content.
- **High productivity** up to 350 tonnes of biomass per ha, against 80 tonnes per ha of traditional sugarcane, it offers a perfect balance.
- Brazil has **mandated a blending** of 27% ethanol with gasoline. In 2019, Brazil saved about 0.5 million barrels per **day of gasoline** and saved \$13 billion worth of imports.
- At present, 78% of Brazilian automobiles run on 27% of **ethanol blend**.

Significance of Brazilian model ?

- **Cropping pattern as per agroclimatic conditions:** Energy cane is suitable on drier and lower fertility soils.
- Brazilian sugarcane ethanol is considered as an '**advanced biofuel**' due to its 61% reduction of total life cycle GHG emissions.
- **Reduced import dependence** of fossil fuels is helping in saving foreign exchange reserve.
- Use of fossil fuels is one of the major sources of Co2 and other GHG emission globally. Use of bio fuel acts as remedy on it.

Issue with Brazilian model:

- Some scientists consider that the successful Brazilian ethanol model is **sustainable only in Brazil due to its advanced agri-industrial technology** and its enormous amount of arable land available.
- According to other authors, it is a **solution only for some countries** in the tropical zone of Latin America, the Caribbean, and Africa.
- It can **compete with food security** of the populous countries like India.
- **Sugarcane is water guzzling crop.** It may imbalance sustainable water uses.

Conclusion:

The government has come up with **National Policy on Biofuels, 2018** in order to promote biofuels in the country. The later-generation biofuels have sprung up which don't use food crops that are explicitly grown for fuel production. It can help in smooth transition to biofuel from conventional energy sources.

National Offshore Wind Energy Policy, 2015

Why in news?

Recently, the Union Ministry of New and Renewable Energy (MNRE) has set a target of installing 5 GW of offshore capacity by 2022 and 30 GW by 2030. India's capacity to generate electricity from wind reached at 39.2 gigawatts (GW) a year in March 2021.

Offshore Wind Energy:

- Offshore wind energy refers to the deployment of wind farms inside the water bodies. They utilise the sea winds to generate electricity. These wind farms either use fixed-foundation turbines or floating wind turbines.
- A fixed-foundation turbine is built in shallow water, whereas a floating wind turbine is built in deeper waters where its foundation is anchored in the seabed. Floating wind farms are still in their infancy.
- Offshore wind farms should be at as minimum as 200 nautical miles from the shore and 50 feet deep in the ocean.
- Offshore wind turbines generated electricity is returned to shore through the cables buried under the ocean floor. Based on priority the coastal load centres distribute this electricity.

Offshore Wind Energy: Benefits

- **Limited availability of land:** In India, where land is limited and the population is increasing, large wind farms positioned over water bodies will be vital.
- **Offshore wind turbines are more efficient** compared to onshore ones. Wind speed over water bodies is high and is consistent in direction. As a result, offshore wind farms generate more electricity per installed capacity.
- **Less number of offshore turbines are required** to produce the same capacity of energy equal to that of onshore ones.
- **Consistent energy generation:** As the offshore wind is stronger during the daytime, it ensures a more consistent and efficient electricity generation when consumer demand is at its highest. In contrast, wind power on land performs better at night when power consumption is lower.
- **Long operating hours:** Offshore wind power allows for longer operating hours due to its higher capacity utilisation factor (CUF) than that of onshore wind farms.
- **Big size possibility:** To increase energy harvest, It is possible to build bigger and taller offshore windmills.
- The wind flow is not restricted by hills or buildings.

Challenges of offshore wind energy:

- **Lack of supporting infrastructure** like local substructure manufacturers, installations vessels and trained workers.
- **Higher installation costs of** offshore wind turbines due to requirement of stronger structures and foundations than onshore wind farms.
- **High cost of generation:** Offshore wind tariffs in India are likely to range between Rs 7-9 per unit as compared to Rs 2.8-2.9 per unit for onshore wind.
- **Offshore wind farms require high maintenance cost** due to damaging action of waves and even high winds.

Offshore Wind Energy Development in India: Recommendations

- **Renewable purchase obligation:** Government-specified obligated entities such as power distribution companies, open access consumers and captive users can purchase clean energy as part of their total electricity consumption through a renewable purchase obligation.
- **Lower taxes:** In India, the GST Law exempts electricity and power sales from GST. In contrast, wind power generation companies cannot claim input tax credits when they pay GST to purchase goods and/or services for setting up the project. The majority of wind farm components need to be imported. If excise duties and GST could be waived, early project development will be more affordable.
- **Feed-in tariff:** Discoms can adopt feed-in tariff (FiT) regulations and make it mandatory to procure offshore wind power. Offshore wind power in the early stages of development can be promoted through FiT until it becomes economically viable.
- **Deemed generation provision:** Offshore wind projects need protection against curtailment concerns due to the inability of State Load Dispatch Centres (SLDCs) to absorb possibly generated large quantities of power. For this, the offshore wind can be given a “deemed generation provision”

Conclusion: The advantages of offshore wind farms and the abundance of offshore wind potential in India enable them to play a huge role in achieving the desired climate commitment and energy security goals.

M-Sand Policy

Why in news?

- The Rajasthan government in early January 2021 declared the policy on manufactured sand (M-sand), giving industry status to the units producing M-sand for construction work and reducing the dependence on bajri (bajri-verbed sand).
- The Supreme Court had banned illegal mining on riverbeds in 2017.

M-Sand: Manufactured sand (M-Sand) is a substitute of river sand for concrete construction. Manufactured sand is produced from hard granite stone by crushing. The crushed sand is of cubical shape with rounded edges, washed and graded to as a construction material. The size of manufactured sand (M-Sand) is less than 4.75mm.

Advantages:

- **Wide availability:** M-Sand can be manufactured nearby construction sites, thus driving down the transportation costs.
- **Denser particle packing:** M-Sand is free of silt and clay particles and has denser particle packing compared to river sand. This ensures lesser impurities and good working properties.
- **High strength:** M-Sand is superior to river sand with its higher compressive strength, higher flexural strength, better damage resistance, better water retention ability, higher unit weight and lower permeability.

Disadvantages:

- **Manufactured sand can be of a coarser and precise surface than regular sand,** which is smooth and adjusted because of normal degree needs more water and cement requirement. This can prompt to accomplish the normal usefulness, prompting expanded expenses.
- **Manufactured sand can contain bigger amounts of micro fine particles than normal sand,** inferable from its creation cycle. This again can influence the strength and usefulness of the tirade or cement.

- Better workability:** M-Sand provides excellent plasticity to the mortar, thus ensuring better workability compared to river sand.
- Economical:** M-Sand is proving highly economical and a perfect replacement of river sand due to its higher durability, better workability, higher strength, reduction in segregation and permeability

Conclusion: However, usage of M-Sand avoids exploitation of river beds for river sand. It helps in preventing environmental catastrophes like water scarcity, ground water depletion etc. It ensures the sustainable development for all.

Ratle Hydro Power Project

In early January 2020, the Union Cabinet had given its approval for the investment of Rs.5281.94 crore for 850 MW Ratle Hydro Electric (HE) Project located on river Chenab, in Kishtwar district of Union Territory of Jammu and Kashmir. The Ratle Hydroelectric Plant is a run-of-the-river hydroelectric power station.

Significance:

- Economic development of J&K:** This hydro power project will meet demand of state electricity. It will provide continuous energy supply for economic activities.
- Employment generation:** Multiplier effect of hydro power plant construction and future use of energy will generate employment opportunities.
- Sustainable energy source:** Being a run-of-the-river hydroelectric power station, e-flow of river will be maintained.
- Power at Cheaper Rates:** Union Territory of Jammu and Kashmir will be benefitted by getting free power worth Rs. 5289 crore.
- The way the electricity is produced does not harm the environment as much as fossil fuels like oil or coal do.
- Hydroelectricity is **very powerful and safe, and produces no waste.**

Conclusion:

Once completed, Ratle Hydro Power Project will substantially add to the power generation capacity of Jammu and Kashmir. It will provide financial and developmental benefits, and enable effective use of western rivers under the Indus Water Treaty.

Vanadium in Arunachal

Why in news?

GSI has found promising concentrations of vanadium in the Palaeo-proterozoic carbonaceous phyllite rocks in the Depo and Tamang areas of Arunachal Pradesh's Papum Pare district. This was the first report of a primary deposit of vanadium in India with an average grade of 0.76% V2O5 (vanadium pentoxide).

About Vanadium:

Vanadium in its pure form is a soft, grey and ductile element primarily derived from mined iron ore, carbonaceous shale or phyllites and steel slag. According to the Indian Bureau of Mines (2018 database), the total estimated reserves or resources of vanadium ore is 24.63 million tonnes, with an estimated V2O5 content of 64,594 tonnes.

Significance of recent findings:

Applications:

- Vanadium mineralization in Arunachal Pradesh is geologically similar to the “stone coal” vanadium deposits of China hosted in carbonaceous shale. This high vanadium content is associated with graphite with fixed carbon content of up to 16%.
- According to GSI, the expected grade of vanadium mineralisation in Arunachal Pradesh is comparable to the important vanadium deposits of the world.
- **The largest deposits are in China, followed by Russia and South Africa**
- **High tolerance:** Vanadium alloys are durable in at very high temperature and extreme environments, and are corrosion-resistant.
- **High strength:** Addition of Vanadium improves the tensile strength of steel and of reinforcing bars used for buildings, tunnels and bridges.
- **Its high strength-to-weight ratio** helps in increasing fuel-efficiency in automotive and aviation industries.
- **Vanadium forms the integral part of vanadium redox batteries.** It has the least ecological impact in energy storage.
- **Vanadium is also used to produce specialty steel alloys** such as high-speed tool steels, and some aluminium alloys.
- Vanadium pentoxide is used as a catalyst for the production of sulfuric acid

Conclusion:

The global demand for vanadium has been skyrocketing but there was a deficit of 17,300 metric tonnes between demand and supply in 2017. According to the GSI specialist ,the vanadium found in Arunachal Pradesh could help boost the local and national economy .

Floating Solar Power Plant

Why in news?

Recently ,the National Thermal Power Corporation (NTPC) Ltd, has commissioned the largest floating solar PV project of 25MW in Visakhapatnam, Andhra Pradesh. This is also the first solar project to be set up under the Flexibilisation Scheme, notified by the Government of India in 2018.

Floating solar

- Floating solar, sometimes called floatovoltaics, refers to a solar power production installation mounted on a structure that floats on a body of water, typically an artificial basin or a lake.
- Two types of systems can be distinguished:
 1. FPV or Floating photovoltaic, that uses photovoltaic panels mounted on the platform, and
 2. Floating Concentrated solar power, that uses mirrors that redirect the solar power to a tower.

Advantages:

- **Avoid land occupation:** It doesn't take up valuable space on land—meaning that it can be used for other purposes, such as farming or construction. Installing floating solar farms on bodies of water, such as reservoirs, avoids this issue.
- **The bodies of water exert a cooling effect**, which improves the performance of solar photovoltaic panels by 5–10 percent. Over time, this translates into significant cost savings.
- **It reduces shading, reduces civil works**, reduces grid interconnection costs, reduces water evaporation, improves water quality, and reduces algal blooming.

- **Combining hydropower generation with floating solar panels** can yield promising results.
- **Case study:** In Portugal, an array of 840 floating solar panels were installed on the reservoir of a hydropower facility on the Rabagão river with a capacity of 220 kilowatts. It yielded promising results than the expectations.

Challenges:

- **High cost of installation:** Engineering and construction costs are usually higher than those of a ground-mounted solar farm.
- **Additional safety issues:** Since floating solar involves water and electricity, more consideration must be given to cable management and insulation testing than on land, especially when cables are in contact with water.
- **Friction and stress:** Floating solar plant has moving parts that are subject to constant friction and mechanical stress.
- **Risk of degradation:** Floating installations are also at risk of degradation and corrosion due to moisture, especially in more aggressive coastal environments.

Conclusion:

Generating renewable energy through floating solar farms is likely to grow as an important part of the effort to address climate change. As the technology develops, the costs and technical challenges are expected to fall.

LAND USE PATTERN AND ITS CHANGING TREND

PYQ

1. Mention the advantages of the cultivation of pulse because of which the year 2016 was declared as the International Year of Pulses by the United Nations. 2017
2. The effective management of land and water resources will drastically reduce the human miseries. Explain 2018
3. The states of Jammu and Kashmir, Himachal Pradesh and Uttarakhand reaching the limits of their ecological carrying capacity due to tourism. Critically evaluate. 2015

Introduction:

Recently Several architects have raised concerns over the **government's proposed change of land-use of plots in the heart of Lutyens' Delhi to make way for a new Parliament House**, residences and office buildings, flagging the potential reduction in land for general public use as well as the lack of a scientific study to justify the amendment of the Master Plan for Delhi-2021 (MPD).

As we push our planetary boundaries, India faces the challenge of supporting 1.3 billion population on 2.4 percent of the total world's land.

- Land is one of the scarce resources, it is required for meeting human and ecosystem needs. It has been coming under intense pressure due to rising population and lack of effective land use planning.
- The **National Commission on Population (NCP)** in India predicts that in the next 15 years (i.e., by 2036), about 38.6 percent of Indians (600 million) will live in urban areas. To balance the need of rising urban population and to maintain environmental sustainability, land use planning is of utmost importance.

Before we move on to land use planning, let us first try to understand what is Land use pattern.

What's Land use Pattern?

- The layout or arrangement of the uses of the land is known as "land use pattern"
- Different types of lands are suited to different uses. Human beings thus, use land as a resource for production as well as residence and recreation
- The land may be used for agriculture, forest, pasture etc.
- **Land use is determined** by many factors like relief features, climate, soil, density of population, technical and socio-economic factors.

Land use pattern in India

- The use of land is **determined both by physical factors** such as topography, climate, soil types as well as human factors such as population density, technological capability and culture and traditions etc.
- **Variety of relief features:** India has land under a variety of relief features, namely; mountains, plateaus, plains and islands.
 - **Agriculture:** About **43 per cent of the land area is plain**, which provides facilities for agriculture and industry. Plains in Indo Gangetic areas are important for **agriculture** because where the soils are deposited as sediments. They are deep and fertile, and the flatness facilitates mechanization of crop production.
 - Fertile alluvial soils, flat surface, slow moving perennial rivers and favorable climate facilitate intense agricultural activity.

- **Mountains** account for 30 per cent of the total surface area of the country and ensure perennial flow of some rivers, provide **facilities for tourism and ecological aspects**.
- **Plateau region:** About 27 per cent of the area of the country is the plateau region. It possesses rich reserves of minerals, fossil fuels and forests.
- **Forest area** in the country is far lower than the desired 33 per cent of geographical area, as it was outlined in the National Forest Policy (1952).

What's Land Use Planning?

- **Regulate usage of land:** Land Use planning encompasses the development of policies to effectively regulate the usage of land. This is to be done for maximizing the use of the available resources and achieving more desirable outcomes in both social and environmental arena.
- **Modern land use goals:** The goals of modern land-use planning often include environmental conservation, restraint of urban sprawl, minimization of transport costs, prevention of land use conflicts, and a reduction in exposure to pollutants.

Why Planning Land Use is important?

Planning for sustainable land use and management – is need of the hour given the inter-linked challenges that India faces.

1. Unsustainability Land use In Indian Agriculture

- **High Dependency on Agriculture:** Seventy percent of the rural households in India depend on land for sustenance. Agriculture is the largest source of livelihood in the country. 86 percent of landowners in India are small and marginal farmers with less than two hectares of landholdings (Agriculture Census 2014).
 - **Rainfed Agriculture:** On 66 per cent of the total cropped area in India, rain-fed agriculture is practiced which contributes to 60 per cent of the value of agricultural GDP of India.
 - **Mismanaged Cropping Pattern:** Procuring wheat and rice through minimum support price, subsidized pricing of water, power, fertilizers. It has led to misalignment of cropping patterns vis-à-vis available resources for irrigation.
 - **Lack of Agro-Climatic Planning:** Wheat, rice, and sugarcane are being grown in areas with low water availability.
2. **To Optimize use of Scarce Land:** Land covers only about thirty per cent of the total area of the earth's surface and all parts of this small percentage are not habitable.
 3. **Sustainable land management:** By examining all land uses in an integrated manner, land-use planning identifies the most efficient tradeoffs between land-use options and links social and economic development with environmental protection and enhancement, thus helping to achieve **sustainable land management**. When carried out effectively, land-use planning increases certainty for stakeholders.
 4. **To avoid Disasters:** In India land-use planning remains very weak and haphazard growth and development is seen all over and permissions for construction are treated in a casual manner, without long-term approach and adequate scientific analysis of the geo-morphology. India is vulnerable to a wide range of natural hazards, particularly flooding, cyclones, drought, extreme heat waves, landslides, wildfire, and earthquakes.
 5. **To Manage conflicts:** Land-use planning is often carried out in a highly polarized public context in which decisions on land allocation and use are a source of conflict and tension. Land-use planning can help manage such conflicts, ease tensions, and bring about the more effective and efficient use of land and its natural resources.

Ninety-five per cent of our basic needs for food, shelter and clothing are obtained from land. Thus, **land is a natural resource of utmost importance**. It supports natural vegetation, wild life, human life, economic activities, transport and communication systems. However, land is an asset of a finite magnitude, therefore, it is important to use the available land for various purposes with careful planning.

SDG 15: Life on Land: By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world.

Impact of Land Use Change

- **Land use change** is defined as planned, government policy induced land transformations with anticipated or unanticipated environmental and social impacts, most often undertaken without prior informed consent of and/or due compensations for the affected, and abetted by failure of administrative or judicial remedies.
- **Increases pressure on land:** Human influence on the land and other natural resources is accelerating because of rapid population growth and increasing food requirements. The increasing agricultural intensity generates pressure not only on land resources but also across the whole environment.
- **Displacement and dispossession:** Individuals or communities lose their homes in exchange for none or meagre compensations, and are expected to relocate to areas identified as rehabilitation sites or migrate to new areas on their own.
 - **Developmental displacement:** A study by the Indian Institute of Technology, Rourkee, estimates that 50 million people have been displaced due to 'development projects' over 50 years in India.
 - **Industrial development:** The study states that of the 50 million people, 16.4 million were displaced by **dams**, 2.55 million by **mines**, 1.25 million by **industrial development** and 0.6 million by **wildlife sanctuaries** and national parks
 - **Dam-induced displacement:** One of the largest dam-induced displacement projects in the recent decades has been the Polavaram Multipurpose irrigation project that involved submergence **of 42,000 ha of land across** the 3 states of Andhra Pradesh, Chhattisgarh and Odisha.
 - **The estimated number** of people facing displacement is **1,17,034 across** 276 villages (as per the 2001 Census). All the displacement is in the state of Andhra Pradesh.
 - **Creation of Protected Areas:** From 1970 to 2008, there have been approximately 100,000 people who have been displaced by the creation of Protected Areas (PAs).
 - **Tribals are most affected:** Around 40% of the project-affected and displaced people from 1951 to 1980 belonged to tribal communities.
- **Leads to Loss of livelihood:** This relates to losing out or giving up access to parts of or entire areas on which livelihoods are dependent. This could include agricultural lands, forest areas and grazing lands. This may occur separately or in addition to physical displacement, causing an incalculable impact on both livelihoods and quality of life.
 - **The Parsa East Kete Besan coal mine** in Chhattisgarh involves land use change of 2,711.034 ha. The mine is located in the Hasdeo Arand region, which is home to a large population of tribal and other traditional forest dwellers.
- **Causes Environmental degradation and pollution:** Land use change has been leading to a decline in agricultural productivity, groundwater contamination, and other related impacts. These have lasting effects on the health, economy and social lives of individuals and communities as a whole. It can be understood from the following examples that how land use change actually leads to environmental degradation.
 - Around 49 areas have been declared unsafe for human habitation in the **Raniganj coalfield area** of West Bengal.
 - The Damodar River is the major source of water in the regions of West Bengal and Jharkhand and is perhaps the **most polluted river in India** as it receives wastes from many industries situated on its banks.
 - Studies have indicated that open cast quarries, coal washeries, thermal power plants, coke-oven plants, cement factories and fertilizer plants add to air pollution.
 - The **construction of large dams** and ports alters the relationship of water and land, destroying the existing ecosystem balance, hydrology and fisheries.
 - Air and **water pollution and soil erosion** are the two main issues that occur when large areas on landscapes get changed for the construction of roads and railway lines.

Changing Trends in land use pattern In India

- Land-use in a region, to a large extent, is influenced by the nature of economic activities carried out in that region. However, while economic activities change over time, land, like many other natural resources, is fixed in terms of its area.

There are **three** types of changes that an economy undergoes, which affect land-use.

- The size of the economy:** Grows over time as a result of increasing population, change in income levels, available technology and associated factors. As a result, the pressure on land will increase with time and marginal lands would come under use.
- Composition of Economy:** The composition of the economy would undergo a change over time. In other words, the secondary and the tertiary sectors usually grow much faster than the primary sector, specifically the agricultural sector.
- Dependency of a particular sector like agriculture:** Though the contribution of the agricultural activities reduces over time, the pressure on land for agricultural activities does not decline.

The reasons for continued pressure on agricultural land are:

In India, the share of population dependent on agriculture is declining much more slowly compared to the decline in the sector's share in GDP.

- The number of people that the agricultural sector has to feed is increasing day by day. This type of change is common in developing countries like India. This process would result in a gradual shift of land from agricultural uses to non-agricultural uses. It can be observed that such changes are sharp around large urban areas. The agricultural land is being used for building purposes.
- Sharp rise in Non-Agricultural areas:** The area under non-agricultural use has risen sharply, and the barren and unculturable land (land that has some top soil unlike barren) reduced drastically. This shows diversion of land for non-agricultural purposes.
- Diversion of Forests Land:** In the recent past, forest land has also been diverted for other uses on a large scale. As a result, forest cover that increased by 67 per cent between 1951 and 1991, **saw an increment of a mere 3.2 per cent between 1991 and 2009.**

To Understand land use change in India over the period of time, it's necessary to understand the land use classification.

Land Use classification

Land can be classified on the basis of ownership as – private land and community land.

- Private land** is owned by individual.
- Community land** is owned by the community for common uses like collection of fodder, fruits, nuts or medicinal herbs. These community lands are also called common property resources.

Different Types of Land Use: Classification

- Land put to Non-Agriculture Use** - Lands occupied by buildings, roads and railways or under water, & other lands put to uses other than agriculture.
- Barren & Unculturable Land** - Land like mountains, deserts, etc. Land which cannot be brought under cultivation except at an exorbitant cost.
- Permanent Pastures & Other Grazing Lands** - all grazing lands whether they are permanent pastures and meadows or not. Village common grazing land is included under this head.

S. No.	Categories	1960-61	2002-03
1	Forest	18. 11%	22. 57%
2	Barren & Waste Land	12. 01%	06. 29%
3	Area under nonagricultural uses	04. 95%	07. 92%
4	Permanent pasture & grazing land	04. 71%	03. 45%
5	Tree crops and grasses	01. 5%	01. 1%
6	Cultivable, land waste	06. 23%	04. 41%
7	Fallow other than current fallow	03. 5%	03. 82%
8	Current fallow	03. 73%	07. 03%
9	Net sown area	45. 26%	43. 41%

- **Land under Miscellaneous:** tree crops & other groves not included in net area sown - This includes all cultivable land which is not included in 'Net area sown' but is put to some agricultural uses.
- **Culturable Waste Land** - 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.
 - The land which has potential for the development of vegetative cover and is not being used due to different constraints of varying degrees, such as erosion, water logging, salinity etc.
- **Unculturable Wasteland** - The land that cannot be developed for vegetative cover, for instance the barren rocky areas and snow-covered glacier areas.
- **Fallow Lands other than Current Fallows** - This includes all lands, which were taken up for cultivation but are temporarily out of cultivation for a period of not less than one year and not more than five years.
- **Current Fallows** - This represents cropped area, which are kept fallow during the current year.

Increase and decrease in land use

Four categories have undergone increases, while four have registered declines.

Share of area under forest, area under non-agricultural uses, current fallow lands and net area sown have shown an increase.

The following observations can be made about these increases:

- **Non-Agricultural Land:** Rate of Increase is highest in land under non-agricultural uses due to following reasons
 - **Changing Structure of Indian Economy:** This is due to the changing structure of Indian economy, which is increasingly depending on the contribution from industrial and services sectors and expansion of related infrastructural facilities.
 - **Rapid Urbanization:** Expansion of area under both urban and rural settlements has added to the increase.
- **Reduction in Wastelands and agriculture lands:** It can be clearly observed that the area under non-agricultural uses is increasing at the expense of wastelands and agricultural land.
- **About Increase in Forest Cover:** increased area under forest cover can be accounted for by increase in the demarcated area under forest rather than an actual increase in the forest cover in the country.
- **Increase in Current Fallow:** The increase in the current fallow cannot be explained from information pertaining to only two points. The trend of current fallow fluctuates a great deal over years, depending on the variability of rainfall and cropping cycles.
- **Decline in Net Sown Area:** Although there's an increase in net area sown which is a recent phenomenon due to use of culturable waste land for agricultural purpose. Before which it was registering a slow decrease. There are indications that most of the decline had occurred due to the increases in area under nonagricultural use. While the pace of expansion of the gross sown area has slowed down, the net sown area is showing a negative trend.

Explanation to Declining Categories of Land Use

The four categories that have registered a decline are barren and wasteland, culturable wasteland, area under pastures and tree crops and fallow lands.

The following explanations can be given for the declining trends:

- **Decline in Wastelands:** As the pressure on land increased, both from the agricultural and nonagricultural sectors, the wastelands and culturable wastelands have witnessed decline over time.
- **Decline in Culturable Wasteland:** The cultural waste land (that can be used for agriculture) has reduced to just half since 1951.

Decline in Pastures: The decline in land under pastures and grazing lands can be explained by pressure from agricultural land. Illegal encroachment due to expansion of cultivation on common pasture lands is largely responsible for this decline

How Declining pasture lands Impacting Livestock?

- Though the permanent pasture land doubled between 1951 and 1991, it has been declining ever since. The land under miscellaneous trees and crops too has shrunk by 85 per cent since 1951. As this land was used for grazing livestock, it has impacted livestock population in the following manner.
- Reducing Livestock Population:** The 19th livestock census conducted in 2012 shows their population is on the decline in India. Especially the numbers of goat, sheep, donkey and camel are decreasing sharply.
- Loss of Indigenous Breeds:** The male cattle and indigenous varieties of almost all livestock which rely of common grazing land are showing a declining trend.

Land Utilization and Population Distribution

Land is used for different purposes such as agriculture, forestry, mining, building houses, roads and setting up of industries. This is commonly termed as Land use.

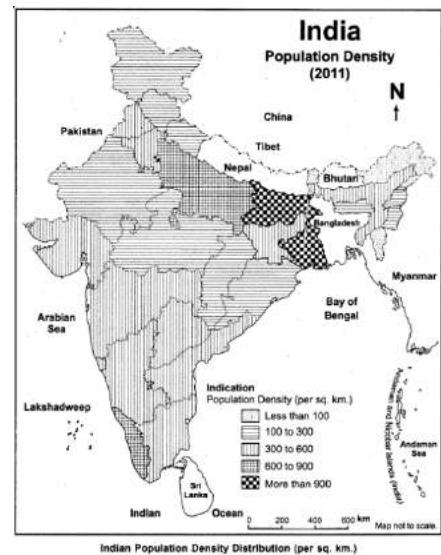
- Land use and Population Distribution:** The uneven distribution of population in different parts of the world is mainly due to varied characteristics of land and climate.
- Densely Populated Areas:** Plains and river valleys offer suitable land for agriculture. Hence, these are the densely populated areas of the world. In India population is mostly concentrated in coastal areas or in the region of fertile plains created by perennially flowing rivers. Population density has impact on intensity of land use.
- Uninhabited areas:** The rugged topography, steep slopes of the mountains, low-lying areas susceptible to water logging, desert areas, thick forested areas are normally sparsely populated or uninhabited.

How does Changes in Land Use Pattern Occur and What is Its Impact?

- Land degradation, landslides, soil erosion, desertification are the major threats to the environment because of the expansion of agriculture and construction activities.
- People and their demands are ever growing but the availability of land is limited
- Today the vast changes in the land use pattern also reflect the cultural changes in our society.

1. Land Degradation

- Continuous use of land over a long period of time without taking appropriate measures to conserve and manage it, has resulted in land degradation. This, in turn, has serious repercussions on society and the environment.
- To make matters worse, almost all Indian states have recorded an increase in degraded land in the past 15 years, with the most rapid increase being noted in the biodiversity-rich northeastern states.
- Human activities have not only brought about degradation of land but have also aggravated the pace of natural forces to cause damage to land.
- Some human activities such as deforestation, over grazing, mining and quarrying too have contributed significantly in land degradation.
 - Deforestation and Land Erosion:** Loss of vegetative cover has made land more susceptible to erosion. Agents of erosion like wind and water have left vast tracts of land barren. Water erodes top soil to an extent of around 12,000 million tonnes (mt) per annum. The loss of top soil represents a permanent depletion of the resource base. The annual loss caused by the erosion of top soil through water comes to Rs.12,000 crores.
 - Mining:** In states like Jharkhand, Chhattisgarh, Madhya Pradesh and Odisha deforestation due to mining have caused severe land degradation.
 - Mining sites are abandoned after excavation work is complete leaving deep scars and traces of overburdening.



- The mineral processing like grinding of limestone for cement industry and calcite and soapstone for ceramic industry generate huge quantity of dust in the atmosphere. It retards the process of infiltration of water into the soil after it settles down on the land.
- In recent years, industrial effluents as waste have become a major source of land and water pollution in many parts of the country.
- **Overgrazing:** In states like Gujarat, Rajasthan, Madhya Pradesh and Maharashtra overgrazing is one of the main reasons for land degradation.
- **Overirrigation:** In the states of Punjab, Haryana, western Uttar Pradesh, over irrigation is responsible for land degradation due to water logging leading to increase in salinity and alkalinity in the soil.

2. LANDSLIDES

Does Land Use Change Leads to Landslides?

People have been living with floods and landslides since ancient history **but it is the land use change due to “unregulated human interference”** that is adding to the vulnerabilities.

Land Use Change can lead to landslides

Some of the landslides occur due to cutting the toe of the hill for road constructions, which results in near vertical slopes with no provision of lateral support.

Study by researchers at Sheffield University, UK.

- India accounted for **28% of construction-triggered landslide events**, followed by China (9%), and Pakistan (6%).
- On the other hand, of the total landslides triggered by rainfall, 16% were reported from India. Of these, 77% occurred during the monsoon. **India also accounted for maximum landslides triggered by mining**, at 12%, followed by Indonesia (11.7%), and China (10%).

3. SOIL EROSION (How Changing Land Use Pattern is causing Soil Erosion at Unprecedented Levels)

As has been discussed earlier that human interference through different mediums is causing a change in land use pattern and it's also one of the most important reason for soil erosion.

- **Crop Production:** The change in land use and land cover (LULC) from natural vegetation to agricultural in mountain areas usually dramatically accelerates soil erosion rates if the land is used for crop production.
- **Commercialization of Agriculture:** The transition to agriculture from natural vegetation often cannot hold onto the soil and many of these plants, such as coffee, cotton, palm oil, soybean and wheat, can actually increase soil erosion beyond the soil's ability to maintain itself.
- **Deforestation:** Increased demand for agriculture commodities generates incentives to convert forests and grasslands to farm fields and pastures.
- **Soil Erosion and Pollution:** The effects of soil erosion go beyond the loss of fertile land. It has led to increased pollution and sedimentation in streams and rivers, clogging these waterways and causing declines in fish and other species.

In Maharashtra, over 70 per cent of the cultivated land has been affected by erosion, of which about a third is no longer cultivable. **In these regions, inappropriate agricultural activities have added to the problem.** For instance, in rain-fed areas, usually only a single crop is grown, leaving the land unused for almost eight months a year. This reduces moisture and organic content of the soil, leading to erosion.

4. DESERTIFICATION and Land Use Change Link

Nearly 30% of India's land area, as much as the area of Rajasthan, Madhya Pradesh and Maharashtra put together, has been degraded through deforestation, over-cultivation, soil erosion and depletion of wetlands.

- **DEPLETION OF WETLANDS:** India's wetlands cover around 152,600 sq km, nearly 5% of the country's geographic area and nearly twice the size of Assam. But deforestation, climate change, water drainage,

land encroachment and urban development are depleting these wetlands--every year, 2-3% of their total area is being lost across the country.

5. **Land Diversions:** Calculations by the Delhi-based non-profit Centre for Science and Environment show that close to 0.57 million hectares (ha) of land was diverted for industrial and non-agricultural purposes between 2007 and October, 2014
 - **Diversion of Common Land in rural areas:** The area under common pool land resources (CPLRs), which are crucial to rural livelihoods in India, has recorded a steady decline over the last three decades. Common land is diverted either as private household assets within a village or assigned for long-term lease to individuals or corporates from outside the village.
 - **The outflows from common property** resources like community forests and grazing lands are not desirable, given their importance in the lives of the landless and poor not only because they depend on these resources, but also because, in the absence of their access to private land, these are the only land resources over which they have legitimate legal and social rights.
6. **Excessive population pressure on land:** India's population of over 900 million people is more than that of the whole world prior to the Industrial Revolution. India with 2.4% of total land area of the World is supporting 18% of the World's population. The per capita availability of agriculture land in India is 0.12 ha whereas World per capita agriculture land is 0.29 ha.
7. **Land fragmentation:** In India the size of land holdings is too small. This is due to overpopulation. Due to the rapid growth of population and the existing law of inheritance, the agricultural land is divided equally among the male children of the deceased farmer. **As per Agriculture Census 2015-16**, the average size of operational holding has declined to 1.08 hectare in 2015-16 as compared to **1.15 hectare in 2010-11**. **The small and marginal holdings (<2 ha) now constitute 86%, while the large holdings (>10 ha) are merely 0.57% of the total land holdings.**

What's the link between Land Use Change and Climate Change?

- **Emission of GHGs:** Land plays an important role in global cycles of greenhouse gases (GHGs, the major GHGs are carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O). Land use activities can result in emissions of such greenhouse gases to the atmosphere or removal of greenhouse gases from the atmosphere.
- **Land As a source and Sink of Carbon:** Land use, and changes in land use, have always been an integral part of the conversation on climate change.
 - That is because land acts as both the source as well as a sink of carbon. Activities like agriculture and cattle rearing, **for example**, are a major source of methane and nitrous oxide, both of which are hundreds of times more dangerous than carbon dioxide as a greenhouse gas.
 - At the same time, soil, trees, plantations, and forests absorb carbon dioxide for the natural process of photosynthesis, thus reducing the overall carbon dioxide content in the atmosphere.
 - This is the reason why largescale land use changes, like deforestation or urbanization, or even a change in cropping pattern, have a direct impact on the overall emissions of greenhouse gases.

Shift in land use and Zoonoses: Recently UNCCD advised to Reverse land use change to prevent zoonoses like COVID-19. Land use degradation creates ground for zoonotic disease like COVID-19 as the interaction and physical distance between animals and humans gets closer.

What does IPCC reports say about land use change?

- The report says that if pre-production activities like cattle rearing and post-production activities like transport, energy and food processing, is taken into account, then food production could contribute as much as 37 per cent of all greenhouse gas emissions every year.
- It points out that nearly 25 per cent of all food produced is either lost or wasted.
- And even the decomposition of the waste releases emissions.

What's the way ahead?

We have shared our land with the past generations and will have to do so with the future generations too. There are many ways to solve the problems arising due to change in land use pattern.

IPCC's special report on land and climate change also evaluated some solutions to use land as a tool against global warming:

- **There are two types of solutions:** Those with immediate impact such as conservation of wetlands, rangelands and mangroves which absorb huge stocks of GHGs like CO₂ from the atmosphere. There are other solutions that are more **long-term**: Planting of trees, reforestation and afforestation.
- **Reversing Desertification:** Avoiding, reducing and reversing desertification would enhance soil fertility and increase carbon storage in soils and biomass while benefiting agricultural productivity and food security. Prevention of desertification is, however, preferable to attempts to restore degraded land.
- **Sustainable Food Production:** Over 30% of food is wasted or lost globally, which contributes to 10% of total GHG emissions from human activities. A number of response options such as increased food productivity, **dietary choices and food losses and waste reduction can reduce the demand for land conversion**. This could free land and create opportunities for enhanced implementation of other strategies listed here.
- **Creation of windbreaks** through afforestation, tree planting and ecosystem restoration programs that can function as “green walls” and “green dams” that reduce dust and sandstorms and sand dune movement.
- **Land Degradation Neutrality:** In his keynote address at a United Nations high-level dialogue on Desertification, Land Degradation and Drought, *Prime Minister Narendra Modi* said India is on track to achieve its national commitment on land degradation neutrality, and that it's working to restore 26 million hectares of degraded land by 2030.
- **Restore and Rehabilitate:** To achieve Land Degradation Neutrality (SDG 15.3), additional commitments in the land use sector, namely to **restore and rehabilitate 12 million hectares** of degraded land per year could help close the emissions gap by up to 25% in the year 2030.
 - The restoration of these areas as part of building back better to avoid future zoonoses would bring other crucial benefits, particularly mitigating **climate change**.
- **Delhi Declaration:** Commitment for a range of issues, including gender and health, ecosystem restoration, taking action on climate change, private sector engagement.
- **Peace Forest Initiative** Parties to this initiative have agreed for recovery of five million hectares of degraded land in India.
 - The country parties have agreed to make the Sustainable Development Goal target of achieving land degradation neutrality by 2030, a national target for action.
- **Climate Smart Land Management Practices:** According to a report by IPCC on land use, increased food productivity, improved cropland management, livestock management, agroforestry, increased soil organic carbon content and reduced post-harvest losses **would help in ecosystem conservation and land restoration**.
- **Adopting Landscape Based Approach:** For instance, the Banni region in Rann of Kutch in Gujarat suffers from highly degraded land and receives very little rainfall. **In that region, land restoration is done by developing grasslands, which helps in achieving land degradation neutrality**. It also supports pastoral activities and livelihood by promoting animal husbandry. In the same spirit, we need to devise effective strategies for land restoration while **promoting indigenous techniques**.
- **Creating Comprehensive Data about disasters:** Moving into a real-time data management system, possibly an Internet of Things (IoT) multi-layered platform that can enable effective management. There's also need for creating a comprehensive data warehouse and data management system that is accessible to the public as well as all departments.
 - For a comprehensive development, there has to be adequate harmonization of authorities at all the three levels, that is- national, state and local level.
- **Consolidation of Landholdings:** It is important to know that farms in India are not only small in size but also distributed in a scattered way. Unless the farm-land is of reasonable size, farmers cannot make proper use of their

resources. In the interest of progressive farming, it is essential that the farmer be given one consolidated piece of land. Hence, the conversion of many small and fragmented holdings into one or two big farms is called Consolidation of Land Holdings.

Conclusion:

SDG 15 aims at protecting, restoring and promoting sustainable use of terrestrial ecosystems, sustainable management of forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.

- The urgency to slow down and reverse land use change cannot be overstated as land is a critical component of biodiversity. Responsible land governance is key to provide an enabling environment for ecosystem restoration, biodiversity protection, land use-based adaptation and for improving the livelihoods of many small-scale farmers.
- Afforestation and proper management of grazing can help to some extent. Planting of shelter belts of plants, control on over grazing, stabilization of sand dunes by growing thorny bushes are some of the methods to check land degradation in arid areas. Proper management of waste lands, control of mining activities, proper discharge and disposal of industrial effluents and wastes after treatment can reduce land and water degradation in industrial and suburban areas.

WATER RESOURCE MANAGEMENT ISSUES AND CONCERNS IN INDIA

Previous Year Questions:

1. The interlinking of rivers can provide viable solutions to the multi-dimensional inter-related problems of droughts, floods and interrupted navigation. Critically examine. 2020
2. What is water stress? How and why does it differ regionally in India? 2019
3. How will the melting of Himalayan glaciers have a far-reaching impact on the water resources of India? 2020
4. “The ideal solution of depleting ground water resources in India is water harvesting system.” How can it be made effective in urban areas? 2018
5. Enumerate the problems and prospects of inland water transport in India. 2016
6. In what way micro-watershed Development projects help in water conservation in drought prone and semi-arid regions of India. 2015
7. What are the economic significances of discovery of oil in Arctic Sea and its possible environmental consequences? 2015
8. India is well endowed with fresh water resources. Critically examine why it still suffers from water scarcity. 2015
9. Bring out the relationship between the shrinking Himalayan glaciers and the symptoms of climate change in the Indian sub-continent. 2013

Day Zero: The day when a city's taps dry out and people have to stand in line to collect a daily quota of water.

For the first time in human history, human use and pollution of freshwater have reached a level where water scarcity will potentially limit food production, ecosystem function, and urban supply in the decades to come.

Chennai, one of India's major cities facing an acute, unprecedented water shortage and witnessing urban floods alternately. According to NITI Aayog's recent assessment Many other big cities, including the national capital Delhi, are likely to run out of groundwater by 2020.

Why is Water Resource Management the need of the hour?

The Niti Aayog report has warned that by 2030, 40 percent of India's population will be deprived of access to clean drinking water.

- Further, as per the NITI Aayog's Composite Water Management Index (2019), 75 percent of households in India do not have access to drinking water on their premises.
- India ranks 120th amongst 122 countries in the water quality index.
- It becomes important to understand issues surrounding the effective management of water so as to reduce human miseries.

Basic facts to begin the answer.

- India has only about 4 percent of the world's renewable water resources but is home to nearly 18 percent of the world's population.
- India witnesses' floods and droughts at the same time in different parts of the country. This leads to a situation of Deluge here droughts there.
- 85% of the precipitation in India comes from the South - West Monsoon which is concentrated over the period of four months from June to September.

Issues with water resources

- **Depletion of Groundwater:**
 - **More Exploitation than recharge:** The annual withdrawal of groundwater in India far exceeds the annual recharging of it.
 - **High dependence on groundwater:** It caters to about 85 percent of rural demand, 50 percent urban requirements, and more than 60 percent of our irrigation needs.
 - **Unregulated extraction:** It has led to overuse in many parts of the country, causing the groundwater table to plummet, drying springs and aquifers.
 - **Lack of Agro-climatic planning:** water-guzzling crops and heavy use of fertilizers have both contributed to Punjab's water crisis depleting groundwater resources.
- **Impact of water scarcity on Economic Growth:** By 2030, the country's water demand is projected to be twice the available supply, implying severe water scarcity for hundreds of millions of people and an eventual 6% loss in the country's GDP.

Water Pollution:

Pesticides Use: The twin issues of pesticide use in the soil and industrial wastes penetrating into the soil are making groundwater toxic or at any rate, unfit for drinking.

Polluted Rivers: Most of the major and minor rivers in India are being turned into drains with industrial and household pollution. The Central Pollution Control Board (CPCB) in 2018 identified 351 polluted river stretches in India. Maharashtra has the highest number of polluted rivers stretches. The data obtained from CPCB stations show that organic and bacterial contamination continues to be the main source of pollution in rivers.

The Yamuna River is the most polluted river in the country between Delhi and Etawah. Other severely polluted rivers are: the Sabarmati at Ahmedabad, the Gomti at Lucknow, the Kali, the Adyar, the Cooum (entire stretches), the Vaigai at Madurai and the Musi of Hyderabad and the Ganga at Kanpur and Varanasi. Groundwater pollution has occurred due to high concentrations of heavy/toxic metals, fluoride and nitrates at different parts of the country.

Agriculture sector specific issues:

- **Excessive Consumption:** It consumes the largest amount (over 85 percent) of India's water.
- **Skewed incentive policy:** Free or highly subsidized power, has led to excessive and irrational consumption of groundwater. It resulted in lowered water table and salinization of soil.

- **Low irrigated area:** More than 60 percent of agricultural land in India is not irrigated, so the failed rains are particularly devastating for farmers. The drought has destroyed crops and dried up wells already stressed by overuse, forcing rural families to move to cities.
- **Poor Maintenance:** There's a growing gap between irrigation potential created and that actually utilised, simply due to improper maintenance.
- **Unscientific Cropping Pattern:** Punjab, Haryana, and West-Uttar Pradesh are the worst-affected Indo-Gangetic states in terms of water stress, and the main reason for this is their 40-year-old cropping pattern in which paddy, sugarcane, and wheat dominate -- all water-guzzlers.

Other General issues:

- **Rising Population:** Per capita water availability is decreasing with an increase in population in a particular region.
 - **Destruction of Wetlands and Lakes:** According to the environment ministry one-third of Indian wetlands have already been wiped out or severely degraded.
 - Bellandur Lake froths during winter and catches fire in summer.
 - Three of the Rajasthan's well-known lakes Udaisagar, Jal Mahal, Jaisamand are among the most polluted in the country
- **Increasing Industrialization and Urbanization:** Consumption of water is escalating further with pressure from industrialization and urbanization. It has been estimated that by 2050, more than half of India or an estimated 800 million people will be living in urban India.
- **Groundwater contamination:** In India, the states of West Bengal, Jharkhand, Bihar, Uttar Pradesh, Assam, Manipur, and Chhattisgarh are reported to be most affected by arsenic contamination of groundwater above the permissible level.
- **Crisis-ridden states mismanage water:** Except for Gujarat and Madhya Pradesh, other water-stressed Indian states have mismanaged their water, according to the Niti Aayog report.
- **Institutional Inadequacies that are roadblocks in management of water resources.**
 - At present, water is being managed under two separate heads--surface water and groundwater. Surface water is managed by the Central Water Commission or CWC and the groundwater is managed by the Central Groundwater Board or CGWB.
 - From a hydrological standpoint, however, the two disciplines are not separate from each other and are interconnected. Therefore, a major shift is needed in the institutional framework of the CWC and the CGWB to make water management more holistic and multidisciplinary.
 - In this context, Mihir Shah Committee, has proposed in its report on India's water reforms in 2016 to restructure the CWC and the CGWB into a National Water Commission that aims to bring both the CWC and the CWGB in its ambit and also fill the various gaps left unaddressed by the two agencies.

Solutions for water resources management

Water Resource Management. (WRM)

- World Bank defines WRM as the “process of planning, developing, and managing water resources, in terms of both water quantity and quality, across all water uses”.
- It includes the institutions, infrastructure, incentives, and information systems that support and guide water management.
- According to the World Bank, water resources management seeks to harness the benefits of water by ensuring there is sufficient water of adequate quality for drinking water and sanitation services, food production, energy generation, inland water transport, and water-based recreational, as well as sustaining healthy water-dependent ecosystems and protecting the aesthetic and spiritual values of lakes, rivers, and estuaries.
- Water resource management also entails managing water-related risks, including floods, drought, and contamination.
- One of the goals of water resource management is water security.
- It is not possible to ‘predict and plan’ a single path to water security for rapidly growing and urbanizing global populations. This is due to climatic and non-climatic uncertainties.
- To help strengthen water security, there is a need to build capacity, adaptability and resilience for the future planning and management of water resources.

Why water resource management is important?

It is important because disastrous water crisis has been creeping up on us for years. Water tables have declined precipitously, even by thousands of feet in some parts of Punjab, Haryana and Andhra Pradesh. Tanks and wells have gone dry. Some rivers have shrunk while other smaller ones have completely dried up. Water rationing is routine in many urban areas, while in many villages women are trudging longer distances to fetch water.

In addition to this, there are following issues

- **Rise in Water Stressed regions:** More than a third of India's population lives in water-stressed areas and this number is set to grow due to depleting groundwater and rising urbanization. India placed thirteenth among the world's 17 'extremely water-stressed' countries, according to the Aqueduct Water Risk Atlas released by the World Resources Institute (WRI).
- **Chronic Water scarcity:** Hydrological uncertainty and extreme weather events (floods and droughts) are becoming more common. A NITI Aayog report in 2018 stated bluntly that 600 million people, or nearly half of India's population, face extreme water stress. That three-fourths of India's rural households do not have piped, potable water and rely on sources that pose a serious health risk.
- **Social and Political conflicts:** Water scarcity is leading to social and political conflicts at different levels of the government. Internal water crises are also a national security concern. There's a Growing resentment among downstream populations toward the affluent, seemingly unconcerned citizens staying upstream, who by the virtue of their position seem to get away with their actions.
- **Skewed Priorities** Diversion of water towards an urban megacity at the cost of the millions living in semi-urban and rural communities in the surrounding regions has been routine practice in India. Such inequity in the access to a resource as fundamental as water is bound to trigger migrations, sociocultural resentment, pressure on urban resources, and competition and conflict. .
- **Climate Change:** It will worsen the situation by altering hydrological cycles, making water more unpredictable and increasing the frequency and intensity of floods and droughts.

- Climate change impacts the water cycle by influencing when, where, and how much precipitation falls.
- It also leads to more severe weather events over time. Increasing global temperatures causes water to evaporate in larger amounts, which will lead to higher levels of atmospheric water vapor and more frequent, heavy, and intense rains in the coming years.
- **Contaminated water resources:** Regardless of improvements to drinking water, many other water sources are contaminated with both bio and chemical pollutants, and over 21% of the country's diseases are water-related. Furthermore, only 33% of the country has access to traditional sanitation.
- **Impact on Public Health:** As its water reserves get dirtier and smaller, India is losing the capacity to safeguard public health, ensure farm productivity, grow the economy, and secure social stability.
- **Water Related Disasters:** When water related disasters hit, they can destroy or contaminate entire water supplies, increasing the risk of diseases like cholera and typhoid to which children are particularly vulnerable.

What are the ways and means of water resource management?

- Since there is a declining availability of fresh water and increasing demand, the need has arisen to conserve and effectively manage this precious life-giving resource for sustainable development. Given that water availability from sea/ocean, due to high cost of desalination, is considered negligible, India has to take quick steps and make effective policies and laws, and adopt effective measures for its conservation.
- Besides developing water saving technologies and methods, attempts are also to be made to prevent the pollution.

Integrated Water Resource Management

It's a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems."

The paradigm shift in management of water resources is possible only by moving from the supply-centric approach to a people-centric one. Managing the demand side of water management is crucial as India cannot increase the per capita availability of water.

- **Judicious allocation of Water:** While allocating water resources, the right to water for life must take first priority, followed by food security, agriculture, livelihoods, and more.
- **Preventing Unsustainable Exploitation:** The market has to be re-figured since as long as people are driven by commercial interest, there would be unsustainable exploitation of groundwater.
- **Need for Behavioural Change:** Raising awareness and changing perceptions on water needs to be an important priority. Even today, water is regarded as an infinite resource and is abundantly wasted in many parts of the country, while others suffer drought-like conditions.
- **Water as a common pool:** There needs to be an understanding at the level of people that no water resource can be privately owned — by an individual, community, corporate organization, or even a government agency. Water is a common pool resource, held in public trust by governments at all levels.

- **Developing Water Protection Zones:** Demarcating 'groundwater protection zones', in which the extraction of water would be strictly regulated. Groundwater security plans should be prepared for each such zone.

Prevention of Pollution:

- **Strict regulation of Polluting industries:** Mining in the nearby areas, which tend to pollute groundwater, are also sought to be regulated in these zones.
- **Reduction in Industrial Footprint:** Industries consuming large amounts of water must calculate and declare their water footprint in their annual reports. They must take steps to progressively bring down this footprint every year, and state this progress in their annual reports.
- **Application of Polluter Pays Principle:** The person creating pollution should be held liable to pay for the damage caused to the water bodies.
- **Application of Modern Techniques like Micro-irrigation:** Some states, like Gujarat, are leading the efficient use of agricultural water by bringing in micro-irrigation to over six lakh farmers, 50 percent of which are small and medium ones.
- **Rainwater Harvesting:** Tamil Nadu was the first state to make rainwater harvesting compulsory for every building to avoid groundwater depletion. The project was launched in 2001 and has been implemented in all rural areas of Tamil Nadu.
- **Reuse of Grey-water:** The above measures should be combined with the reuse of greywater for agriculture, it will result in a significant reduction of demand from our water resources.
- **Differential Pricing:** Rich should be charged more for the use of water than a poor and a certain amount of water should be freely available. In the villages in Marathwada (Maharashtra), Water ATMs have been installed and water is provided at the rate of 25 paise per litre.
- **Water Bill in Rural Areas:** There will be more efficient usage of water especially in the rural areas if the government starts charging for its water service on the lines of its electricity supply service. But the Government needs to ensure that it has the proper infrastructure to supply water to the houses.
- **River Basin Level Planning:** Given the integral link between aquifers, groundwater, and river flows, it is important that planning for water management is done at the level of the river basin itself.
- **Participatory and community management of water:**

The government needs to encourage local participation for conserving water in the country. Hiware Bazar is a good example.

- **Hiware Bazar**, a village in Maharashtra's drought-prone Ahmednagar district, was sliding into an abyss after its environmental degradation. But in less than a decade it turned itself around into one of the most prosperous villages of the country. It used funds from government schemes, to regenerate its natural resources--forests, watershed and soil--led by a strong village body. The village very well manages the 300-400 millimeters (mm) of rainfall that it receives every year.

- **Traditional Water Conservation Practices:** Johads, Stepwells, Virdas, Zing, Taanka, Kaata, Ahar Pynes are some of the traditional methods followed for the conservation of water in different regions of the country. They need to be repaired and revived.

Conclusion:

- Besides above measures, modern methods of water conservation and management like Micro Watershed management and application of Micro Irrigation technique can be of great help. There is need to encourage watershed development, rainwater harvesting, water recycling and reuse, for sustaining water supply in long run.
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Let's look at some of the modern scientific methods of water conservation and management.

Micro-Water Shed Management and Development:

It's one of the most efficient method of conserving water and managing scarce Water resources with a decentralized approach. Size of Micro watershed ranges from 100 to 1000 Hect. So, it gives scope for adopting area specific approach for better water resource management.

In what way micro-watershed development projects help in water conservation in drought-prone and semi-arid regions of India? (PYQ)

What's watershed?

- Watershed is defined as any surface area from which rainfall is collected and drains through a common point.

"A watershed is a drainage area on earth's surface from which runoff resulting from Precipitation flows past a single point into a larger stream viz., a river, a lake or an ocean".

A watershed could be described as fan shaped (near circular) or fen shaped (elongated). Hydrologically the shape of the watershed is important because it controls the time taken for the runoff to concentrate at the outlet.

- **Watershed management is the integration of technologies within the natural boundaries of a drainage area** for optimum development of land, water, and plant resources to meet the basic needs of the people and animals in a sustained manner.

Watershed sizes are classified into three: micro, mini, and macro watersheds.

TYPES OF WATERSHEDS

Watersheds is classified depending upon the size, drainage, shape and land use pattern.

- Macro watershed (> 50,000 Hect)
- Sub-watershed (10,000 to 50,000 Hect)
- Milli-watershed (1000 to 10000 Hect)
- **Micro watershed (100 to 1000 Hect)**
- Mini watershed (1-100 Hect)

Amongst the above watersheds, **Micro-Watershed** is of utmost importance to develop successful strategy of water resource management.

Micro watershed

The smallest one: **covers 100-1000 ha.** It covers regional planning at the village level with the objective to improve the efficiency of water use for the betterment of agricultural productivity and the value addition of rural populations. (SWAJAL Scheme)

BENEFITS OF MICRO WATERSHED MANAGEMENT

- **For draught prone area:** Micro-watershed management became inevitable for the development in drought-prone and semi-arid regions that could sort out the problem of water scarcity and drought. Micro-watershed projects can prevent unwanted evaporation by **increasing the biomass component of the area.**
- **Restoration of Natural Water resources:** By Restoring the natural resources of water collection like ponds, lakes, etc.
- **Infrastructure Development:** It leads to development of infrastructures like tanks, artificial ponds, check dams, etc. to store the rainwater and increase the moisture level of the soil.
- **Increased Water user Efficiency:** It also includes Improving **water use efficiency** for agriculture with methods like drip irrigation and sprinkle irrigation.
- **Prevention of Soil Erosion:** It also helps in Preventing soil erosion, planting trees in the wastelands, groundwater reaching, and conservation of soil moisture.
- **Improves Quality of Life:** Micro Water shed management helps in Improving the quality of life of the drought-prone region by the increased availability of water both for drinking and irrigation purposes
 - E.g., Women and Girls will not have to trudge longer distances for fetching water.
- **It improves the quality of life of villagers through increased productivity of the land, availability of water—** surface and ground, an increase in the vegetation cover, improving cattle health resulting in higher milk production, and improving the overall environment by tree plantation.
- **Corresponding Development in Vegetation:** Increasing the vegetation occur in semi-arid regions by rational utilization of water resources. Micro-watershed development can result in phenomenal success in regions like Vidarbha, Bundelkhand, & Rajasthan.

Conclusion

Thus, **Micro water shed management** is an area specific decentralized approach with improved chances of better implementation. Activities such as desiltation of common water bodies like wells, lakes and building of check dams on small rivers will improve water availability.

It also gives scope for application of traditional knowledge of communities in conservation of water.

Water use efficiency

What is water use efficiency? Describe the role of micro-irrigation in increasing the water-use efficiency. – 2016

Water use efficiency (WUE) is defined as the amount of carbon assimilated as biomass **or grain produced per unit of water used by the crop.** It is about careful management of water supply sources, use of water serving technologies, reduction of excessive demand and other actions. There can be following methods to increase water use efficiency.

Micro Irrigation

- Micro irrigation is the slow application of continuous drips, tiny streams or miniature sprays of water above or below the soil surface.

- Micro irrigation system is effective in saving water and **increasing water use efficiency** as compared to the conventional surface irrigation method. Besides, it helps reduce water consumption, growth of unwanted plants (weeds), soil erosion and cost of cultivation.
- Micro irrigation can be adopted in all kinds of land, especially where it is not possible to effectively use flooding method for irrigation.
- In **flooding method of irrigation**, a field is flooded with water. This results in significant run-off, anaerobic conditions in the soil and around the root zone, and deep irrigation below the root zone, which does not supply sufficient water to the plants. **It is, therefore, one of the most inefficient surface irrigation methods.**

Sprinkler irrigation

- It is a method of applying water in a manner similar to rain. It is suited for most row, field and tree crops.
- Water can be sprayed over or under the crop canopy. If a site is known to be windy most of the time, sprinkler irrigation will not be suitable. The sprinkler breaks up the water **into droplets sized 0.5–4 mm**. The drop size is controlled by pressure and nozzle size of the sprinklers. The average rate at which water is sprayed onto the crops is measured in mm/hour.



DRIP IRRIGATION

- It is a type of micro-irrigation system that has the potential to save water and nutrients by allowing water to drip slowly to the roots of plants, either from above the soil surface or buried below the surface. The goal is to place water directly into the root zone and minimize evaporation. In the drip irrigation process, water and nutrients are delivered across the field in pipes called '**dripper lines**' featuring smaller units known as '**drippers**'.
- Each dripper emits drops containing water and fertilizers, resulting in the uniform application of water and nutrients directly to each plant's root zone, across an entire field.

Advantages of Micro Irrigation

- **Helps in Saving of Water:**
 - Water requirement in drip or sprinkler irrigation is much less as compared to any other conventional method of irrigation. This is because of irrigation of a smaller portion of land, decreased evaporation from the soil surface and reduction or elimination of run-offs.
 - Waterlogging, which occurs under flat surface flood irrigation, is rare in case of micro-irrigation. Since micro-irrigation system allows high level of water control application, water can be applied only when needed and losses due to deep percolation can be minimized or avoided.
 - Micro-irrigation can reduce water usage by 25–40 per cent as compared to overhead systems and 45–60 per cent as compared to surface irrigation.
- **Uniform Water application :**
 - Micro-irrigation systems ensure uniform water application. Therefore, all plants in a field receive equal amount of water. Higher uniformity results in efficient irrigation, thereby, causing less wastage of water, power and fertilisers.
- **Helps in saving electricity:**
 - Micro-irrigation systems require less electricity as compared to other systems. Usually, delivery pipe in micro-irrigation systems operate at low pressure (2–4 bar). Therefore, these require less energy for pumping.

- **Improves chemical application:**

- Microirrigation system can apply chemicals to plants through **fertigation unit**.
- ‘Fertigation’ is the application of fertilisers used for making soil amendments in order to improve plant growth. Since the fertilisers are applied directly to the root zones of the plants, a reduction in the total amount of fertiliser applied is possible, which saves an average of 25–50 per cent of the total cost.
- Fertigation results in **balanced nutrient application**, reduced fertiliser requirement of **around 7 to 42 per cent** (thus, saving expenditure cost incurred by farmer), higher nutrient uptake and nutrient use efficiency.
 - **Success story of Israel:** a desert nation with water scarcity has become a water surplus nation because it adapted micro-irrigation practises, especially drip irrigation that saves **almost three-fourths of the water used for irrigation done through open canals**.

- **Reduces weeds and diseases:**

- Weeds are the unwanted plants that grow in lawns, gardens and agricultural fields. They compete with the crops for nutrients, moisture and sunlight, which can reduce the crop quality and the yield. These also serve as a habitat for diseases and insect-pests, which attack the main crop.

Challenges in Adoption of Micro-Irrigation Technologies:

- Although government is promoting Micro-irrigation through Pradhan Mantri Krishi Sinchai Yojana or “**more crop per drop**”. By giving financial assistance of up to 55 percent for small and marginal farmers and 45 per cent for other farmers for adoption of micro-irrigation systems. Still Farmers are not enthusiastic about Micro-Irrigation.
- **Capital Intensive:** The overall impression among the farmers is that MI is capital intensive and suited only to large farmers who have Access to capital and equipment. Government data show that the micro-irrigation is expensive in terms of per hectare cost, and that it further depends on the size of farm as well as the type of crop grown.
- **Technology Intensive:** Farmers lacking in knowledge of technology and information about the functioning of micro irrigation and techniques like fertigation, usually hesitate to adopt new methods.
- **Fragmentation of Landholdings:** Small land-holdings are not economically viable to invest with modern irrigation techniques. The declining size of landholdings impacts farm incomes and farm income is closely associated with the capability of the farmer to adopt expensive micro-irrigation systems.
- **Lack of Awareness about government schemes:** Many farmers do not get access to government subsidy or get entangled into red tape

For accelerating MI adoption in the country, following measures can be taken

- Reduction in capital cost of the system (achieving economies of scale)
- Provision of technical support for regular MI operation and maintenance through Krishi Vigyan Kendras.
- Relaxation of farm size limitation in providing MI subsidies and
- Creation of a single state level agency or a Special Purpose Vehicle (SPV) for speedy implementation of the MI program.

What should be the role of National Water Commission?

AS WE HAVE DISCUSSED EARLIER ABOUT MIHIR SHAH COMMITTEE’S RECOMMENDATIONS TO FORM NATIONAL WATER COMMISSION TO PLAY AN EFFECTIVE ROLE IN FOLLOWING MANNER.

- **Irrigation reform:** Enable and incentivize state governments to implement all irrigation projects in reform mode with an overarching goal of **har khet ko paani**.
- **River rejuvenation:** Develop a nation-wide, location-specific programme for rejuvenation of country's rivers to effectively implement the triple mandate of **nirmal dhara, aviral dhara, swachh kinara**.
- **Sustainable Management:** Create an effective promotional and regulatory mechanism that finds the right balance between the needs of **development and environment**, protecting **ecological integrity** of the nation's rivers, lakes, wetlands and aquifers, as well as coastal systems.
- **Aquifer mapping and participatory groundwater management:** The NWC will lead the national aquifer mapping and groundwater management programme and work closely at the village and watershed levels, given the highly decentralized nature of groundwater usage in all the river basins.
- **Water security:** Insulate the agrarian economy and livelihood system from pernicious impacts of drought, flood and climate change and devise policies and programmes for tackling these challenges.

Government Interventions

- **Jal Shakti Ministry** - Formed in 2019 by integrating earlier two water-related ministries for water management in the country.
- **Swajal Scheme:** Under the National Rural Drinking Water Programme, the Ministry in February 2018 has initiated a project in the name of "**Swajal**" that is designed as a demand driven and community centred program to provide sustainable access to drinking water to people in rural areas. It encourages Partnership between village communities, NGOs and the government as the facilitator.
- **Jal Jeevan Mission (2019)** - To provide piped potable water to every rural household by 2024. In the past year, the Jal Jeevan Mission.
- **Interlinking of Rivers project** - To ensure greater equity in the distribution of water by enhancing the availability of water in drought-prone and rain-fed areas.
- **National Hydrology Project (2016)** - To improve the extent, quality, and accessibility of water resources information and to strengthen the capacity of targeted water resources management institutions in India.
- **Atal Bhujal Yojana (ABHY)** - Launched in 2019 to improve the management of groundwater resources in selected states.
- **PM Krishi Sinchayi Yojana** - To improve farm productivity and ensure better utilization of the resources in the country i.e., **Per Drop, More Crop**.
- **National water mission** - To ensure integrated water resource management helping to conserve water, minimize wastage and ensure more equitable distribution both across and within states.

State level Measures

- In Rajasthan, there is a scheme called '**Mukhya Mantri Jal Swavlamban Abhiyan**'.
- One of its objectives is to ensure effective implementation of water conservation and water harvesting related activities in rural areas.

- Maharashtra has launched a project called '**Jalyukt-Shivar**', which aims to make 5000 villages free of water scarcity every year.
- The Telangana government has launched a mission called **Mission Kakatiya**, the objective of which is to enhance the development of agriculture-based income for small and marginal farmers, by **accelerating the development of minor irrigation infrastructure**, strengthening community-based irrigation management and adopting a comprehensive programme for restoration of tanks.
- Concerned about the water crisis in rural areas, the **Prime Minister of India** has recently written a personal letter **to 'gram pradhans'** (village chiefs) requesting them to conserve rainwater during the forthcoming monsoon.
- The Prime Minister has recently also said that the government will ensure **piped drinking water** to every household in the next five years. It seems to be one of the most ambitious projects that are taken in the last few decades.

Conclusion

The COVID-19 pandemic has demonstrated the critical importance of sanitation, hygiene and adequate access to clean water for preventing and containing diseases. All this will not be possible without effective management of available water resources.

SDG Goal 6: Ensure access to water and sanitation for all

6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally

6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity

Availability and access to water, sanitation and hygiene (WASH) services is fundamental to fighting the virus and preserving the health and well-being of millions. COVID-19 will not be stopped without access to safe water for people living in vulnerability.

TRANSPORT AND COMMUNICATION

PYQ

- How is efficient and affordable urban mass transport key to the rapid economic development of India? 2020

Transport:

Introduction :

- Transport system **carries passengers and things from one place to another.**
- **Efficient , accessible and cheaper mode** of transportation is necessary for the development of any nation.
- These are often termed as **socio-economic arteries of the country** which carries not only labour ,machinery ,final produce but also ideas , skills , culture etc. Thus helps in **national integration.**

Utility of transportation in improving industrial growth :

- **Moving inputs and outputs** : Transportation enables **movement of raw material , labour to industries and delivers the final product to the consumers.** Hence, it is the main channel to complete any trade transaction.
- **Location of Industry** : Transportation cost is a **vital parameter in deciding location of industries.** Hence efficient and cheap transportation facilities are attracting industries in their region.
- **Access to remote areas** : Efficient and wide spread transportation facilities **helps to establish industries in backward areas** e.g. gas pipelines enable establishment of petrochemical complexes in Barauni and Mathura. and **taps the market in remote areas** e.g. Railway penetration helped to gather raw material from remote areas and deliver final products.
- **Specialization** : Transport **helps to move labour and capital in desired location** which results in division of labour and specialization of expertise.
E.g IT hubs in Bangalore , Pune have attracted talent and capital across the nation.
- **Economic growth** : A good transportation system is **vital to attract development which would create employment and spur economic growth.** Transport cost decides the competitiveness of the produced goods and services.
E.g. Lack of transportation facilities is the main region behind poor industrial development in resource rich North eastern regions.
- **Employment generation** : Surface , Water and Aviation sector provides employment opportunities to millions of people. The infrastructure development for transportation also spurs other industries like steel , cement etc
- **New startups** : New startups like **Ola , Uber and privatisation of railway operations , Metro development** have huge prospects in future to increase the efficiency of the Indian transportation system.
E.g. **Swiggy , Delhivery , Zomato startups largely depends on efficient transport system**
- **Supply chain** : Transport plays an important role in providing efficient **supply chain facilities with cold storage and processing.** Transportation of preserved material and processing of material during travel time results in value addition enhancing its value addition.
 - E.g. **Delivery of perishable agriculture produce within stipulated time** is vital for improving remuneration for farmers and food processing industries.

Railway transport system :

- The sector is highly responsible for **propelling India's overall development.**
- The Indian Railways is the lifeline of India. With its vast network across the length and breadth of India, **it is not just a mere transporter of passengers and goods but also a social welfare organisation.**
- Indian Railway is the **4th longest rail network** in the world **having largest passenger customers and fourth largest freight volume.**
- Share of the railways in the transportation of surface freight has declined due to shortfall in carrying capacity and lack of price competitiveness.

Objectives specified by Niti ayog :

- **Infrastructure** : Increase the speed of infrastructure creation to 19 km/dat by 2022-23.
- **Electrification** : Achieve 100% electrification of broad gauge track by 2022-23.
- **Revenue** : Increase the share of non fare revenues in total revenue to 20 percent.
- **Safety** : Improving safety standards to achieve zero fatalities.

Challenges of the Indian railways :

- **Passenger transport** : Cross subsidisation burden and high operating ratio have prevented Indian railways from providing high quality services and safety features.
- **Average speed** : Average speed of railways is very low compared to railways of developed nations. Because of these reasons the passenger crowd is shifting towards road and aviation transport.
- **Freight transport** : High competition from road transport due to cheaper rate and destination based delivery.
- **High operating cost** : On one hand railways have been struggling to enhance its revenue on the other hand expenditure on staff management , salaries , pensions , medical facilities etc have been increasing due to increase in salaries after pay commission recommendations.
- **High congestion** : Overcrowded railway network delays delivery of passengers and goods hence it results in waste of productive time of resources and decline in output.
- **Poor connectivity and electrification** : Penetration of railways in hilly states like Himachal Pradesh , Uttarakhand , North East etc is very poor. The rate of electrification of tracks is very slow.
- **Social burden** : The railway sector has been termed as 'split personality'. It is a commercial organisation having a heavy load of social obligations like suburban passenger services concessions to certain sections of passengers and certain freight commodities.

Government Initiatives :

- **Freight corridors** : The commencement of the two Dedicated Freight Corridors (DFCs) by 2022 is required on priority basis .
- **Privatisation** : Based on recommendations of Amitabh Kant Panel private players have been allowed in railway operations. It will attract innovation , investment in the sector. It will provide world class train services and would help in increasing train speed.
- **Railway board** : Based on recommendations of the Bibek Debroy committee, the government has merged technical and non-technical services of the railways. The railway board has been restructured on the functional lines of the company board.
- **Rail development authority** : It is entrusted with rational tariff determination , setting up of performance standards and technological upgrades.
- **National rail plan** : Government has envisaged to integrate the rail network with other modes of transport to develop a multimodal transportation network.
- **Modernisation** : Electrification of railways , development of green corridors , use of bio toilets etc are some of the measures in rail modernisation. Along with these, 'Rashtriya Rail Sanraksha Kosh' was created to finance railway safety projects.

Way Forward :

- Adoption of the roll-on roll-off model of transporting loaded trucks on rail on the DFCs, which apart from boosting revenues has the added advantage of reducing the overall carbon footprint.
- There have been suggestions to commercialise the Railways's Production Units and outsource the medical services.
- Rationalisation of fare structures and subsidies , modernisation of stations and improvement in the safety features.

- Enhance ease of doing business to attract investment and to promote efficient resource allocation.
- India is a signatory to the **2015 Paris Agreement**, committed to achieving targeted reductions in carbon emissions in a time-bound manner. The railways need to fasten its electrification eliminating coal dependency.

Road Transport :

Introduction :

- It has the **largest share** in movement of both passengers and freight in India.
- The demand for mobility on roads has **risen continuously and sharply** in recent decades.
- It provides a **cheaper , convenient alternative** and **only avenue which provides destination based delivery**.

Objectives specified by Niti ayog :

- Achieve the **Bharatmala Phase 1** target by 2021-22.
- **Double the length of NATIONAL HIGHWAYS BY 2022-23.**
- **Improve regulatory framework** to achieve better compliance , road safety and quality.
- Being a signatory to **Brasilia Declaration** , reduce the number of road accidents by 50% by 2020.

Challenges :

- **Overstrained Highways** : The existing length of National Highways is mere **2.2% of the country's total road network** and it carries **40% of India's total road traffic**.
- **Budgetary allocation** : Budgetary allocation for construction of **new highways and maintenance of roads** is very less than requirement.
- **Accidents** : India has a **high accident death rate compared to Bangladesh , Srilanka**.
- **Cost escalation** : Slow land acquisition process , environment clearances and slow work progress increases average cost of road construction.

Public Transportation system in Cities :

Introduction :

- **Urban population** : By next census urban population would reach **40% of the Indian population**.
- **Private vehicle share** : In Indian cities due to inefficient public transport system utilisation of private vehicles is high which also **increases traffic and pollution level**.
- **Congestion** : Congested streets and polluted air are common experiences in India's metropolises.
- **Quality of life** : When cities fail at mobility, the result is congestion, lost productivity, worsening pollution and a terrible **quality of life**. India's big cities have all these attributes.

Challenges :

- **Bus transport** : Buses available per one lakh persons are very less compared to developed countries. The buses operated by governments are **not properly designed, are uncomfortable and badly maintained**.
- **Connectivity** : Last mile connectivity is absent hence public transport fails to provide end to end services.
- **Traffic and pollution** : High traffic and long routes taken wastes productive time of resources which declines economic growth.
- **Poor planning** : Due to improper planning and bad selection routes , **Bus rapid transport systems have failed to bring desired results**. e.g. Pune BRT system failed to attract local public as expected earlier.
- **Road design** : Faulty road design and poor construction **increases probability of accidents and congestion**.

Measure to be taken :

- **Integrated public transport systems** : It should be developed to **provide end to end transport services**.
E.g. Ferry services from home to bus/metro station and further from metro/bus station to office/hotel etc.
Pune metro authority is planning to allow bicycles within the metro to ease further journey.

- **Intelligent transport system(ITS) : NITI ayog** has developed ITS draft to provide real time intelligent transport facilities to passengers.
- **Metro station hub** : Develop metro station into business places. **Metro stations can provide space for offices , shopping outlets etc which will motivate people to take public transport.**
- **Bus Service** : Increase buses per lakh passengers and comfortable designs should be selected to attract more passengers.
- **Intermodal Common Mobility Card** : Launch of these cards would facilitate seamless travel in different modes like metro , bus , local trains etc.

Way forward :

- Comprehensive public mobility plan for every city considering local demands must be formulated.
- Footpaths and cycling paths should be integrated as part of the public transport system.
- Government should promote startups to provide urban mobility solutions for sustainable transport system with minimum congestion , fatality and pollution

Civil Aviation :

Introduction :

- The **aviation passenger traffic in India is increasing at a higher rate than the global average.**
- **First class railway passengers are moving towards aviation transport** which is faster and safe.
- **Presently cargo traffic is very less** but with investment and technology share of the cargo will increase in future.
- India has a huge **untapped domestic market** which will **boost economic growth with employment generation.**

Objectives of Niti ayog :

- **Affordability** : Enhance the affordability of flying to increase aviation share in domestic travel.
- **Cargo** : Doubling the cargo handled by the aviation sector.
- **MRO industry** : Providing a boost to the maintenance , repair and overhaul(MRO) industry.
- Expand the aviation sector to handle **one billion trips a year.**

Challenges :

- **Infrastructure** : Due to rapid expansion of the aviation sector , airspace , parking bays and runway slots are becoming scarce . **Mumbai and Chennai airports are already close to saturation.** It decreases efficiency and safety in handling passengers and cargo.
- **Taxes on aviation turbine fuel(ATF)** : Due to high taxes and lack of competition among providers , ATF is relatively expensive in India. Since it remains outside the GST network , there are also regional disparities in price.
- **Predatory Pricing** : Selling products below cost price to eliminate rival companies is **bad for the economy.** It also results in compromise in safety of passengers.
- **Lack of skilled workers** : There is shortage and gaps in availability of industry recognised skills- from pilots to ground handling personnel.

Way forward :

- **UDAN scheme** : Enhance aviation infrastructure and complete the planned airports under the udan scheme. Augment the capacity of the international airport under **international udan initiative.**
- **Investment** : Attract more private investment in the sector by providing incentives. **Reduce taxes on MRO services and consider granting infrastructure status for MRO.**
- **Promote air cargo growth** : Promote “**Fly-from-India**” through creation of transhipment hubs.
- **Ease regulatory environment** : Open up the aviation market by deregulating it to help increase passenger and freight traffic in India. **Adopt a consistent model for tariff determination** so that it reduces passenger cost.

Shipping and Inland waterways :

Introduction :

- Around 90% of India's external trade by volume and 70% by value are handled by ports.
- Inland waterways carry less than 2% of India's freight traffic.

Niti ayog objectives :

- Double the share of freight transported by coastal shipping and inland waterways by 2025.
- Reduce the turnaround time at major ports up to 1-2 days by 2022-23.
- Augment the capacity of inland water transport by increasing the least available depth.

Challenges :

- **Draught levels** : Most of the Indian ports lack capability to handle large container vessels due to inadequate depth. Shallow depth adversely affects a port's potential to become a hub port.
- **Connectivity** : Weak connectivity to hinterland production centres and gateway ports often leads to higher costs and delays.
- **Transhipment port** : Due to absence of transhipment port in India a large share of containers in India are currently transhipped through other ports like Colombo , Singapore.
- **High capital for Indian vessels** : Due to high cost of capital freight transport through Indian waterways have become uncompetitive.
- **Issues in inland waterways** : The varying depths due to meandering and erosion hinder the processes like unloading , non-mechanised navigation lock systems etc

RoPax Ferry :

- It means a roll on roll off cum passenger ferry service launched by the Ministry of shipping.
- It reduces travel time, pollution and congestion on surface transport.
- E.g. Ghogha-Hazira Ferry service. It will work as a gateway to the South Gujarat and Saurashtra region which will reduce the distance between Ghogha to Hazira from 370 km to 90km .

Way forward :

- **Open up India's dredging market** : The government should open the dredging to attract international players to maintain required depth at ports to attract large vessels and enable them to become hub ports.
- **Implementation of sagarmala** : Completion of various projects under sagarmala aimed at improving port connectivity , setting up coastal economic zones , single window clearances for cargo clearances and establishing new ports are critical to increase throughput.
- **Last mile connectivity** : IWT should be integrated to multimodal connectivity with proper road and rail connectivity for seamless transfer of goods.
- **Investment** : Financing for inland vessels could be made part of priority sector lending by banks.

Interlinking of river :

- **Rainfall** : In India most of the rainfall occurs during June to September and rainfall is not uniform across the country. This causes simultaneous floods and droughts in India.
- **The National River Linking Project (NRLP)** intends to conserve water from the monsoon in reservoirs and transport this water through river linking projects to water scarce areas.
- The Inter-link project includes three parts:
 - a northern Himalayan rivers inter-link component.
 - a southern Peninsular component.

- an intrastate rivers linking component.
 - **Nodal agency** : National Water Development Agency (NWDA) is the nodal agency of the project.
 - The linking of Godavari and Krishna was completed in 2015. The next project being taken up is the Ken-Betwa link.

Benefits :

- **Transfer Excess Water** : River linking projects could transfer sufficient water in **peninsular rivers and canals** which can be utilised for **inland waterways transportation**.
 - **Logistics cost** : This project would **enhance infrastructure for logistics and movement of freight and decrease logistics cost**.
 - **Clean transport mode** : Development of cleaner , low carbon mode of transport would help in decreasing carbon footprints and would facilitate cheaper mode of transportation.
 - **Inland waterways** : Proposed waterways on peninsular rivers like Kaveri river(NW 55) , Manjara river(NW70) would receive required water to maintain enough depth for most time of the year.

Criticism :

- **Poor EIA** : In depth analysis of socio-economic and ecological impacts of this project is lacking.
 - **Social and ecological cost is very high**. Constructions of reservoirs cause submerging of forests , displacement of people and disrupts biodiversity of the region.
E.g. **The Ken-Betwa project will affect** the core area of the Panna national park.
 - Hence, before implementing **the projects scientific and technical assessment** needs to be undertaken to assess its feasibility.

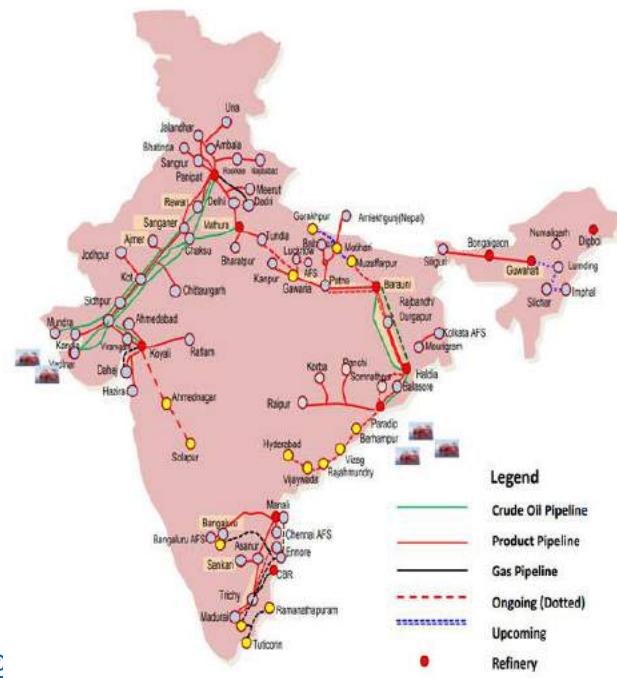
Development of Pipeline transport :

Introduction :

- Pipelines are the **most convenient , efficient and economical mode of transporting petroleum , petroleum products , natural gas , water , milk etc.**
 - Solids can also be transported through pipelines after converting them into **slurry**.
 - Pipelines have relieved **increasing pressure on the existing surface transport system.**

Advantages :

- **Suitable mode** : They are the most convenient mode of transporting liquids and gases. Transit losses are minimal through pipelines .
 - **Easy to lay** : Pipelines are easy to place in **difficult terrains and even under water**. Even they are not affected by seasonal variations like floods ,snow fall , cyclones etc.
 - **Low maintenance** : Pipelines require very **low energy and little maintenance**.
 - **Environment friendly** : Pipelines are safe , accident free and environment friendly.
 - **Cheap** : Transportation cost is very **low compared to other modes of transportation**.
 - **Industrial development** : It brings industries in nearby regions e.g. **Establishment of fertilizer industries in near gas pipelines (Jagdishpur , Sawai Madhopur).**



- **Lack of flexibility** : Pipelines can't be laid everywhere , they can be utilised for few destinations.
- **Capacity** : Its capacity is fixed and cannot be increased.
- **Initial cost** : Initial cost is very high hence requires high capital investment.
- **Security** : They are vulnerable to attacks from non-state actors. E.g. Destruction of international TAPI pipeline by terrorist groups.
- **Repair** : Underground pipelines are difficult to repair and leakage detection is very difficult.

Some important Pipelines in India :

- Naharkatia-Nunmati-Barauni Pipeline.
- Mumbai High-Mumbai-Ankleshwar-Koyali Pipeline.
- Salaya-Koyali-Mathura Pipeline.
- Hajira-Bijapur-Jagdishpur Gas Pipeline.

Regional development :

- Pipelines are an important **agent of attracting petrochemical and fertilizer industries in vicinity**. Dispersal of pipelines have helped in regional development by establishing industries and through employment generation. E.g. **Development of the HBJ gas pipeline** has fostered construction of power plants (Kawas,Gj ; Auraiya,UP) and fertilizer industries(Sawai Madhopur, RJ ; jagdishpur , UP)along the route.
- Development of **petrochemical complex's in Mathura , Barauni region** was a result of pipeline penetration in this region.
- It provides a boost to other **ancillary industries** and service providers to the pipeline maintenance.

Way forward :

- India that aspires to be an **economic superpower** is visibly in need of a transport policy that is in tune with the times.
- Policy would be based on two prominent parameters :
 - **assessing the transport requirements for the next two decades.**
 - **assessing the investment requirements of the sector.**
- Future development in the transport sector would be based on increasing share of **public transport , utilisation of clean fuels like electricity , CNG gas , Bullet trains and cheaper aviation fares etc.**
- Enhancing **budgetary allocation** and attracting **private investment through PPP mode** would decide the fate of the sector.

HUMAN SETTLEMENTS AND ASSOCIATED ISSUES

PYQ

1. Critically examine the effects of globalization on the aged population in India. 2013
2. Are we losing our local identity for the global identity? Discuss. 2019
3. Discuss the positive and negative effects of globalization on women in India. 2015
4. How do you explain the statistics that show that the sex ratio in Tribes in India is more favourable to women than the sex ratio among Scheduled Castes? 2015
5. The growth of cities as I.T. hubs has opened up new avenues employment but has also created new problems. Substantiate this statement with examples. Urbanization. 2015
6. With a brief background of quality of urban life in India, introduce the objectives and strategy of the 'Smart City Programme'. 2015
7. Discuss the various economic and socio-cultural forces that are driving increasing feminization of agriculture in India. 2015
8. Smart cities in India cannot sustain without smart villages. Discuss this statement in the backdrop of rural urban integration. 2015
9. Discussion the various social problems which originated out of the speedy process of urbanization in India. 2013

In geography a **settlement, locality or populated place** is a **community in which people live**. The **complexity of a settlement** can range from a small number of dwellings grouped together to the largest of cities with surrounding urbanized areas.

- Settlements may include hamlets, villages, towns and cities.

Settlements can broadly be divided into two types – rural and urban.

- The major difference between rural and urban areas is the function. Rural areas have predominantly primary activities,
 - whereas urban areas have domination of secondary and tertiary activities.
- Generally the rural areas have lower population density than urban areas.

TYPES AND PATTERNS OF RURAL SETTLEMENTS

If we group settlements found all over the country, these can broadly be grouped under four categories:

- **Compact/clustered/nucleated settlement:** in such settlements all the dwellings are concentrated in one central sites and these inhabited area is distinct and separated from the farms and pastures.
 - These settlements are distributed over the entire northern Indo-Ganga plain
- **Semi-compact/Semi-clustered/fragmented settlement:** Such settlements are characterized by small but compact nuclears around which hamlets are dispersed.
 - It covers more area than the compact settlements.
 - Such settlements are situated along streams in Manipur Mandla and Balaghat districts of Madhya Pradesh, and Rajgarh district of Chhattisgarh.
- **Hemleted settlement:** These type of settlements, are fragmented into several small units. The main settlement does not have much influence on the other units.
 - This segregation is often influenced by social and ethnic factors. The hamlets are locally named as faliya, para, dhana, dhani, nanglay etc.
- **Dispersed settlement.** This is also known as isolated settlements. Here the settlement is characterized by units of small size which may consist of a single house to a small group of houses.

- It varies from two to seven huts. Therefore, in this type, hamlets are scattered over a vast area and does not have any specific pattern.

Urbanisation in India

The population transfer from rural to urban regions, the resulting decline in the number of people living in rural areas, and the methods in which societies adjust to this transition are all referred to as urbanisation.

Status of Urbanisation in India

Urbanization in India was mainly a post-independence phenomenon, due to adoption of a mixed system of economy by the country, which gave rise to the development of the private sector.

- As per the Census of India 2011, Currently, India's population stood at 1210 million, with an urbanisation level of 31.1%.
- The rate of urbanisation in India is rapidly growing. In 2011, more than 30% of the population lived in cities, and by 2030, that number is predicted to rise to 41%.
- Despite the fact that the rate of urbanisation poses an unparalleled management and policy challenge, India has yet to hold a national discussion about how to deal with this seismic transformation in the country's makeup.
- Today's urban India is "distributed," with a vast spectrum of large and small cities strewn over the country.

Problems with India's Urbanisation

- **High Population Pressure:** On the one hand, rural-urban movement hastens the pace of urbanisation; on the other hand, it puts an undue strain on existing public services.
 - As a result, slums, crime, unemployment, urban poverty, pollution, congestion, ill-health, and a variety of deviant social activities plague the cities.
- **Unplanned Development:** The strategy for developing a city includes unplanned development, which exacerbates the divide between the rich and the poor that exists in metropolitan areas.
- **Slums are overflowing:** There are approximately 13.7 million slum dwellings in the country, which contain a population of 65.49 million people.
 - In India, up to 65 percent of cities have neighbouring slums, where people live in small dwellings next to one other.
- **Inadequate Housing:** Housing is the most distressing of the myriad social problems that have arisen as a result of urbanisation.
 - The great majority of city dwellers live in filthy circumstances and in densely populated areas.
- **Problems Caused by the Pandemic:** The Covid-19 pandemic has worsened the plight of the urban poor and slum residents.
 - Slum dwellers' capacity to earn a living was seriously harmed by the sudden imposition of complete Covid shutdown.
- **Non-Inclusive Welfare Programs:** The benefits of welfare programmes for the urban poor sometimes only reach a tiny percentage of those who are eligible.
 - Slum residents do not get the majority of relief cash and benefits, owing to the fact that these settlements are not legally recognised by the government.
- **Heritage of Past construction:** With few exceptions, most of the cities of the town have grown without the early guidance of comprehensive city plans. Some which have grown, based on plan, have now outgrown their earlier designs.

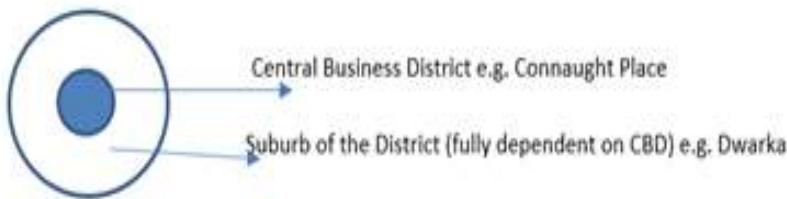
'Class Ghettoization' and Migration to Urban areas

'Class Ghettoization' refers to the phenomenon of isolating the members of one class in a separate place. This manifests into inequality at the socio-economic and political level.

- This is gaining its pace in India because of the growing urban population and unplanned urbanisation.

The faulty pattern of urbanization

- Due to overpopulation and better pull factors, the urban city gives rise to new areas called suburbs. But due to unplanned urbanisation and suburbanization there are pockets of slums developed in between



them.

- E.g. Sanjay Colony is a slum in South Delhi situated in the Okhla industrial area.

- Any compact housing cluster of 20 households with poor infrastructure and inadequate sanitation facilities is referred to as a slum as per 2011 census definition.

Social-cultural implications

- Gated communities:** The rise of gated communities manifest into cosmopolitan areas surrounded by lower-middle-class, poor ghettos/slums. This creates a huge socio-cultural divide between these areas.
- Social Immobility:** lack of opportunity leads to informalization of ghettos in terms of employment which results in lack of upward social mobility.
- Unconnected with home:** Due to the nature of the job, they remain socially and politically unattached from their hometown thus further delineating them from society.
- Double Jeopardy:** Slums are habited by lower castes, minorities, and poor from rural areas hence caste and religious ghettoization further augment their alienation. Most of them are illegal habitations, living under constant threat of removal.
- Mental Health:** Huge mental barrier between the different habitations of slums and so-called civil habitations; there is a feeling of inferiority complex in slum habitats thus inhibiting their growth as a proper human.
- Education and Public health:** They have to rely on public schools and hospitals which majorly are in an archaic state. Whereas others have good convents and private hospitals 24/7 with world-class facilities.
- Water supply and sewerage problem:** Slum dwellers have to rely on tankers which is also not regular and the issue of tanker mafias exists. In spite of Swachh Bharat Abhiyan, basic sewerage issue pertains.
- Infrastructure:** There is a visible difference in terms of street lights, roads, community gardens etc.
- Economy:** The slums and suburbs serve as employees of the cosmopolitan population as household workers, employees of companies owned by cosmopolitan people.
- Informalisation of employment:** mainly employed as rag pickers or low paying uncertain jobs like fruit thela etc.
- Urban crime:** Due to lack of basic amenities, opportunities, alienation, and informalisation of employment, the youth are more prone to crime exposure.
- COVID-19 impact:** This pandemic has further deteriorated their fragile lifestyle due to a standstill economy.

Measures/Suggestions

- In-situ Slum rehabilitation program will remove the fear of removal from their sites e.g. PM Awas Yojana, "Jahaan Jhuggi Wahin Makan" scheme of Delhi Government, etc.
- One Nation One Ration Card for nutritional security.
- PM SVANidhi to empower street vendors holistically with credit facilities.

- NGOs like Teach for India are taking the lead in educating slum children thus making slum children to compete with cosmopolitan students.
 - Other states should follow the Delhi Education model in improving public schools.
- Smart City Mission has the potential to mitigate poverty from the cities as it aims to target basic services for the people in a holistic manner.
- Similar to MGNREGA there should be an urban counterpart to provide rights based employment.
- There should be constant positive engagement between the so-called developed islands and slums by bridging the cultural gaps through various cultural programmes.
- Gender sensitive infrastructure should be a priority as it has a positive role on health, education, income, and housing in slum families. Had this been in place, slums like Dharavi would not be in the news for being a COVID-19 hotspot.

Article 38 of the Indian constitution endeavours to eliminate inequalities in status, facilities and opportunities, not only amongst individuals but also amongst groups of people residing in different areas or engaged in different vocations. Thus, at earliest the shoots of class ghettoization are removed, better will be to realise Article 38.

Urban areas and Air Pollution

Along with urbanisation comes industrialisation, vehicular pollution and burning of fossil fuel. Noxious industrial fumes or dust from various industries such as VPT or for that matter vehicular pollution, the geographical location of the city is acting as a catalyst for the rapid growth of air pollutants.

- India was the 5 most polluted country in 2019, with Ghaziabad in the National Capital Region ranked as the most polluted city in the world, according to a global compilation of PM 2.5 particulate pollution data by IQAir.

Impact of Air pollution

- Urban heat island effect: "Rapid urbanisation has led to the growth of concrete jungle and blacktop roads.
 - Almost 85 per cent of the urban area is covered with concrete structures and metal roads. This is trapping the solar energy and resulting in the creation of the Urban Heat Island (UHI) phenomenon.
- Health Issues: Long-term exposure to outdoor and household air pollution contributed to over 1.67 million annual deaths from stroke, heart attack, diabetes, lung cancer, chronic lung diseases and neonatal diseases in India in 2019, according to the State of Global Air 2020.

Causes of Air Pollution

- Unplanned urbanization: haphazard growth of urban areas has led to the proliferation of slums and poor public transport has increased the burden of personal vehicles on the road.
 - Landfills used for waste management also release pollutants in the air.
- Burning of urban waste, diesel soot, vehicular exhaust, road and construction dust, and power generation.
- Poor governance: the issue of environment and pollution is still to get the policy priority it deserves.
 - While agencies liked CPCB and SPCBs continue to be under-resourced and under-staffed,
 - the multiplicity of the state authorities at the ground level leads to poor coordination, lax enforcement of rules, and lack of accountability as seen in Delhi.
- The absence of environmental governance continues to be a major challenge.

Steps to Combat Air Pollution

- the National Clean Air Programme (NCAP), which was intended to build and strengthen the institutional capacity to monitor air quality across India.
- Governments should make the use of personal vehicles in cities less attractive through strict road pricing mechanisms like Congestion tax, Green-house Gas tax.
- Need to speed up the journey towards LPG and solar-powered stoves.

- **Addressing vehicular emissions is within India's grasp** but requires a multi-pronged approach. It needs to combine the already-proposed **tighter emission norms (in the form of BS-VI)**, with a **push for shared mobility and public transport** and adoption of alternate mobility technologies.

Combating air pollution is a public concern and, as a result, everyone's responsibility. As a result, organised and coordinated efforts with active participation from all stakeholders are required. This should involve the federal, state, and municipal governments, as well as cities, the general public, and people.

Urban areas and water Pollution

With rapid urbanisation, the country is facing a massive waste management challenge. Over 377 million urban people live in 7,935 towns and cities and generate 62 million tonnes of municipal solid waste per annum. Only 43 million tonnes (MT) of the waste is collected, 11.9 MT is treated and 31 MT is dumped in landfill sites.

- According to the World Bank, India's daily waste generation will reach 377,000 tonnes by 2025.
- Lakes/water bodies are battling: waste disposal, deposition of pollutants and Continuous disposal of waste has severely depleted the lake's water quality.

Dismal situation of Urban water bodies in India

Because of unplanned expansion, some of India's major urban centres have become home to dying Water bodies, disrupting water systems and vegetation cycles.

- In the National Capital Territory of Delhi alone, due to haphazard urbanisation, as many as 232 Water bodies are already off the recovery list.
- Bangalore lost at least 66 Water bodies between 1973 and 2007.
- Chennai has fared the worst in conserving Water bodies. All that remains in the name of a wetland ecosystem in the city, is the Pallikaranai marsh, which has shrunk to a tenth of its size since 1965.

Causes of Urban water bodies pollution

They are polluted through agricultural runoff and discharge of untreated sewage and other waste from urban areas. Under normal conditions, water bodies do retain pollutants from surface and subsurface runoff from the catchment and prevent them from entering into streams and rivers.

- **Rapid Unplanned Urbanisation:** Rapid urbanisation in India during the recent decades has given rise to a number of environmental problems such as water supply, wastewater generation and its collection, treatment and disposal.
- **discharge of untreated sewage:** Nearly 80% of the water supplied for domestic use passes out as wastewater. In most cases, this wastewater is let out untreated and causes large scale pollution of the surface water.
- **Industrial Discharge:** Their solid wastes and sludges get scattered around or dumped in unlined pits and effluents flow to streams through storm- drains or stagnate in depressions to percolate, leach or get washed-off during the next rainy season.
- **Limitations of State authorities:** the state Disaster Mitigation Plan has a limited scope when it comes to intervening in matters of unplanned urban infrastructure, including drainage and urban sewage systems.
- **Religious and Social Practices:** Carcasses of cattle and other animals are disposed of in rivers or water bodies. Dead bodies are cremated on the water bodies. Partially burnt bodies are also flung into the water bodies.
 - All this is done as a matter of religious faith and in keeping with ancient rituals. These practices pollute the river water and adversely affect the water quality.

Significance of urban Water bodies

- **Reduce urban heat island effect:** Water in Water bodies will absorb more heat before the surrounding begins to get warmer and subsequently evaporates. Furthermore, Water bodies also reflect solar radiation, giving a moderating effect.

- **Water bodies stabilize the microclimate parameters** such as relative Humidity, temperature and air movements etc. Water bodies regulate the diurnal variation of air temperature, making it ambient. Thus affecting the rate of evaporation, due to this vapour pressure increases which ultimately reduces the relative humidity.
- COP 13 of the Ramsar convention was centered around the theme of '**Water bodies for a Sustainable Urban Future**', marking the importance of urban Water bodies by providing drinking water, livelihoods, recreation, flood absorption, reducing temperatures, and filtering waste.

Measures needed to improve the conditions of urban Water bodies:

- **Improving the capacity of urban drainage systems**: so it would manage waste discharge and municipal waste effectively.
- **Restricting encroachment and fragmentation** of urban Water bodies.
- **Ensuring planned Urbanization** so that it takes the delineation and protection of catchment areas, drainage channels and areas of lakes, ponds etc.
- **Stakeholder participation and capacity building** for better management of urban Water bodies.

Water bodies act as detoxifiers to purify the environment and as a sponge and sluice to protect the urban ecosystem from hazards posed by numerous anthropogenic and geomorphological factors.

Impact of Urbanisation on climate change

- **Affects hydrological cycle** - Rapid urbanisation impacts hydrological cycle and water bodies through the increase of impervious surface **Water/Sanitation**.
- **Changes in local weather** - Rapid Urbanisation has led to increase in the diameter of cities thus the **natural vegetation and temperature pattern get affected adversely**. Further pace of industrialization and vehicular pollution **influencing the heat budget and diurnal temperature pattern**.
- **Urban heat island** - This phenomenon is occurring frequently **due to substantial modification of surface energy and change in water balance**. Heat waves can kill hundreds of people and may become more frequent and intense with increasing urbanisation.
- **Precipitation pattern changing** - The tall buildings in the urban areas of mega cities increase the surface aerodynamic roughness, strengthening the air convection and resulting in **stagnant weather systems**. Thus the **precipitation amount and/or intensity in urban areas get affected**.
- **Other Impacts** - Further higher emissions in urban areas be it vehicular or thermal plants in the outskirts, **dust bowl effect** becoming predominant these all are **changing micro climates** because of poor developmental planning.

Climate Smart Cities Assessment and its impact:

- To inculcate Climate-Sensitive Approach to Urban Planning and Development the Climate Smart Cities Assessment framework, **for 100 smart cities, was launched by the Ministry of Housing and Urban Affairs**.
- **The framework has 30 diverse indicators, across 5 sectors**, that monitor and guide the cities to help them to assess their own preparedness to tackle the issue of climate change as well as degrading air quality.

The framework seek to deal with urban impact on climate change through the interventions in following sectors -

- **Energy and Green Buildings** - It aims to achieve energy efficient street lighting in the city, green building adoption and promotion. With this **energy demand of cities is met in a sustainable way** so that pollution is minimized.
- **Urban Planning, Green Cover & Biodiversity** - Increase in green cover promotes **biodiversity and maintains ecological balance**. It will make an **effective heat sink in cities** and further diurnal temperature patterns would not get adversely affected. Apart from this **it will make cities disaster resilient**.

- **Mobility and Air Quality** - Adequate availability of Public Transport would be ensured along with this Clean Technologies shared vehicles promoted so that minimum vehicular pollution occurs. Thus phenomena like temperature anomaly, urban heat island and air pollution tackled in urban areas.
- **Water Resource Management** - Effective Water Resources management and adoption of an energy-efficient wastewater management system ensures availability of potable water and reduces pollution of water. Thus it will support local water bodies and flora and fauna there. Further flood/ water stagnation risk would be minimized through efficient drainage patterns.
- **Waste Management** - It aims to manage landfills and dump sites on scientific lines so that a minimum amount of toxic gases and polluting gases get discharged into the atmosphere. Further dry waste recovered & recycled leading to waste minimization.

Significance

- This program will provide us with yardsticks which we can then use to modify our plans towards fighting climate change.
- Also, the framework is expected to create awareness, citizen engagement, and an environment of Key Performance Indicator-driven spending and promote a circular economy.
- The focus is clearly on the community, the neighbourhood and the citizen; and tangible steps that can be taken towards the clear impacts.

At present India is seeing a high pace of urbanisation but its unplanned nature and deregulated development created socio-economic implications. Situation further worsened due to its interwoven relation with climate change. Climate Change the Climate Smart Cities Assessment framework breaks this intricate bonding and through this sustainable development goal 11 (Sustainable cities and communities) can be achieved.

Smart City Mission: A remedy to India's unplanned Urbanisation

It is an innovative programme under the Ministry of Housing and Urban Affairs of the Government of India that aims to boost economic growth and improve people's quality of life by facilitating local development and utilising technology to produce smart outcomes for citizens.

- It focuses on inclusive and sustainable development, as well as looking at compact regions to establish a replicable model that will serve as a beacon for other ambitious cities.
- From the financial year (FY) 2015-16 to 2019-20, the Mission will cover 100 cities over a period of five years.

Issues associated with smart city mission

- **Inadequate private participation**- At the outset, the Smart City Mission set a goal of private participation funding 21 percent of the overall mission cost.
 - Only 15% of the projects currently being implemented are in the form of a public-private partnership (PPP).
- **Financial Mismanagement**: While the top 60 cities have reported all of their projects, and the costs of most projects are specified in the project proposals (94 percent), only 17 cities were able to identify the sources of funding at the project level.
- **Increased focus on a few key areas** of the Smart City, such as transportation, energy and ecology, water and sanitation, housing, and economy, which account for over 80% of the SCM budget.
 - Other financing categories like as IT, governance, culture and heritage, and health and education account for barely 15% of the total.

Success Stories in Smart Cities Mission

- **Ahmedabad**: Free Wi-Fi on BRTS corridors in Ahmedabad increased ridership by 20,000 in March 2018 over February 2018.
- **Bhopal**: Property tax receipts have increased in Bhopal, and the city's transportation services may now be tracked online.

- **Rajkot—the crime rate has dropped by 18%** in the last two quarters, and traffic challan issuing has improved, indicating a shift in behaviour. **Littering, public urination, and garbage burning at night have all decreased as a result of the cleaning effort being monitored by CCTV cameras.**

What does India need?

To control its unplanned urbanisation, India must act on numerous fronts:

- **Inclusive Cities:** In cities, the poor and lower-income groups must be integrated into the mainstream.
○ The planning should take into account the needs of the marginalised groups, such as housing, health, water, transportation, and other services at reasonable pricing.
- **Urban Governance:** India's city governance needs to be overhauled. Large cities throughout the world have empowered mayors with long terms and clear accountability for the city's success, in contrast to India's current urban governance.
- **Integration:** To establish sustainable cities or metropolitan regions, integrate multiple urban development and related programmes at the municipal, state, and national levels.
- **Devolution must be accompanied by greater reforms in urban finance**, which will lessen cities' reliance on the federal government and states while also releasing internal revenue streams.
- **India must make urban planning a central**, recognised function by investing in talented people, a rigorous fact foundation, and innovative urban design.
○ This can be accomplished through a "**cascaded" planning structure** in which large cities have metropolitan-level 40-year and 20-year plans that connect municipal development plans.
- **Affordable housing is a significant concern for low-income populations**, and in the absence of a feasible model that meets their needs, India can tackle the problem by enacting a series of regulations and incentives that would bridge the price-affordability gap.
- **Delivery of Services:** The major job of ULBs should be to manage the water supply and sewerage system. They should be in charge of water supply and distribution in their geographical jurisdictions, whether from their own sources or through collaboration with parastatals and other service providers.

In recent years, the government has launched a number of initiatives targeted at urban planning and administration, including Smart City, AMRUT, Digital India, Swach Bharat, and HRIDAY.

For these programmes to succeed, they need a solid foundation of effective planning and management.

The Ministry of Urban Development has launched a programme to help urban local governments strengthen their capability. **The development of urban regions has a significant impact on India's economic development. As a result, in order to achieve sustainable and inclusive growth and development, good urban planning and management becomes a must.**

PHYSICAL GEOGRAPHY

GEOMORPHOLOGY

PYQ

1. Discuss the geophysical characteristics of Circum- Pacific Zone. 2020
2. Define mantle plume and explain its role in plate tectonics. 2018
3. How can the mountain ecosystem be restored from the negative impact of development initiatives and tourism? 2019
4. How does the Juno Mission of NASA help to understand the origin and evolution of the Earth? 2017.
5. Why are the world's fold mountain systems located along the margins of continents? Bring out the association between the global distribution of Fold Mountains and the earthquakes and volcanoes. 2014.
6. Explain the formation of thousands of islands in Indonesian and Philippines archipelagos. 2014
7. What do you understand by the theory of continental drift? Discuss the prominent evidences in its support. 2013

Origin and evolution of earth

Since the earth is a member of the solar system, it is commonly believed that origin of earth is connected with that of the solar system.

Big Bang theory

- According to this theory, **universe originated around 13.6 billion years ago**. There was **big explosion on a singular point known as singularity** after which the universe started expanding.

A number of theories have been put forward but none of them seems to perfectly explain the origin. Some of the important theories are:

Nebular hypothesis

- It was given by Immanuel Kant and Laplace in the 18th century.
- This theory says that **initially there was large hot gaseous nebula** which **lost its heat due to radiation** and as result it cooled and contracted.
- **Due to contraction, its speed of rotation increased.** Consequently, the centrifugal force created bulge in the equatorial region. When the centrifugal force exceeded the gravitational pull, a gaseous ring got separated. The repetition of the process led to the formation of successive rings.
- The material in the ring accreted to form planets while the **central nebula resulted in sun**.

Limitations

- The hypothesis is **unable to explain the fact that there is 98% angular momentum** in the planets and **only 2% is in sun**.
- **There was not enough mass** in the ring to provide the gravitational pull for the formation of planets.

Planetaryesimal hypothesis

- It was given by Chamberlain and Moulton.
- It says that due to near approach of a larger star, **tidal distortions were raised on the surface of sun**. These **tidal distortions along with eruptive forces of the sun led to shooting up of gaseous lumps** to greater distances. They cooled down ultimately to form planetesimals which gradually coalesced to form planets.
- This hypothesis explains the **occurrence of falling meteorites**.

Limitations

- Material from the interior of the earth would be hot, so gases would disperse to space rather than condense.

Gaseous Tidal hypothesis

- It was given by Jeans and Jeffrey.
- **Bi-parental origin of Sun:** Like Planetesimal hypothesis, it also considers bi-parental origin of the solar system. However, it does not consider the role of disruptive forces in the sun.
- **Limitation** is same as the planetesimal theory.

Protoplanet Hypothesis

- **Formation of proto planets:** According to this theory, rapidly rotating material(nebula) developed large vortexes (rotating mass of gases) at various places on the disc of the nebular material. Each of these vortexes accreted surrounding material by gravitational attraction which led to the formation of proto planets.
- **Satellites of planets:** Smaller vortexes developed inside the larger vortexes and gave rise to spinning discs that ultimately became satellites of planets.

Conclusion: All the theories have their own limitations and new discoveries often add to the demerits of theories. Thus, origin of solar system and earth continues to be an enigma.

Age of the earth

The age of the earth was attempted through two distinct processes:

1. Indirect methods
2. Radioactive methods

Indirect methods

- Sedimentation clock:** It takes into account average annual rate of sedimentation and thickness of all strata deposited during the geological history to determine age of the earth.
- Salinity clock:** It takes into account accumulation of sodium in ocean water to determine the age of earth. This method estimated that earth was formed 100 million years ago.
- Evolutionary change of animals:** Evidence of process of evolution is found in form of fossils. It estimates the age of earth to be 1000 million years ago.
- Rate of cooling of earth:** Assuming that the earth began as molten mass with temperature to be around 3900 deg. Celsius, Lord Kelvin estimated the age of earth to be 100 million years.
- Varved sediments:** Varve implies glacial-like deposit containing rhythmically laminated sediments of clay and silt. By counting the no of pairs of bands in given section, the time represented by the section can be ascertained in years.

Radioactive methods

- **Radioactive decay:** The basic principle underlying all the radioactive methods is that a radioactive parent nuclei decays into stable daughter element at a constant rate. Radioactive decay is usually expressed in half life period which the time required for the half of the original radioactive element to disintegrate.
- **Determination of age:** Some of the common methods used for the determination of age of earth are uranium-lead method, thorium-lead method, potassium-argon method, Rubidium strontium method and radio-carbon method.

Conclusion: The best method of estimating the age of the earth is by Uranium-lead, rubidium-strontium and potassium-argon methods. On the basis of radioactive methods, age of earth is estimated to be 4.5 billion years.

Movements of earth

Earth possesses various motions, which are as follows:

- **The Earth Rotates About Its Axis:** The Earth rotates on its axis relative to the Sun in one "mean solar day"
- **Earth-Moon System Orbits a "Gravitational Centre":** Both the Moon and the Earth orbit a common centre of gravity. Earth pivots around this point once every Lunar Month
- **The Earth Revolves Around the Sun Once a Year:** The Earth's orbit around the Sun is an ellipse and travels at different speeds during the year - slowest at Aphelion (furthest point from the Sun) and fastest at Perihelion (closest point to the Sun)
 - **Earth's orbit (the path)** is approximately 940,000,000 km (580,000,000 mi) in 365.2421896698 days. So, the "year" is not exactly 365½ days (sometimes called the Julian Year).
- **The Sun and Earth Revolve Around the Solar System "Gravitational Centre":** The Earth does cause the Sun to wobble but it is a very tiny motion. On the other hand, Jupiter (the heaviest planet in the solar system) causes a much more appreciable wobble in the Sun. Sun wobbles around a point just outside its surface every 11.859 years (the length of Jupiter's orbit).
 - Although slow, this wobble is detectable - and it also means the Earth is orbiting a slowly wobbling Sun
- **The Earth's Orbit Precesses every 25,770 years:** The Earth's North-South rotation axis "wobbles" like the slow rotational tilting of a spinning top over a period of 25,770 years. This is known as **Precession** and affects the direction in the sky to which the North Pole points and, in fact, the orientation of the entire orbital path of the Earth.
 - Precession is caused by the **gravitational attraction of the Sun** (and the Moon) tugging on the Earth's equatorial bulge.
- **The Galaxy is moving through the Universe:** The Milky Way Galaxy and the Andromeda Galaxy are approaching each other at about 400 km/s

Polar Variation

- **Magnetic north** is one of three "north poles" on our globe. First, there's true north, which is the northern end of the axis on which our planet turns. The dynamo of Earth's core creates a magnetic field that is slightly tilted from the planet's rotational axis. The northern end of this planet-size bar magnet is what's known as geomagnetic north. Then there's magnetic north, what your compass locates, which is defined as the point at which magnetic field lines point vertically down.
- **The Earth wobbles** causing the location of the North and South Poles to vary by 3 to 15 m. This Chandler Wobble causes the latitude of any position on the Earth to move a few metres in this 14-month cycle and affects GPS readings.

Earth's magnetosphere

- Earth's internal magnetism creates a region around the planet known as the **magnetosphere**.
- Our magnetosphere is part of a dynamic, interconnected system that responds to solar, planetary, and interstellar conditions – and it all starts deep inside Earth.
- **Shape of the magnetosphere-**
 - Our magnetosphere is a vast, comet-shaped bubble, and it has played a crucial role in our planet's habitability.
 - On the Sun-facing side of Earth – where the magnetic field is compressed by the constant bombardment of the solar wind – the magnetosphere extends some 6 to 10 times the radius of Earth.

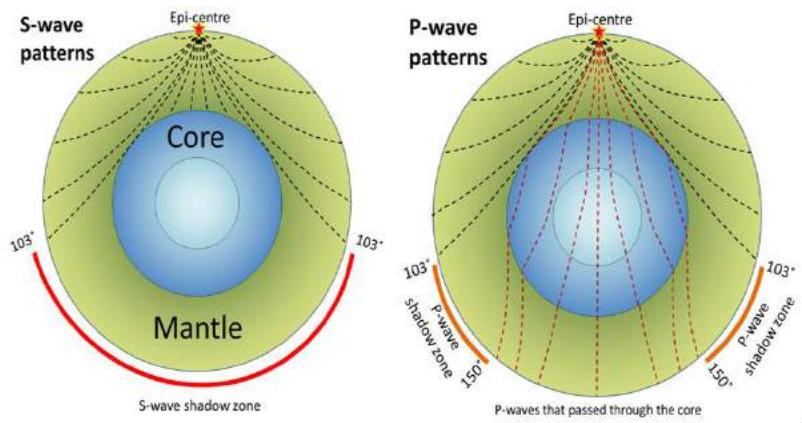
- The side of the magnetosphere facing away from the Sun – the nightside – stretches out into an immense **magnetotail**, which fluctuates in length and can measure hundreds of Earth radii, extending far past the Moon's orbit at 60 Earth radii.
- Strongest magnetosphere-** While several planets in our solar system have magnetospheres, Earth has the strongest one of all the rocky planets

How is magnetosphere formed?

- As electrically charged, molten iron churns far below Earth's surface, within the planet's outer core, it generates a magnetic field large enough to extend far out into space.

Magnetosphere's role in making earth habitable.

- Life on Earth initially developed, and continues to be sustained, under the protection of this magnetic environment.
- The magnetosphere shields our home planet from harmful solar and cosmic particle radiation**, as well as erosion of the atmosphere by the solar wind – the constant flow of charged particles streaming off the Sun.



Internal structure of the earth

Direct observation of the earth is not possible due to the fact that **interior becomes hotter with depth**. Hence all the important sources of data about the internal structure of the earth are **indirect and logically derived from other sources**. Today, much of the information about the interior of the earth is obtained from the study of propagation of earthquake waves.

Three types of earth-quake waves are:

- Longitudinal, primary or P-waves:** They are **similar to sound waves**. They can travel in solid, liquid and gases. They have **short wavelength and high frequency**
- Transverse, Secondary waves, S waves or Sheer waves:** In such waves particles move to and fro at right angles to the path of the wave. They travel only in **solid medium**. They also have **short wavelength and high frequency**
- Surface waves, L waves, Rayleigh or R waves:** They are **transverse waves** and are confined to the outer skin of the crust. These are responsible for **most destructive forces of earth quake**. They have **low frequency, long wave length and low velocity**.

Recent developments: Apart from these three waves, geologists have encountered a mysterious seismic wave originating from some distance off the coast of Mayotte(an island between Africa and Madagascar) in November, 2018. The characteristics of the wave was **different from all the three waves mentioned above**. These were low frequency monochromatic waves that were observed for more than 20 minutes. Geologists are yet to ascertain the origin and impact of the waves.

Shadow Zone

- Specific areas on earth where waves are not reported are known as shadow zone. **Both P and S waves are observed from the epi-centre to 103 degrees**. Beyond 150 degrees, only P waves are observed and no S waves are observed.
- Thus, shadow zone of P waves extends from 103 degrees to 150 degrees from the epi-centre. While the shadow zone of S-waves exists beyond 103 degrees.

OnlyIAS Nothing Else

The P and S-wave velocities change with depth and each change can be related to the change in materials. Each region of changing velocity demarcates a **zone of discontinuity**. The following information is inferred about the interior of the earth.

- The shells of increasing densities are found towards the centre of the earth.
- Each shell is formed of different materials.

On the basis of **seismic investigations**, earth's interior has been broadly divided into three major parts:

1. The Crust
2. The mantle
3. The Core

1. The Crust

- It is the **uppermost shell of the earth**. Its thickness over oceans is **5 to 10 kms** while on continents is 35 kms, in orogenic belts thickness is 55 to 70 kms. **Mohorovicic discontinuity** marks its lower boundary
- In the continental regions, underneath a zone of superficial sediments, the crust can be divided into sial and sima separated by Conrad discontinuity
 - **Sial**: It is the **upper continental crust**. It is rich in silica and aluminium. Its thickness is around 11 kms
 - **Sima**: It is known as **lower continental crust**. It is rich in silica and magnesium. Its thickness is around 22 kms.

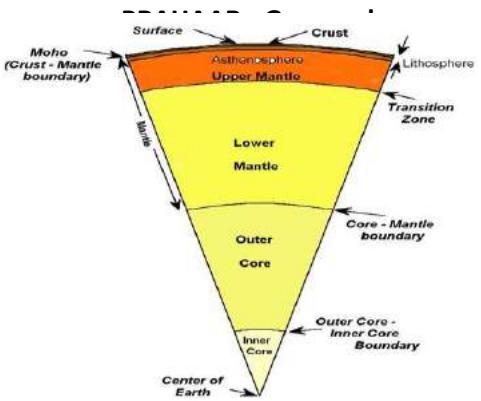
A **change from oceanic to continental crust takes place at the peripheries of the major continents where there are marginal seas and island arcs.**

2. The Mantle

- **Source of internal energy**: It is the second major part of the earth which is the **source region of most of earth's internal energy** and forces responsible for sea floor spreading, continental drift, orogeny and major earth-quakes. It extends from Mohorovicic discontinuity upto a depth of 2900 kms, i.e., it has **thickness of 2965 kms**.
- **The discontinuity** between mantle and core is known as **Gutenberg-Weichert discontinuity**.
- **Increase in their velocities**: Since P and S waves record increase in their velocities in mantle, it is concluded that material of **mantle is denser than crust**. The upper mantle **extends up to a depth of 1000 kms** and the lower mantle extends from 1000kms till Gutenberg-Weichert discontinuity.
- The **upper layer of the upper mantle**, known as **Gutenberg layer** is characterized by decrease in seismic velocity. The crust and the upper part of the Gutenberg layer together constitutes lithosphere.
- **Plastic state**: Below the lithosphere lies the asthenosphere which is in plastic state.

3. Core

- It is the **innermost part of the earth** which is separated from the mantle by Gutenberg-Weichert discontinuity.
- **Liquid state**: It extends upto the centre of the Earth. Since the S-waves do not pass through the outer core, it suggests that **outer core is liquid**.
- **The pressure** in the core is assumed to be **over three million atmospheres**, while the **temperature is around 6000 deg. Celsius**.



- The core consists of outer core and inner core. The **outer core is in liquid state while the inner core is in solid state due to increase in pressure.**
- It is believed that core is **made up of nickel and iron.**

Distribution of Oceans and Continents

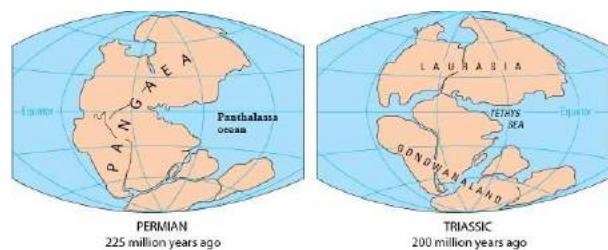
The distribution of oceans and continents as it is today has not been the same **throughout the geological history.** Various theories have been put forward to explain the relative motion of the oceans and the continents.

Continental Drift Theory

- Alfred Wegner was the first person who put forward a comprehensive theory of **Continental Drift** in 1912.
- He considered that all the continents were once joined together in the form of Pangaea, surrounded by sea on all sides known as Panthalassa. Pangaea first broke into Laurasia and Gondwana, forming northern and southern components respectively. In the subsequent phases, Laurasia and Gondwanaland continued to break to occupy today's position.

Evidence for Continental Drift

- Jig saw fit of the continents-** shorelines of the continents suggests that they have been separated from each other. For eg., the shorelines of Africa and America facing each other.
- Rocks lying across the continents having same age-** belt of ancient rocks which are 2000 mill. years old from the coastlines of Brazil and Western Africa are same.
- Glacial deposits-** Gondwana system of sediments from India are same across six different land masses. The base is composed of tillite (a form of glacial deposit), which indicates prolonged glaciation. The tillite provides clear evidence of **paleoclimates**.
- Placer deposits-** rich placer deposits of gold are found in the Ghana coast but there is **absence of source rock** in the region. Gold bearing veins are found in Brazil which assumed to be the source of placer deposits.
- Fossil distribution-** the fossils of Mesosaurus, a small reptile found in shallow brackish waters are found in South Africa and Brazil, which indicates the two localities must have been close.



Force responsible for causing the drift

Wegner suggested two forces responsible for drifting the continents.

- Polar fleeing force-** it is associated with **rotation of the earth.**
- Tidal force-** it is due to the **attraction between the sun and the moon.**

According to Wegner, when these **forces are applied over a long duration, they result un drifting of continents.** Although the theory of Wegner has been accepted, the forces responsible for causing the drift has been rejected.

Convectional Current Theory

- It was given by Arthur Holmes in 1930s.
- He suggested convection currents operating in the mantle portion to be responsible for the movement of continents. The **convection currents in turn are produced from thermal differences caused due to presence of radioactive elements.**

Sea Floor Spreading

- Relief of ocean floors were mapped:** The continental drift theory was based on the analysis done from the examination of continents. After the second world war, seas and oceans were studied on large scale and relief of ocean floors were mapped.
- Oceanic crusts are much younger:** It was revealed that there are mid oceanic ridges in the oceans from where volcanic eruptions are common. Rocks found on either side of mid oceanic ridges are found to be of same age and same chemical composition. Also, the oceanic crusts are much younger than continental crusts.
- New oceanic crusts are created:** All these facts made Harry Hess to propose the concept of sea floor spreading in 1961. He said that ocean floor spreads when the volcanic eruption at the crest of the mid oceanic ridge pushes the oceanic crust. New oceanic crusts are created near the mid oceanic ridge and the older ones are consumed at the boundary of oceans and continents in the deep trenches.

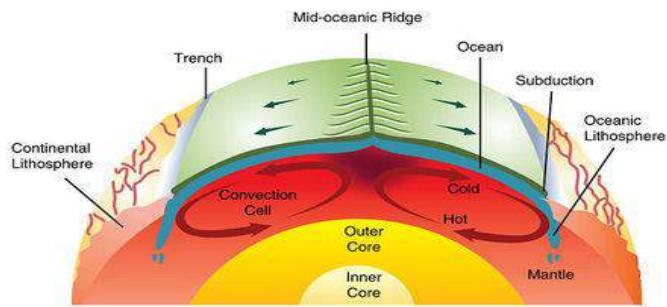


Figure: illustrating sea floor spreading.

Plate Tectonic Theory

- The concept of sea floor spreading was given by McKenzie, Parker and Morgan in 1967.
- The lithosphere is divided into a dozen major and several minor plates. A single plate can be made of all oceanic lithosphere or all continental lithosphere, but nearly all plates are made of a combination of both.
- Movement of the plates over Earth's surface is termed plate tectonics. Plates move at a rate of a few centimeters a year, about the same rate fingernails grow.

Mechanism of Plates Movement

- Hot mantle from the two adjacent cells rises at the ridge axis, creating new ocean crust. The top limb of the convection cell moves horizontally away from the ridge crest, as does the new seafloor.
- The outer limbs of the convection cells plunge down into the deeper mantle, dragging oceanic crust as well. This takes place at the deep-sea trenches. The material sinks to the core and moves horizontally. The material heats up and reaches the zone where it rises again.

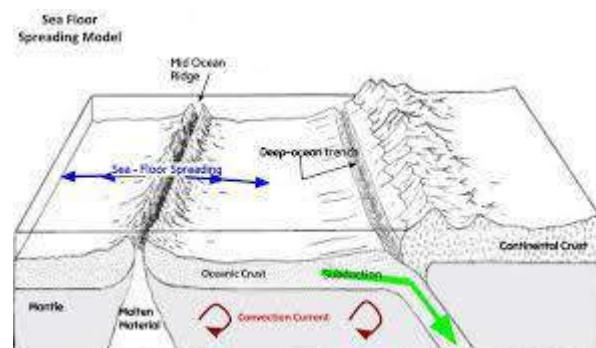


Figure: illustrating mechanism of plate movement.

Plate Boundaries

- Plate boundaries are the edges where two plates meet.
- Most geologic activities, including volcanoes, earthquakes, and mountain building, take place at plate boundaries. The type of plate boundary and the type of crust found on each side of the boundary determines what sort of geologic activity will be found there.

Type of plate boundaries

1. Divergent Plate Boundaries

- Plates move apart at mid-ocean ridges where new seafloor forms.
- Between the two plates is a **rift valley**. Lava flows at the surface cool rapidly to become basalt, but deeper in the crust, magma cools more slowly to form gabbro. So, the **entire ridge system is made up of igneous rock** that is either extrusive or intrusive. **Earthquakes are common at mid-ocean ridges** since the movement of magma and oceanic crust results in crustal shaking.

Figure: Mid-oceanic ridge passing through Iceland (land) separates the North American and the Eurasian ridge.

- When divergent plate boundaries occur within a continent, it results into **intercontinental rifting**.
- Magma rises beneath the continent, causing it to become thinner, break, and ultimately split apart. **New ocean crust erupts in the void, creating an ocean between continents.**

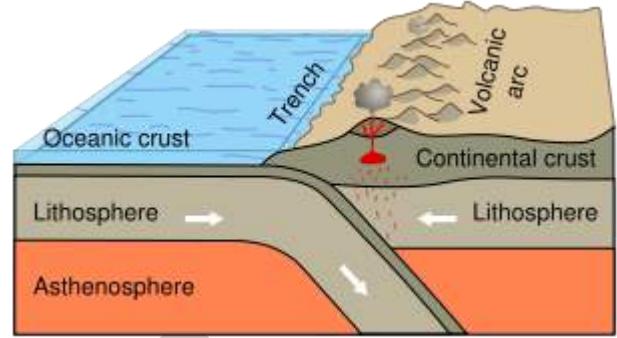


Figure: The Arabian, Indian and African plates are rifting apart forming the Great Rift valley in Africa.

2. Convergent Plate Boundaries

- When two plates converge, the result depends on the type of lithosphere the plates are made of.
- Hitting of two enormous slabs of lithosphere together results in magma generation and earthquakes.

Ocean-Continent

- When **oceanic crust converges with continental crust, the denser oceanic plate plunges beneath the continental plate.**
- This process, called **subduction**, occurs at the **oceanic trenches**. The entire region is known as a **subduction zone**. Subduction zones have a lot of intense earthquakes and volcanic eruptions.
- The **subducting plate causes melting in the mantle**. The magma rises and erupts, creating volcanoes. These coastal volcanic mountains are found in a line above the subducting plate. The volcanoes are known as a **continental arc**.
- Example: The volcanoes of North-Eastern California—Lassen Peak, Mount Shasta, and Medicine Lake volcano—along with the rest of the Cascade Mountains of the Pacific Northwest are the result of subduction of the Juan de Fuca plate beneath the North American plate

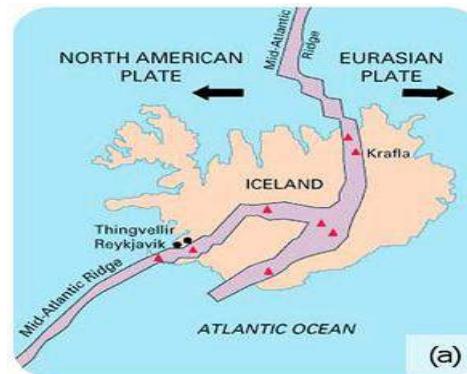


Figure: Subduction of an oceanic plate beneath a continental plate causes earthquakes and forms a line of volcanoes known as a continental arc.

Ocean-Ocean

- When two oceanic plates converge, the older, denser plate will subduct into the mantle. An ocean trench marks the location where the plate is pushed down into the mantle. The line of volcanoes that grows on the upper oceanic plate is an island arc.
- Example: Japan is an arc-shaped island arc composed of volcanoes.

Figure: Subduction of an ocean plate beneath an ocean plate results in a volcanic island arc, an ocean trench and many earthquakes.

Continent-Continent

- Continental plates are too buoyant to subduct. Since it has nowhere to go but up, this creates some of the world's largest mountains ranges. Magma cannot penetrate this thick crust so there are no volcanoes, although the magma stays in the crust.
- Metamorphic rocks are common because of the stress the continental crust experiences. With enormous slabs of crust smashing together, continent-continent collisions bring on numerous and large earthquakes.
- Example: The world's highest mountains, the Himalayas, are the result of the collision of the Indian Plate with the Eurasian Plate

3. Transform plate boundaries

- Transform plate boundaries are seen as transform faults, where two plates move past each other in opposite directions. Transform faults on continents bring massive earthquakes
- Example: A transform plate boundary between the Pacific and North American plates creates the San Andreas Fault, the world's most notorious transform fault.

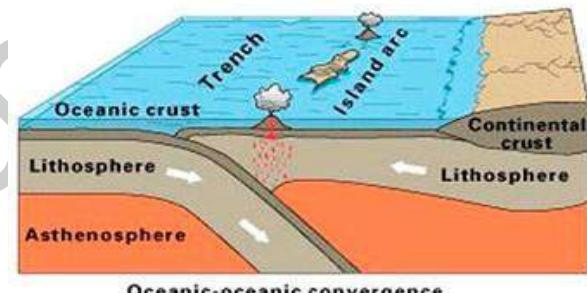
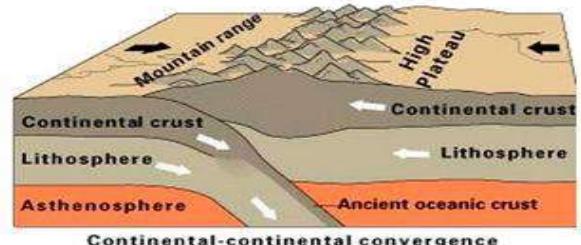


Figure: At the San Andreas Fault in California, the Pacific Plate is sliding northwest relative to the North American plate, which is moving southeast.

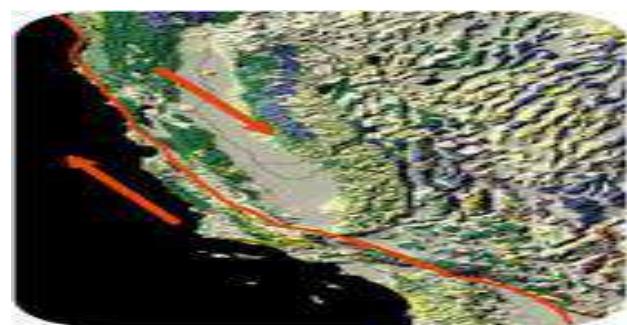


Recent Research: South Island Subduction Initiation Experiment

About the study:

- A study was done by the scientists aboard the research vessel Marcus Langseth who set out to the region in 2018 as part of the South Island Subduction Initiation Experiment. The scientists studied the Puysegur margin in the "Roaring Forties," the latitudes between 40 degrees south and 50 degrees south where the winds and currents are brutal.
- New research demonstrates how the Puysegur Trench, a deep split in the south Tasman Sea floor, created a youthful subduction zone. The Puysegur Trench was formed by the subduction of the Indo-Australian Plate under the Pacific Plate to the south of New Zealand.

Findings of the study



- About 45 million years ago, a bit of the hidden continent of Zealandia got stretched and shifted, which led the denser oceanic crust to hit into it.
- **Formation of new plate boundary:** A new plate boundary between the continental Australian and oceanic Pacific plates began to form because of a force called extension - Tectonic forces pulled the two plates apart like putty.
- **Creation of Solander basin:** As continental crust is thicker and more buoyant, the extensional forces working at the plate boundary couldn't crack Zealandia. Instead, the continental crust merely stretched as it spread, creating a thinned-out zone now known as the Solander basin. At the plate boundary, oceanic crust bumped up against oceanic crust, and continental crust against continental crust.
- **Sliding of Australian plate under the Pacific plate:** The difference in buoyancy of plates allowed the denser Australian plate to slide under the lighter Pacific one, especially because the boundary between these plates was already weakened by the earlier strike-slip faulting.
- **Zealandia:** The secret continent of Zealandia is found on the boundary between the Australian and Pacific plates. Zealandia is a submerged section of continental crust the size of Australia around New Zealand.

Earthquakes

- An earthquake is the shaking of the surface of the Earth, resulting from the sudden release of energy in the Earth's lithosphere that creates seismic waves. At the Earth's surface, earthquakes manifest themselves by shaking and sometimes displacement of the ground.
- When the **epicenter** of a large earthquake is located offshore, the seabed may be displaced sufficiently to cause a tsunami. The location below the earth's surface where the earthquake starts is called the **hypocenter**, and the location directly above it on the surface of the earth is called the **epicenter**.
- Sometimes an earthquake has **foreshocks**. These are smaller earthquakes that happen in the same place as the larger earthquake that follows. The largest, main earthquake is called the **mainshock**. Mainshocks always have aftershocks that follow.
- **Example-** on 14 August, 2021 an earthquake of 7.2 magnitude hit Haiti in which more than 2000 people died.

What causes earthquakes?

- The plate boundaries are made up of many faults, and most of the earthquakes around the world occur on these faults.
- Since the edges of the plates are rough, they get stuck while the rest of the plate keeps moving.
- Finally, when the plate has moved far enough, the edges unstuck on one of the faults and there is an earthquake.

Recording earthquakes

- Earthquakes are recorded by instruments called **seismographs**. The recording they make is called a **seismogram**.
- Earthquake events are scaled according to **magnitude or intensity of the shock**. The magnitude scale is known as **Richter scale**. It relates to the energy released during the quake. It is expressed in absolute numbers from 0 to 10.
- The intensity scale is known as Mercalli scale. It takes into account visible damage caused by the quake. The range is expressed from 1 to 12.

Types of earthquakes

1. **Tectonic earthquake**- generated due to sliding of rocks.
2. **Volcanic earthquake**- it is a special type of earthquake observed in areas of active volcanoes.

3. **Collapse earthquake**- it is due to intense mining activity which results into collapse of roofs causing minor earthquakes.
4. **Explosion earthquake**- due to explosion of chemical or nuclear devices.
5. **Induced earthquake**- occurs in areas of large reservoirs.

Effects of earthquakes

- Shaking and ground rupture, landslides and avalanches, fires, soil liquefaction, tsunami, floods

Global distribution of earthquakes

- The world's greatest earthquake belt, the **circum-Pacific seismic belt**, is found along the rim of the Pacific Ocean, where about 81 percent of our planet's largest earthquakes occur. It has earned the nickname "Ring of Fire".
- The **Alpide earthquake belt** extends from Java to Sumatra through the Himalayas, the Mediterranean, and out into the Atlantic. This belt accounts for about 17 percent of the world's largest earthquakes.
- The third prominent belt follows the submerged **mid-Atlantic Ridge**. The ridge marks where two tectonic plates are spreading apart (a divergent plate boundary).

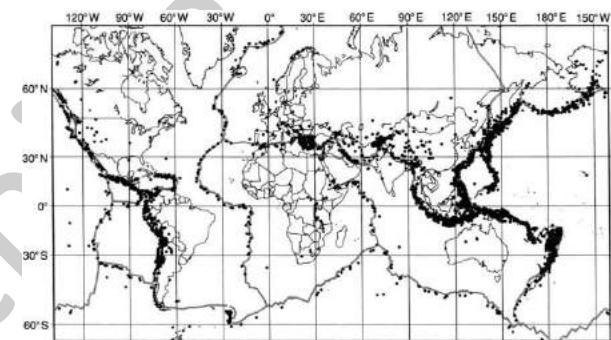


Figure: Global earthquake distribution

Seismic mapping of India

- Considering the recorded history of earthquakes in the country, **a total of ~59% of the land mass of India** (covering all states of India) **is prone to earthquakes of different intensities**.
- As per the seismic zoning map of the country, the **total area is classified into four seismic zones**.
- Zone V is seismically the most active region, while zone II is the least. Approximately, ~ 11% area of the country falls in zone V, ~18% in zone IV, ~ 30% in zone III and remaining in zone II.

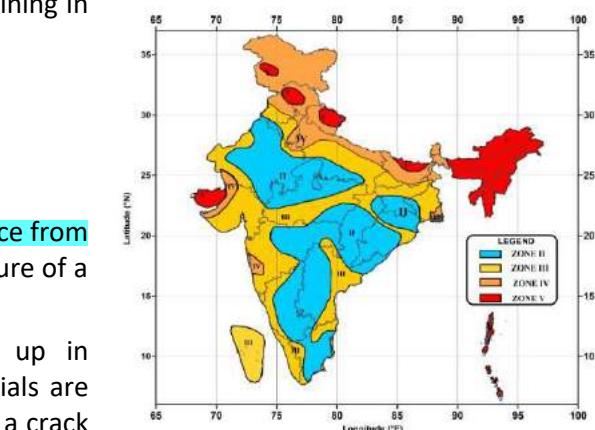


Figure: Seismic map of India.

Volcanoes

- The term "volcano" refers to an opening in the Earth's surface from which lava, gases, ash and rock fragments erupt. The structure of a volcano grows with every eruption.
- Below the surface, lava is called magma and builds up in underground reservoirs. Magma and other volcanic materials are channelled to the surface where they are expelled through a crack or hole. Recently, **Sangay volcano** which is one of the highest active volcanoes in the world and **one of Ecuador's most active ones erupted**.

Parts of volcano

1. **Magma chamber**- is a hollow within the volcano where magma and gases accumulate.
2. **Conduit**- volcanic materials move from the magma chamber toward the surface via a pipe-like passageway called a conduit.

3. **Vent**- is an opening on the surface of a volcano that emits lava, gases, ash or other volcanic materials. Some volcanoes have multiple vents, but there is only one main vent, or central vent.
4. **Crater**- central vent may be surrounded by a bowl-shaped depression called a crater. Craters form when explosive eruptions occur.
5. **Slopes**- sides or flanks of a volcano that radiate from the main or central vent.

Types of volcanoes

Composite Volcanoes

- Composite volcanoes are made of **felsic to intermediate rock**. The viscosity of the lava means that eruptions at these volcanoes are **often explosive**. The **viscous lava cannot travel far down the sides** of the volcano before it solidifies, which creates the steep slopes of a composite volcano. Viscosity also causes some eruptions to explode as ash and small rocks. The **volcano is constructed layer by layer**, as ash and lava solidify, one upon the other.

Shield Volcanoes

- Shield volcanoes get their name from their shape. Although shield volcanoes are not steep, they may be very large. Shield volcanoes are common at spreading centers or intraplate hot spots. The lava that creates shield volcanoes is fluid and flows easily. The spreading lava creates the shield shape. Shield volcanoes are built by many layers over time and the layers are usually of very similar composition. The low viscosity also means that shield eruptions are non-explosive.

Cinder Cones

- Cinder cones are the **most common type of volcano**. A cinder cone has a **cone shape**, but is much smaller than a composite volcano. Cinder cones rarely reach 300 meters in height but they have steep sides. Cinder cones grow rapidly, usually from a single eruption. Cinder cones are composed of small fragments of rock, such as pumice, piled on top of one another. The rock shoots up in the air and doesn't fall far from the vent. The exact composition of a cinder cone depends on the composition of the lava ejected from the volcano. Cinder cones usually have a crater at the summit.

Super volcanoes

- Super volcano eruptions are extremely rare in Earth history. A super volcano must erupt more than 1,000 cubic km of material. Example: 25 km³ of material erupted from Mount Pinatubo, a large eruption in the Philippines in 1991. Super volcanoes are a fairly new idea in volcanology. The exact cause of super volcano eruptions is still debated. Scientists think that a very large magma chamber erupts entirely in one catastrophic explosion. This creates a huge hole or caldera into which the surface collapses.

Volcanic landforms

Extrusive landforms

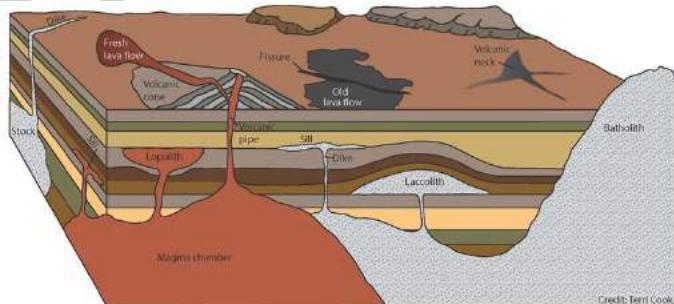
- **Craters**- form as the result of explosive eruptive activity at a volcanic vent where rock, magma, and other material is ejected leaving a conical void.
- **Calderas**- are large-scale landforms that develop after enormous eruptions of magma empty underground magma chamber(s). The volcanic landscape above the void(s) collapses downward and forms the caldera.
- **Diatremes and Maars**- volcanic landforms are produced by explosive eruptions that cut into pre-eruption rock and form tephra ring deposits surrounding the crater.
- **Lava Flows**- Lava can flow out of fissures and vents forming a variety of features depending on the composition and viscosity. The two types of basaltic lava flows are: 'A'a and Pahoehoe.

- **Lava Tubes-** Lava tubes are formed as an active lava flow continues to flow beneath its own cooling exterior. The molten lava is insulated in the underground conduit of and continues to drain. The remaining empty passage is called a lava tube or lava cave.
- **Fumaroles-** Fumaroles emit steam and gas in volcanic areas as a result of water that comes into contact with high temperature rock underground.
- **Geothermal Features-** Heat from volcanic activity can create features such as hot springs, geysers, and mud pots.

Intrusive landforms

The lava that cools inside the crustal portions takes diverse forms. These forms are called intrusive forms.

- **Batholiths:** These are the **cooled portion of magma chambers**. It is a **large body of magmatic material** that cools in the deeper depth of the crust molds in the **form of large domes**. They appear on the surface only after the denudation processes eliminate the overlying materials. These are **granitic bodies**.
- **Laccoliths:** These are large dome-shaped intrusive bodies with a level base and linked by a pipe-like channel from below. It bears a similarity to the surface volcanic domes of the composite volcano, only these are located at deeper depths. It can be considered as the localized source of lava. The **Karnataka plateau** is patterned with dome hills of granite rocks.
- **Lopolith:** When the lava moves upwards, a part of the same tends to move in a horizontal direction wherever it finds a weak plane. It can get rested in various forms. If it develops into a **saucer shape, concave to the sky body**, it is called lopolith.
- **Phacolith:** It is a **wavy mass of intrusive rocks** found at the **base of synclines or the top of the anticline** in the folded igneous country. These wavy materials have a definite outlet to source beneath in the form of magma cavities.
- **Sills:** The **near horizontal bodies** of the intrusive igneous rocks are called sill. The thick horizontal deposits are called sills whereas the thinner ones are called sheets.
- **Dykes:** Dykes are the most commonly found intrusive forms in the western Maharashtra area. When the lava makes its channel through cracks and the fissures, it **solidifies almost perpendicular to the ground**. This gets cooled in the same position to grow a wall-like structure. Such structures are known as dykes. These are regarded as the feeders for the eruptions that led to the development of the Deccan traps.



Credit: Terri Cook

Significance of volcanic landforms: Some of the extrusive landforms are centres of tourist attraction. For eg., the old faithful geyser in Yellow stone national park in USA. The intrusive landform on the other hand are the source of commercial minerals.

Volcanoes and environment

Context: - Recently, Sulphur dioxide (SO₂) emissions from a volcanic eruption in the Caribbean (La Soufriere Volcano) have reached India, raising concerns about increased pollution and acid rain in the country's north.

How does volcanic eruption impact global temperature?

- **Cooling effect:** Volcanic emissions reaching the stratosphere can have a cooling effect on global temperatures.
- The most significant climate impacts from volcanic eruptions into the stratosphere results from the conversion of sulphur dioxide to sulphuric acid, which condenses rapidly in the stratosphere to form fine sulphate aerosols.

- The aerosols increase the reflection of radiation from the Sun back into space, cooling the Earth's lower atmosphere or troposphere.
- Past experience:** bigger eruptions during the past century have caused a decrease in temperature of 0.27 degree Celsius or more on the Earth's surface for up to three years.

Impact of volcanic eruption on pollution

- SO₂ emissions** that lead to high concentrations of SO₂ in the air generally also lead to the formation of other sulfur oxides (SOx).
- Particulate matter:** SOx can react with other compounds in the atmosphere to form small particles. These particles contribute to Particulate Matter (PM) pollution.
- Impact on human health:** small particles may penetrate deeply into the lungs and in sufficient quantities can contribute to health problems.
- Acid Rain:** Acid rain results when sulphur dioxide (SO₂) and nitrogen oxides (NO_x) are emitted into the atmosphere and transported by wind and air currents.
- The SO₂ and NO_x react with water, oxygen and other chemicals to form sulfuric and nitric acids. These then mix with water and other materials before falling to the ground.

Rock and Rock cycles

Rock is an aggregate of one or more mineral but they do not have definite composition of mineral constituents. Feldspar and quartz are the most common mineral found in rocks.

Types of rocks

1. Igneous rock

- Igneous rocks are formed from the solidification of molten rock material. Some form below Earth's surface while others form on or above Earth's surface. **Intrusive igneous rocks crystallize below Earth's surface**, and the slow cooling that occurs there allows large crystals to form. **Examples of intrusive igneous rocks** are: diorite, gabbro, granite, pegmatite etc. **Extrusive igneous rocks** erupt onto the surface, where they cool quickly to form small crystals. Some cool so quickly that they form an amorphous glass. These rocks include: andesite, basalt, dacite etc.

2. Sedimentary Rock

- Sedimentary rocks are formed by the accumulation of sediments. There are three basic types of sedimentary rocks. **Clastic sedimentary** rocks form from the accumulation and lithification of mechanical weathering debris. Examples include: sandstone, siltstone, shale etc.
- Chemical sedimentary** rocks form when dissolved materials precipitate from solution. Examples include: some dolomites, iron ore, limestones, and rock salt etc.
- Organic sedimentary** rocks form from the accumulation of plant or animal debris. Examples include: chalk, coal etc.

3. Metamorphic rock

- Metamorphic rocks have been modified by heat, pressure, and chemical processes, usually while buried deep below Earth's surface. Exposure to these extreme conditions has altered the mineralogy, texture, and chemical composition of the rocks. There are two basic types of metamorphic rocks.
- Foliated metamorphic rocks** have a layered or banded appearance that is produced by exposure to heat and directed pressure. Examples of foliated rocks include: gneiss, phyllite, schist, and slate

- **Non-foliated metamorphic rocks** do not have a layered or banded appearance. Examples of nonfoliated rocks include: hornfels, **marble**, novaculite, **quartzite**, and **skarn**.

Rock Cycle

- The rock cycle is a process in which rocks are continuously transformed between the three rock types igneous, sedimentary and metamorphic. Rocks of any type can be converted into any other type, or into another rock of the same type. Conversion to metamorphic rocks requires conditions of increased temperature and/or increased pressure. Conversion to sedimentary rocks occurs via the intermediate stage of sediments. Conversion to igneous rocks occurs via the intermediate stage of magma.

Landforms and their evolution

Landforms found on the earth's surface are the result of interplay between internal and external forces. The soft rocks are easily worn down by these forces. While the relatively harder rocks are not so easily worn down.

Therefore, rocks have a great influence on the landforms developed in an area. The internal forces are perpetually elevating the earth's surface and the external forces are constantly wearing down such elevations to make, the surface level. This is how various landforms are formed by constant action of agents of gradation.

Wind/Aeolian Landforms

These landforms are more prevalent in hot desert regions. These landforms have conditions such as insufficient rainfall, very less vegetation cover, high rate of evaporation etc.

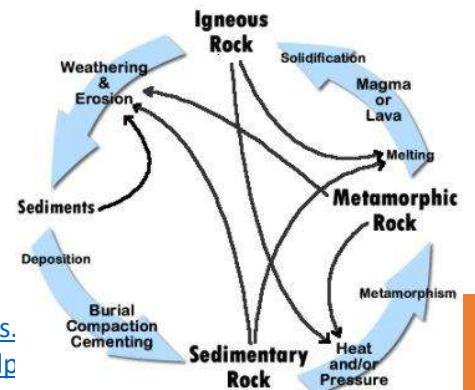
Erosion landforms

- **Ventifacts:** These are geomorphic features made of rocks that are abraded, pitted, etched, grooved, or polished by wind-driven sand or ice crystals. They are most typically found in arid environments with little vegetation to interfere with these erosive processes. If ancient ventifacts can be preserved without being moved or disturbed, they are excellent paleo-wind indicators (movement of the wind in the geological past) as the grooves and striations cut into the rock are parallel with the wind direction.
- **Yardangs :** These are streamlined ridges of compact sand lying in the direction of the prevailing wind, formed by wind erosion of surrounding material
- **Deflation Hollows:** These are also known as blowout dune, created when loose surface material is scooped out by the wind, leaving a hollow.
- **Mushroom rocks:** These are also known as **pedestal rocks**. Wind carrying the sand particles erodes the lower part of the rocks more as compared to upper part. It is because with more height sand carrying capacity of the wind decreases due to gravity. This results in peculiar shape of the rock resembling mushroom.
- **Zeugen:** These are **tabular structure** which have a layer of soft rocks lying beneath a surface layer of more resistant rocks. Difference in erosional effect of the wind on soft & resistant rock surfaces, carve them into weird looking ridge & furrow landscape. Mechanical weathering initiates their formation by opening up joints of the surface rocks. Wind abrasion further eats into underlying softer layer so that deep furrows are developed
- **Inselberg:** They are basically **isolated residual hills** rising abruptly from the ground level. These are characterized by very steep slopes & rather rounded tops. They are often composed of granite or gneiss. These are probably relics of an original plateau, which has been almost entirely eroded away.

Depositional landforms

Sand dune

- A dune is a **mound of sand formed by the wind**, usually along the beach or in a desert. Dunes form when wind blows sand into a



sheltered area behind an obstacle. Dunes grow as grains of sand accumulate. Every dune has a windward side and a slipface. A dunes windward side is the side where the wind is blowing and pushing material up. A dunes slip face is simply the side without wind. A slipface is usually smoother than a dunes windward side.

- Types of sand dunes:

- **Crescentic dunes** are shaped like crescents, or the shape of a wide letter C.
- **Linear dunes** form straight or nearly straight lines.
- **Star dunes** have pointed ridges and slipfaces on at least three sides.
- **Parabolic dunes** are similar to crescentic dunes. Their shapes are roughly the same, but the slipface of a parabolic dune is on its inward side.
- **Dome dunes** are the rarest type of dune. They are circular and do not have a slipface.

Loess

- It consists of **fine dust blown by the wind** beyond the desert. It is usually homogeneous and highly porous. Example: loess deposited along the Mississippi river valley.

Landforms of glaciation

Glacier is a mass of moving ice which moves due to gravity. Erosion by glacier is mainly by plucking and abrasion. In plucking, glacier freezes the beds of underlying rocks and tears out individual blocks. In abrasion, glacier scratches the valleys of individual floors.

Erosional landforms

Cirques

- Cirques are bowl-shaped, amphitheatre-like depressions that glaciers carve into mountains and valley side walls at high elevations.

Nunataks, Arêtes, and Horns

- Nunataks, arêtes, and horns are the result of glacial erosion in areas where multiple glaciers flow in multiple directions. When the ice is present, they form stark, rocky outcrops above it, adding to the beauty of these harsh landscapes. Once the ice retreats, these uniquely-shaped features provide clear evidence of past glacier flow

Crevasse

- A crevasse is a deep, wedge-shaped opening in a moving mass of ice called a glacier. Crevasses usually form in the top 50 meters (160 feet) of a glacier, where the ice is brittle.

Bergschrund

- A bergschrund is a special type of crevasse. Bergschrunds are cracks that appear between the moving ice of a glacier and the non-moving, or stagnant, ice of a mountain or cliff.

U shaped valley

- Glaciated valleys are formed when a glacier travels across and down a slope, carving the valley by the action of scouring. They have a characteristic U shape in cross-section, with steep, straight sides and a flat or rounded bottom

Hanging valley

- A valley carved out by a small tributary glacier that joins with a valley carved out by a much larger glacier.

Fjord

- It is created when glacially valleys intersect the ocean and are partially flooded.

Depositional landforms

Moraines

- Moraines are **formed by the deposition of glacial till** as the glacier melts. **Lateral and medial moraines** consist of glacially-transported rock and debris. They form on the sides of glaciers (lateral moraines) or at the boundary between two tributary glaciers (medial moraines). Either way, they often mark the edges of an ice body. **Terminal and recessional moraines** mark the farthest reaches of a glacier—its terminus—at a given point in time. They are usually built from rocks and debris that are transported to the glacier toe in the ice and melt out there.

Glacial Till and Glacial Flour

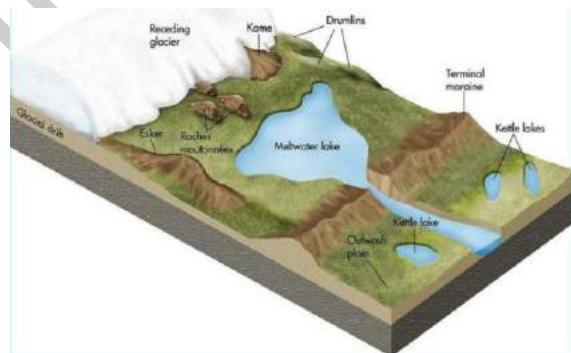
- Glacial till **contains sediments of every size**, from tiny particles smaller than a grain of sand to large boulders, all jumbled together. Glacial flour is that smallest size of sediment (much smaller than sand) and is responsible for the milky, colored water in the rivers, streams, and lakes that are fed by glaciers.

Glacial Erratics

- They are **large, isolated boulders deposited by retreating, melting glaciers**. Erratics, are generally the largest rocks left behind by the retreating glaciers. Generally smooth from glacial abrasion and appear “misplaced” in the landscape.

Kames, Eskers

- Kames and Eskers are melt water deposits. Kames tend to be stratified and associated with surface deposits. Eskers form along melt water channels that are emerging from tunnels beneath the glacier. They are depositional ridges of sands and gravel that mark the “course” of the melting glacier or course of the melt water tunnel.



Drumlins

- Drumlins are **long, linear hills of glacial till** deposited by ice sheets. Similar to medial and lateral moraines, smaller, irregular shaped. Drumlin fields are areas with numerous drumlins.

Roche moutonnée

- It is a rock formation **created by the passing of a glacier**. The passage of glacial ice over underlying bedrock often results in asymmetric erosional forms as a result of abrasion on the "stoss" (upstream) side of the rock and plucking on the "lee" (downstream) side.

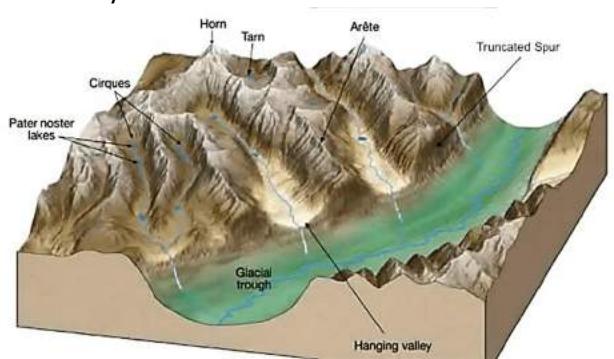


Figure: showing depositional landform

Significance of glaciated landforms: Glaciated landforms are indicators of paleoclimate (climate of the past). For example, the glaciated boulders found in Talcher in Orissa suggests that the region might have been under the influence of glaciers in the past.

Karst Landform / Landforms formed due underground water

These landforms are formed in the limestone regions with sufficient rainfall.

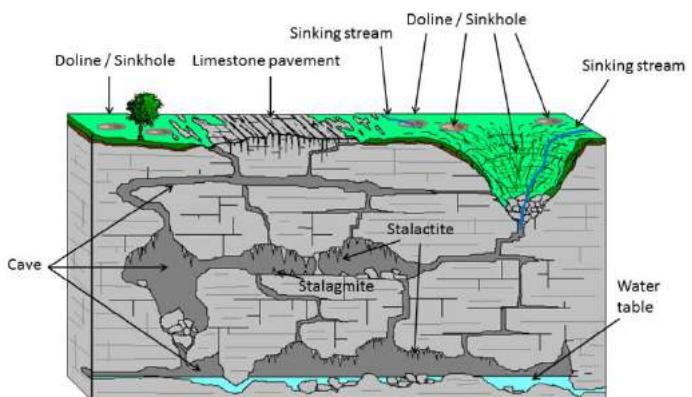
Erosional Landforms

- **Sinkholes:** A sinkhole is a depression or hole formed when the land surface sinks due to underground bedrock dissolution or cave collapse. In developed areas, catastrophic sinkhole collapse can cause significant damage and loss of life.
- **Doline:** It is formed by the combination of several sinkholes

- **Uvala:** These are larger depressions formed by the merger of several dolines and sinkholes.
- **Polje:** These are very large depressions, the part of which may form due to faulting.
- **Disappearing stream:** The surface runoff goes down under a swallow hole and flows as underground stream and re-emerges at some distance via a cave opening.

Depositional Landforms

- **Stalactites:** These are downward hanging pillars which are formed by the precipitation of minerals inside the cave. Most stalactites have pointed tips.
- **Stalagmites:** It is an upward growing mound of mineral deposit that have precipitated from the water dripping on the floor. They have mostly rounded or flattened tip.
- **Pillar:** When stalactites and stalagmites join, a pillar is formed.



Significance of Karst landscape: Karst and caves have high cultural and historical values. Many artifacts documenting early human development have been preserved in karst areas: most of our knowledge on our ancestors is based on cave findings. Karst and caves are extremely valuable natural resources, hosting a wide variety of often unique ecological niches. Besides the often extremely rich variety of plants and animals, including endemic species, found in karst areas, caves are also unique microbiological habitats.

According to UNESCO "Groundwater in karst aquifers represents the most significant as well as the safest source of drinking water". It is estimated that karst aquifers presently supply about 25 % of the world's drinking water.

Fluvial landform

Fluvial systems are dominated by rivers and streams. Stream erosion may be the most important geomorphic agent.

Erosional landform

Waterfall

- A waterfall is when a river falls over a vertical slope. It is found in the youth stage of a river where there are areas of hard and soft rocks

Canyon and Gorge

- A gorge is a deep valley with very steep to straight sides and a canyon is characterised by steep steplike side slopes and may be as deep as a gorge. A gorge is almost equal in width at its top as well as its bottom. In contrast, a canyon is wider at its top than at its bottom. In fact, a canyon is a variant of gorge.
- Gorges are also formed where:
 - a river flows along a line of weakness
 - a river maintains its course across a landscape which is slowly being uplifted.
 - a river cuts across a plateau composed of horizontal and alternate layers of hard and soft rocks

River Valleys

- An elongated lowland between ranges of mountains, hills, or other uplands, often having a river or stream running along the bottom. It is typically a low-lying area of land, surrounded by higher areas such as mountains or hills. It can also be seen as a path between two mountains, or a depression in a single mountain. Valleys start as small and narrow rills; the rills will gradually develop into long and wide gullies; the gullies will further

deepen, widen and lengthen to give rise to valleys. Depending upon dimensions and shape, many types of valleys like V-shaped valley, gorge, canyon, etc. can be recognised.

Potholes

- These are **holes scoured into bedrock** by swirling water/sediments. Abrasion by sediment which enters a depression; bedrock scoured by swirling sediment. Water able to erode due to power associated with velocity and cavitation; eddies

Stream Terraces

- These are **bench like ledges** or flat surfaces that occur on the sides of many river valley. From a distance they may appear as successions of several steps of big natural staircase rising up the river bed. Stream terraces are features, often floodplains, left behind from periods when a stream was flowing at a higher elevation and has down-cut to a lower elevation. Stream terraces often appear as plateaus on existing valley walls and indicate former elevations.

Structural benches

- Step like sequence of geomorphic surfaces. Differential erosion of alternately arranged hard and soft rocks forming step-like valleys known as structural benches

River meanders

- It is a **loop like channel** in the course of a river. Meanders are produced when water in the stream channel erodes the sediments of an outer bend of a streambank and deposits this and other sediment on subsequent inner bends downstream. This process reinforces the riffle-pool structure of a stream.

Peneplain

- These are **low featureless plain** formed at the end stage of cycle of erosion. These have extremely low relief. Example: the plains of Telangana.

Depositional landforms

The deposition of load carried by the streams is affected by a variety of factors like decrease in channel gradient, spreading of stream water over larger area, obstructions in channel flow, decrease in the volume and discharge of water, decrease in the velocity of streams and increase in load.

Alluvial fan and cones

- Alluvial fans are fan-shaped deposits of water-transported material (alluvium). Alluvial fans have gentler slopes than the cones

Natural levees

- An embankment of silt and sand built up by a stream along both its sides. Narrow belt of ridges of low height along the river banks. Formed due to deposition of sediments during flood periods when the water overtops the river banks and spreads over adjoining flood plains. Not all the streams build natural levees

Flood Plain

- An area of low, flat land along a stream or river, formed mainly of river sediments and is subject to flooding

Channels and bars

- An elongate accumulation of sand, lying parallel to the shore. An elevated region of sediment that has been deposited by the flow

Delta

- The **depositional feature of almost triangular shape** at the mouth of a river debouching either in a lake or a sea is called delta. It is the characteristic feature of old stage.
- Types of deltas:
- **Arcuate Delta:** It is fan-shaped Delta. Example, the River Nile Delta in Egypt and the Ganges Delta in India.

- **Bird's foot Delta:** Named because it forms like a bird foot's claw. Example, Mississippi river Delta, the USA.
- **Cuspate Deltas:** It is formed where sediments are deposited onto a straight shoreline with strong waves. Example, Tiber River of Italy.
- **Estuarine Delta:** It is formed at the mouth of submerged rivers depositing down the sides of the estuary. Example, the Seine River of France, the Deltas of Narmada and Tapi
- **Lacustrine Delta:** It is formed when a river flows into a lake. Example, Lough Leanne river Delta, Ireland.
- **Truncated Delta:** Sea waves and ocean currents modify and even destroy Deltas deposited by the river through their erosional work.
- **Abandoned Delta:** When the river shifts its mouth, the Delta already made is left abandoned. Such a Delta is called an abandoned Delta. Example, Yellow river Delta, China

Significance of fluvial landforms: Plains formed out of the deposition of fluvial system are one of the fertile regions of the world which has supported a no of civilizations. Also the rocks brought by the fluvial system represents the mineral composition of the source rocks.

Coastal landforms

- In general, the coastal environment can be defined as that area lying at the interface between land and Oceans (or other large body of water).
- It includes both the zone of shallow water within which waves are able to move sediment, and the area landward of this zone, including beaches, cliffs, and coastal dunes, which is affected to some degree by the direct or indirect effects of waves, tides, and currents.

Erosional landform

The process of erosion can create different landforms along the coastline.

Headlands and bays

- When a stretch of coastline is formed from different types of rock, headlands and bays can form. A bay is an inlet of the sea where the land curves inwards, usually with a beach. Bands of soft rock such as clay and sand are weaker therefore they can be eroded quickly. This process forms bays. When the softer rock is eroded inwards, the hard rock sticks out into the sea, forming a headland.

Cliffs and wave-cut platforms

- Cliffs are shaped through erosion and weathering. Soft rock erodes quickly and forms gentle sloping cliffs, whereas hard rock is more resistant and forms steep cliffs. A wave-cut platform is a wide gently-sloping surface found at the foot of a cliff.
- A wave-cut platform is formed when the following occurs:
 - The sea attacks the base of the cliff between the high and low water mark; A wave-cut notch is formed by erosional processes such as abrasion and hydraulic action - this is a dent in the cliff usually at the level of high tide.; as the notch increases in size, the cliff becomes unstable and collapses, leading to the retreat of the cliff face; the backwash carries away the eroded material, leaving a wave-cut platform; the process repeats; the cliff continues to retreat.

Caves, arches, stacks and stumps

- Caves, arches, stacks and stumps are erosional features that are commonly found on a headland. **Cracks** are widened in the headland through the erosional processes of hydraulic action and abrasion. As the waves continue to grind away at the crack, it begins to open up to form a **cave**. The cave becomes larger and eventually breaks through the headland to form an **arch**. The base of the arch continually becomes wider through further

erosion, until its roof becomes too heavy and collapses into the sea. This leaves a **stack** (an isolated column of rock). The stack is undercut at the base until it collapses to form a **stump**.

Depositional landforms

When water loses its energy, any sediment it is carrying is deposited. The build-up of deposited sediment can form different features along the coast.

Beaches

- Beaches are made up from eroded material that has been transported from elsewhere and then deposited by the sea. For this to occur, waves must have limited energy, so beaches often form in sheltered areas like bays. Constructive waves build up beaches as they have a strong swash and a weak backwash.
- **Sandy beaches** are usually found in bays where the water is shallow and the waves have less energy.
- **Pebble beaches** often form where cliffs are being eroded, and where there are higher energy waves.
- A cross-profile of a beach is called the **beach profile**. The beach profile has **lots of ridges called berms**.
- A sandy beach typically has a gentle sloping profile, whereas a **shingle beach** can be much steeper.

Spits

- A spit is an **extended stretch of sand** or shingle jutting out into the sea from the land. Spits occur when there is a change in the shape of the landscape or there is a river mouth. Spits are formed in the following ways. Sediment is carried by longshore drift. When there is a change in the shape of the coastline, deposition occurs.

A long thin ridge of material is deposited. This is the spit. A hooked end can form if there is a change in wind direction. Waves cannot get past a spit, therefore the water behind a spit is very sheltered. Spits are deposited here to form salt marshes or mud flats.



Bars

- Sometimes a spit can grow across a bay, and joins two headlands together. This landform is known as a bar. They can trap shallow lakes behind the bar, these are known as **lagoons**. Lagoons do not last forever and may be filled up with sediment.

Significance of coastal landforms: They are one of the most preferred tourist locations. The beaches are source of commercially important minerals. For eg., gold found on the beaches of Subarnarekha River; thorium found on the beaches of monazite sands of Kerala.

Conclusion: Landforms are not only the physical features of the earth's surface but also the basis of human civilization. The landforms on the earth's surface have influenced human life in different ways. Fertile plains have been formed by the rivers originating in the mountains. These rivers are our perennial source of water for irrigation and other purposes. The plateaus are often described as the storehouse of minerals. Similarly other landforms influence humans and landforms also get influenced by humans.

OCEANOGRAPHY

PYQ

1. Discuss the causes of depletion of mangroves and explain their importance in maintaining coastal ecology. 2019
2. How do ocean currents and water masses differ in their impacts on marine life and the coastal environment? Give suitable examples? 2019
3. Assess the impact of global warming on coral life system with examples. 2019
4. What are the consequences of spreading of 'Dead Zones' on marine ecosystem? 2018
5. Account for variations in oceanic salinity and discuss its multi-dimensional effects. 2017
6. How does the cryosphere affect global climate?
7. Explain the factors responsible for the origin of ocean currents. How do they influence regional climates, fishing and navigation? 2015
8. Critically evaluate the various resources of the oceans which can be harnessed to meet the resource crisis in the world. 2015
9. Major hot deserts in northern hemisphere are located between 20-30 degree north and on the western side of the continents. Why? 2013

Oceans cover more than 70% of the earth's surface. Its health, humanity's well-being, and the living environment that keeps us all alive are all intricately interwoven. Despite this, ocean acidification, climate change, polluting activities, and over-exploitation of marine resources have made oceans one of the most endangered ecosystems on the planet.

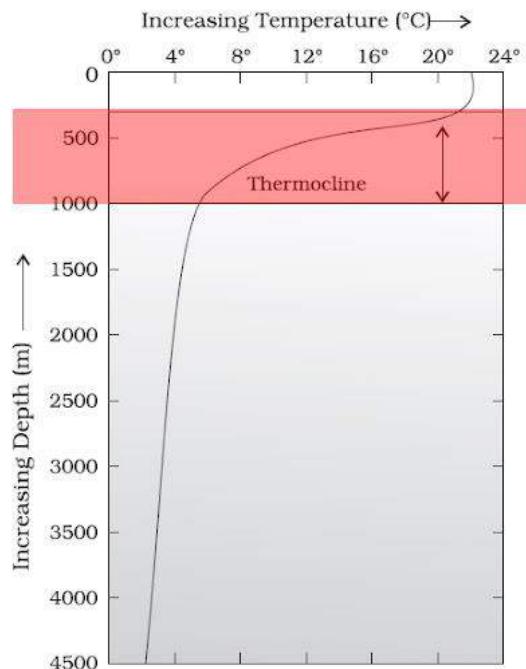
Salinity

- The entire content of dissolved salts in saltwater is referred to as salinity.
- The amount of salt (in gm) dissolved in 1,000 gm (1 kg) of saltwater is used to calculate it.

- Parts per thousand, or ppt, is a common unit of measurement.
- Average salinity is 35.2 parts per thousand.
- Lake van and Dead Sea have the highest salinity so it is impossible to sink in them.

Factors Affecting Ocean Salinity

- Rate of evaporation:** Regions with high temperature and low humidity experience a high rate of evaporation and have high salinity. Temperate oceans Low salinity due to lower evaporation rate and temperature.
- addition of freshwater:** freshwater added through continuous precipitation, streams and icebergs. The salinity is low in the equatorial region. Baltic, Arctic and Antarctic water Have low salinity due to cold climate and little evaporation.
- Water mixing by currents:** enclosed sea Where water mixing is low, experiences high salinity whereas freely moving water in the ocean has low salinity.



Vertical Distribution of Salinity

- Salinity varies with depth**, although this fluctuation is also influenced by latitudinal differences.
 - Cold and warm currents have an impact on the decrease.
- Salinity rises with depth at high latitudes. It rises to a maximum of 35 metres in the middle latitudes, then falls. Subsurface salinity is lower towards the equator.
- Salinity rises with depth in general, but there is a separate zone termed the **halocline** (compared to thermocline) where salinity rises rapidly.

Impact of salinity

- Salinity levels are important for two reasons.**
- First, along with temperature, they directly affect seawater density (salty water is denser than freshwater) and therefore the circulation of ocean currents from the tropics to the poles.
 - These currents control how heat is carried within the oceans and ultimately regulate the world's climate.
- Second, sea surface salinity is intimately linked to Earth's overall water cycle and to how much freshwater leaves and enters the oceans through evaporation and precipitation. Measuring salinity is one way to probe the water cycle in greater detail.
- Any changes in salinity and ocean currents can affect regional climates and marine life.

Ocean Acidification

- Ocean acidification (OA) refers to the ongoing decrease in ocean pH, which is caused primarily by the oceanic uptake of excess carbon dioxide (CO₂) from the atmosphere.
- When CO₂ is dissolved in seawater, some of it will be used during photosynthesis by marine plants and phytoplankton, and some will react with the water to form carbonic acid.

- When CO₂ is absorbed by seawater, two things happen: 1) the seawater pH decreases (thus the term ocean acidification), and 2) the number of available carbonate ions decreases.

Atmospheric acidity impact oceanic ecology

- Human emissions of pollutants have caused significant changes to the acidity of the atmosphere. Increased acidity in the atmosphere is disrupting the ecological balance of the oceans.
- Atmospheric acidity affects the quantity and distribution of nutrients (nitrogen, phosphorus and iron) delivered to the ocean.
- Increasing acidity since the Industrial Revolution increased the proportions of phosphorus and iron that are soluble by 14 per cent and 16 per cent respectively. These increases will have had a direct fertilizing effect on marine phytoplankton."

Over the same time period, pollutant emissions have at least doubled the amount of nitrogen added to the oceans via the atmosphere.

Movement of Oceans

Waves, tides, and currents are the three types of movements that occur in oceans.

Waves

- Friction between the wind and the surface water layer causes waves to form. The greater the wave, the stronger the wind. When they approach the shore or shallow waters, they immediately die off.

Tides

- Tsunamis, storm surges, and tides are all examples of tidal waves (meaning waves with large wavelengths).

Currents

- Ocean currents are similar to river flow. They show a constant volume of water moving in a specific direction.
- Ocean currents circulate in a regular pattern. Warm water flows from the equatorial region to poles. Whereas cold currents flow from polar regions to the equator and have low surface temperature.

Ocean currents are governed by two types of forces:

- Primary forces, which initiate water movement:
 - Insolation:** The water expands when heated by sun radiation. The ocean water level near the equator is roughly 8 cm higher than in the middle latitudes.
 - atmospheric circulation:** The surface ocean water is dragged by the wind's frictional force. The size and direction (Coriolis force) of ocean currents are controlled by winds.
 - The oceanic circulation pattern is similar to the atmospheric circulation pattern on Earth.
 - Coriolis force:** In the northern hemisphere, the Coriolis force causes the water to move to the right. For example Gulf Stream, while in the southern hemisphere, it moves to the left, for Eg. Brazilian current and West wind drift.
 - Land Mass:** It obstructs and diverts the current, for example Tip of South Chile diverts West wind drift northward as Peruvian current.
- Secondary factors, which impact current flow:
 - The secondary forces are temperature and salinity differences. Ocean currents' vertical motion is affected by differences in water density (vertical currents).
 - High-salinity water has a higher density than low-salinity water.

- Water that is denser sinks, and water that is lighter rises.
- Climate change: As greenhouse gases trap more energy from the sun, the oceans are absorbing more heat, resulting in an increase in sea surface temperatures and rising sea level. Changes in ocean temperatures and currents brought about by climate change will lead to alterations in climate patterns around the world.
- For example: The Atlantic Meridional Overturning Circulation (AMOC) is losing its stability and is quite likely to decline

Climate change and Ocean Circulation

- while ocean circulation in some regions shows a decelerating trend—for example, in the North Atlantic—across the planet as a whole there was a “surprising significant acceleration of global mean circulation during the past two decades.
 - A remarkable increase in the global mean sea surface wind speed over the past two decades play a role in modulating climate heat uptake.
- Impacting Marine Life: some fish species only spawn at particular temperatures. The accelerated movement of water masses might therefore alter spawning grounds, or it may impact the connectivity between marine ecosystems.
- Impact Carbon Cycle: Antarctic winds strongly affect the break-out and melting of sea ice, which in turn affects the levels of algae which can grow rapidly in surface waters when sea ice is reduced.
 - Changes in the levels of algae growth in the waters surrounding the Antarctic are important enough to affect the global carbon cycle.
- heatwaves underwater are becoming more frequent and intense as the world warms, putting stress on ocean ecosystems.
- Eddie Killing: Eddies are circular currents that wander around the ocean like spinning tops, ranging from tens to hundreds of kilometers in diameter.
 - They mimic weather systems in the atmosphere and serve as a feeding grounds for sharks, turtles, and fish. Eddies often spin off major ocean currents and typically die within a matter of months.
 - Eddies boost ocean heat intake, ocean mixing at the surface, and the exchange of gases with the atmosphere.
- Wind destroys ocean eddies by applying stress to the ocean’s surface and slowing eddies’ spin to the point of extinguishing them.
 - The movement of the ocean is critical in regulating the climate of the Earth”.
 - Eddies can affect the trajectories of major currents: For example, eddies are widely believed to play a crucial role in causing the warm waters of the Gulf Stream to curve away from the eastern United States, keeping the climate of Canada, Greenland, and the Labrador Sea cold.

Impact of climate change on Ocean

- Marine life: Warming oceans have driven the critically endangered North Atlantic right whale population from its traditional and protected habitat, exposing the animals to more lethal ship strikes, disastrous commercial fishing entanglements and greatly reduced calving rates.

- **Interfere with Oceanic circulation:** Due to a warming climate, the Atlantic Meridional Overturning Circulation is slowing down, causing the Gulf Stream to move North, injecting warmer and saltier slope water into the Gulf of Maine.
- **The warming Gulf of Maine has reduced the abundance of copepods,** the tiny crustaceans that serve as the right whales' favourite snack.
 - This has reduced right whale calving rates and forced the whales to abandon their mid-summer feeding grounds in the Gulf of Maine. Instead, the whales have headed north to the cooler waters of the Gulf of St. Lawrence.
- **Promote Catastrophic Events:** The rise and fall of sea levels **influence the likelihood of volcanic eruptions** on the Greek island of Santorini.
 - **Falling sea levels remove mass from the Earth's crust** and the crust fractures as a result. These fractures allow magma to rise and feed eruptions at the surface.
- **Global Sea level Rise:** The rate at which sea levels are rising is accelerating by about 0.1mm per year each year.
 - More than 60% of sandy beaches in Gambia and Guinea-Bissau may be lost to erosion by rising seas, while Australia is expected to lose nearly 12,000 km of sandy coastline.

Coral reefs and Climate change

- **Corals are the backbone of marine ecosystems** in the tropics. **They are threatened by rising water temperatures** caused by global warming and they are among the first ecosystems worldwide that are on the verge of ecological collapse.
- High temperatures hit coral reefs especially hard by causing widespread **bleaching events, where corals eject the symbiotic algae in their tissues.**
- **Coral bleaching**, which is becoming stronger and more frequent due to **heat stress.**

Significance of Coral reefs for Ocean ecosystem

- **Economic Significance:** Coral reefs have an estimated global value of £6 trillion each year, due in part to their **contribution to fishing and tourism industries and the coastal protection** they provide.
- **Harbour Biodiversity:** Coral reefs **support more species per unit area** than any other marine environment, including about 4,000 species of fish, 800 species of hard corals and hundreds of other species.
- **Support Livelihood:** Healthy coral reefs support **commercial and subsistence fisheries** as well as jobs and businesses through **tourism and recreation.**
- **Buffer against Natural disasters:** Coral reef structures **buffer shorelines** against 97 percent of the energy from waves, storms, and floods, helping to prevent loss of life, property damage, and erosion.
 - When reefs are damaged or destroyed, the absence of this **natural barrier** can increase the damage to **coastal communities** from normal wave action and violent storms.
- **Give story line of evolution:** Corals are an important paleoclimate archive in the ocean because their calcium carbonate skeletons incorporate the chemical properties of past oceans and so reflect past climate and environmental conditions.

But some coral communities are becoming more heat tolerant as ocean temperatures rise. For Example Phoenix Islands Protected Area (PIPA) in the central Pacific Ocean recovered and experienced minimal losses during a heatwave event in 2009-2010.

Ocean pollution

Ocean pollution is a complex mixture of toxic metals, plastics, manufactured chemicals, petroleum, urban and industrial wastes, pesticides, fertilisers, pharmaceutical chemicals, agricultural runoff, and sewage.

- Some debris sinks, some is eaten by marine animals that mistake it for food, and some accumulates in ocean gyres.
- Other forms of pollution that impact the health of the ocean come from sources like oil spills or from accumulation of many dispersed sources.
- More than 80% arises from land-based sources and it reaches the oceans through rivers, runoff, deposition from the atmosphere – where airborne pollutants are washed into the ocean by rain and snow – and direct dumping, such as pollution from waste water treatment plants and discarded waste.

Ocean pollution is heaviest near the coasts and most highly concentrated along the coastlines of low-income and middle-income countries.

Impact of Ocean Pollution

- **Impact marine life:** Sea animals are common victims of ocean pollution. Oil spills, for instance, will ensnare and suffocate marine animals by permeating their gills. When the oil gets into seabird feathers, they may not be able to fly or feed their young.
- **Interfere with food chain:** Marine animals also mistake small plastic debris for food or become entangled in or strangled by plastic bags and discarded fishing nets.
- **A threat to human health:** Excess nitrogen and phosphorus in seawater also cause oxygen depletion. When a great deal of oxygen depletion occurs in an area of the ocean, it can become a dead zone where no marine life can survive.
- **Depletion of oxygen in seawater:** As excess debris in the ocean slowly degrades over many years it uses oxygen to do so, resulting in less oxygen in the ocean. Low levels of oxygen in the ocean lead to the death of ocean animals.

Dead zone

"Dead zone" is a more common term for hypoxia, which refers to a reduced level of oxygen in the water.

Hypoxia occurs when dissolved oxygen (DO) concentration falls to or below 2 ml of O₂/liter. When a body of water experiences hypoxic conditions, aquatic flora and fauna begin to change behaviour in order to reach sections of water with higher oxygen levels.

why dead zones formed repeatedly in North Pacific during warm climates?

- During high sea levels, dissolved iron from the flooded continental shelves can be transferred to the open ocean and promote intense phytoplankton growth in the surface waters.
- Changes in ocean circulation, including intensified upwelling to bring more nutrients into the surface waters and stronger currents that could transfer iron from the continental shelf to the open ocean.
- The hypoxia occurs after intense growth of phytoplankton (marine algae) in the surface waters.
- When the phytoplankton die, they sink deeper into the ocean and decompose, which depletes the oxygen and releases carbon dioxide into the water below the surface.

Regional dead zones occur in coastal areas around the world due to the temperature effects of climate warming, as well as nutrient enrichment of coastal waters from agricultural fertilizers.

- One of the largest dead zones forms in the Gulf of Mexico every spring (farmers fertilize their crops and rain washes fertilizer off the land and into streams and rivers).

Nutrient pollution (eutrophication) depletes oxygen in coastal waterways as fertiliser, sewage, animal and aquaculture waste promote the growth of algae, which deplete oxygen as they decompose. The main features of a coastal area that becomes deoxygenated are:

- High biological production from over-enrichment by high nitrogen and phosphorus loads;
- a stratified water column from salinity, temperature, or both, mostly in water depths of less than 100 m;
- and long water residence time allow for the development of phytoplankton blooms, the containment of fluxed organic matter, and the development of sturgeon.

Ocean microplastics

The world's sea floor is littered with an estimated 14 million tonnes of microplastics, broken down from the masses of rubbish entering the oceans every year, according to Australia's national science agency.

- Microplastics** are plastic particles less than 5mm in diameter. They contribute to over 80% of the ocean debris. The plastic materials discarded by humans' traverse through land and are passed to the oceans by wind or rivers.

Impact of microplastics

- Affect the food chain:** Marine organisms such as fish, crabs and prawns consume these microplastics by misidentification as food. Humans consume this seafood which leads to several health complications.
- Affect the health of marine organisms:** Various studies have shown that once ingested, microplastics can settle in the stomach and lead to reduction in feeding capacity of organisms.
 - They can also be detrimental to the intestinal function and reproductive system.
- Ocean pollution:** Plastic pollution that ends up in the ocean deteriorates and breaks down, ending up as microplastics.
- Impact on human health:** The impact of marine plastic pollution on human health tops a list of health-related concerns over marine threats.

Mitigation of Ocean Pollution:

- Nutrient reduction methods with legislative requirements**, set specified targets, and used monitoring to discover problems and respond to management strategies. These can be adapted to the requirements and economy of the local area.
- Work on climate change:** a significant climate mitigation effort is required, primarily through urgent, radical, and massive worldwide reductions in greenhouse gas emissions caused by human activity.
- Increased oxygen observation and experimentation—by integrating existing programmes and networks and focusing on areas where more data can help analyse the current state and trends of oxygen change.
- Assessments of the consequences on human economies and societies**, particularly where fisheries, aquaculture, and livelihoods are threatened.
- Fishery management** that is adaptive and ecosystem-based, spatial planning to establish refugia that improve ecosystem resilience, activities that minimise local ecosystem stress, capacity building, and socio-ecological adjustments that lessen human impacts could all be explored.

ISSUES IN NEWS**ATLANTIC MERIDIONAL OVERTURNING CIRCULATION (AMOC)**

The Atlantic Meridional Overturning Circulation (AMOC), according to the recently released IPCC Report, is losing its stability and is quite likely to decline in the twenty-first century.

The Atlantic Meridional Overturning Circulation (AMOC) is a large system of ocean currents that carry warm water from the tropics northwards into the North Atlantic.

It is, like a conveyor belt, driven by differences in temperature and salt content: **The water's density**.

- As warm water flows northwards it cools and some evaporation occurs, which increases the amount of salt.
 - Low temperature and a high salt content make the water denser, and this dense water sinks deep into the ocean.
 - The cold, dense water slowly spreads southwards, several kilometres below the surface.
- Eventually, it gets pulled back to the surface and warms in a process called "upwelling" and the circulation is complete.

Is AMOC changing?:

Since 2004, oceanographers have been continuously measuring the AMOC. **The AMOC fluctuates from year to year**, according to the data, and these variations are likely to have an impact on the weather.

If it gets weakened?

- **It would raise sea levels along the US east coast**, increase the number and intensity of storms that affect the UK, cause more harsh winters, and increase the number and severity of destructive heatwaves and droughts across Europe.
- The downward movement of the tropical rain belt may result in more storms or a drier Sahel in Africa.

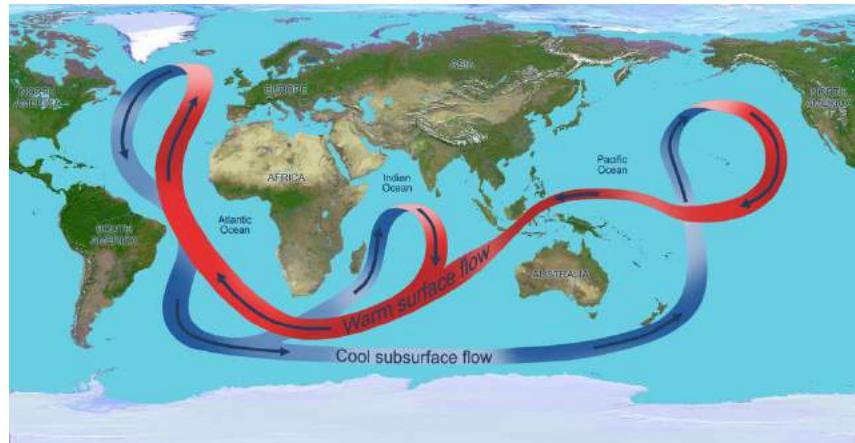
Causes of its Decline

- Global warming has long been anticipated to impair the world's major ocean systems, according to climate models.
- The melting of the Greenland ice sheet has resulted in a freshwater inflow.
 - Researchers discovered that a section of the Arctic ice known as the "Last Ice Area" has also disappeared in July 2021.
 - The freshwater from melting ice lowers the water's salinity and density.
 - The water is now unable to sink as quickly as it once did, weakening the AMOC flow.

Importance of AMOC

It is essential for **redistribution of heat and energy throughout the globe**, as the warm water it transports releases heat into the atmosphere, as well as **collecting and storing atmospheric carbon**.

- The east coast of North America and the west coast of Europe are both affected by AMOC.
- It provides Europe with pleasant weather.



AMOC and Indian weather

Rising temperatures in the **Indian Ocean**, according to recent research, can assist increase the AMOC and prolong its slowing.

- As the Indian Ocean warms, it **produces more precipitation**, which attracts more air from other regions of the world, including the Atlantic.
- The increased precipitation in the Indian Ocean will limit precipitation in the Atlantic and raise saline levels in the seas.
- This saline water in the Atlantic will turn colder and sink faster than usual as it travels north via AMOC, acting as a jump start for AMOC and strengthening circulation.

LA NIÑA

After over a decade of absence, the World Meteorological Organization (WMO) has declared the return of La Niña to the central and eastern equatorial Pacific Ocean.

- The La Niña of 2020 is projected to be moderate to strong, with the possibility of extending into 2021.
- Rainfall in the Horn of Africa could be below average, while East and Central Africa will be drier than typical.
- The World Meteorological Organization's weather models predict above-average rainfall for Southeast Asia, the Pacific Islands, and the northern part of South America.
- The average Sea Surface Temperature will be 2-3 degrees Celsius lower (SST).

El Niño and La Niña are weather phenomena that occur in the Equatorial Pacific as a result of changes in ocean temperatures. They are two phases of the **El Niño-Southern Oscillation (ENSO) cycle**, which occur opposite each other.

- In the east-central Equatorial Pacific, the ENSO cycle depicts temperature changes between the ocean and atmosphere.
- El Niño and La Niña episodes endure nine to twelve months on average, but some long-term phenomena might last years.

La Nina

In Spanish, La Nina translates to "**The Little Girl.**" El Viejo, anti-El Nino, or simply "a chilly occurrence" are some names for it.

- La Nina occurrences occur when sea surface temperatures in the east-central Equatorial Pacific are below average.
- The sea surface temperature has dropped by more than 0.9°F for at least five consecutive three-month seasons, indicating this.
- A La Nina event occurs when the water temperature in the Eastern Pacific becomes considerably cooler than normal, resulting in a strong high pressure system over the eastern equatorial Pacific.



El Nino

El Nino, which means "little boy" in Spanish, was the name given to it by the Spanish immigrants.

- El Nino was soon used to indicate more than only the warming of coastal surface waters; it was also used to describe erratic and extreme climate fluctuations.
- El Nino events do not follow a predictable cycle and occur at sporadic intervals of two to seven years.
- They really blow in the other direction (towards South America rather than Indonesia) from west to east. As a result, warm surface water at the equator accumulates along the South American coast before moving north to California and south to Chile.

Impact on Indian Climate

- **El Nino:** In India and Southeast Asia, strong El Nino occurrences cause weaker monsoons and even droughts.
- **La Nina:** Unlike El Nino, La Nina's chilly air covers a broader area of India.

Rainfall linked with the summer monsoon in Southeast Asia tends to be higher than average during a 'La Nina year,' notably in northwest India and Bangladesh.

The Indian economy, which relies on the monsoon for agriculture and manufacturing, benefits in general.

- **La Nina affects the Indian subcontinent by bringing cold air from Siberia and South China** into the region, where it combines with tropical heating to create a north-south low-pressure system.
 - La Nina's chilly air, which is related with this north-south trough, tends to spread further south towards India.
- This is in stark contrast to the El Nino-associated northwest-southeast surge of chilly air.
- Because of the north-south pressure pattern, western disturbances have a lower influence.
 - The chilly temperatures may reach as far as Tamil Nadu, although they are unlikely to have a significant impact on the North East.

Madden Julian Oscillation (MJO)

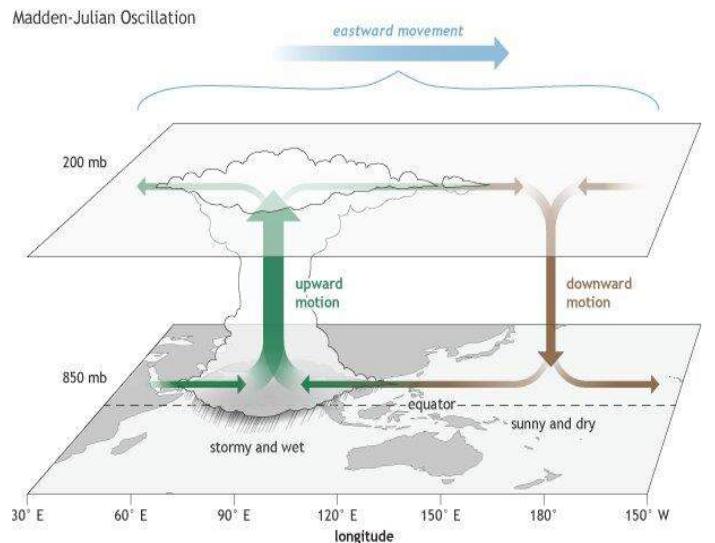
The Arabian Sea branch of the south-west monsoon is banking on an itinerant Madden-Julian Oscillation (MJO) wave for a typical monsoon, according to the **India Meteorological Department (IMD)**.

- The MJO wave is a global band of low-pressure areas that moves from West to East on a regular basis, determining the initiation and strength of low-pressure areas, depressions, and cyclones, as well as overseeing monsoon onsets throughout its path.

Phases of Madden-Julian Oscillation

The MJO is divided into two phases. The planet is frequently split in half by strong MJO activity. Half of the time is spent in the increased convective phase, while the other half is spent in the suppressed convective phase.

- Enhanced rainfall (or convective) phase:** surface winds converge, and air is pushed up into the atmosphere. The winds change direction near the top of the atmosphere (i.e., diverge). Condensation and rainfall are likely to increase as a result of such rising air motion in the atmosphere.
- Suppressed rainfall phase:** Winds converge at the top of the sky, pushing air to descend and subsequently diverge at the surface, resulting in reduced rainfall. As air descends from high altitudes, it heats and dries, preventing rain.



Impact of MJO on Indian Monsoon

- The Indian Ocean Dipole (IOD), El Nino, and the (MJO) are all oceanic and atmospheric phenomena that have a substantial impact on weather.
- The Indian Ocean Dipole (IOD) only affects the Indian Ocean, whereas the other two have an impact on weather on a worldwide scale up to the mid-latitudes.
- IOD and El Nino are still hovering over their respective places, while MJO is on the move.
 - When it is over the Indian Ocean during the Monsoon season, it brings good rainfall over the Indian subcontinent.
 - On the other hand, when it witnesses a longer cycle and stays over the Pacific Ocean, MJO brings bad news for the Indian Monsoon.
- It's associated with both increased and decreased rainfall activity in the tropics, and it's crucial for Indian monsoonal rainfall.

Deep Ocean Mission

The Cabinet Committee on Economic Affairs has approved the Ministry of Earth Sciences' (MoES) request for the Deep Ocean Mission (DOM).

- In 2018, the DOM's design for exploring the ocean's deepest depths was revealed. The draught Blue Economy Policy was also released by the MoES earlier.

It will be a mission-mode initiative to support the Indian government's Blue Economy Initiatives.

- The sustainable use of ocean resources for economic growth, improved livelihoods and jobs, and ocean ecosystem health is known as the blue economy.
- Only five countries today have the technology and experience required for such missions: the United States, Russia, France, Japan, and China.

- India will be the sixth country in the world to have it.
- **It will focus on deep-sea mining technology** such as underwater vehicles, underwater robotics, and ocean climate change consulting services, among other things.
- **A desalination facility powered by tidal energy** and a submersible vehicle capable of exploring depths of at least 6,000 metres are two significant projects proposed under DOM.

DOM's Importance for India

- **Explore EEZ:** India's Exclusive Economic Zone (EEZ) covers 2.2 million square kilometres. EEZs are UNCLOS-defined boundaries that grant a state exceptional rights in the exploration and utilisation of marine resources.
- **Exploration of Polymetallic Nodules:** The UN International Sea Bed Authority has given India a 75,000-square-kilometer location in the Central Indian Ocean Basin (CIOB) for the extraction of polymetallic nodules (PMN).
- **Meet Energy Demands:** Even if only 10% of that reserve could be obtained, it would be enough to supply the world's energy needs for the next 100 years.
- **Promote research and development:** It will aid in the development of new technologies in the sector, ranging from underwater vehicles to underwater robotics, hence strengthening India's standing in the field of ocean research.
- **Leveraging the blue economy:** The Mission will aid in the country's overall economic progress by leveraging the blue economy.

Seabed 2030

Seabed 2030 is a **collaborative project between the Nippon Foundation of Japan** and the **General Bathymetric Chart of the Oceans (GEBCO)**. It aims to bring together all available bathymetric data to produce the definitive map of the world ocean floor by 2030 and make it available to all.

- Bathymetry is the measurement of the shape and depth of the ocean floor.
 - It was launched at the United Nations Ocean Conference in 2017.
- It is aligned with the UN's Sustainable Development Goal (SDG) 14 to conserve and sustainably use the oceans, seas and marine resources.
- The Seabed 2030 project comprises four Regional Centers and a Global Center.

Using technology such as deepwater hull-mounted sonar systems and Autonomous Underwater Vehicles, the Seabed 2030 Project intends to gather higher quality information with a minimum resolution of 100 metres at all locations (AUVs).

The Significance of Ocean Floor Research:

- **Understanding ocean circulation patterns**, which affect climate and weather patterns, tides, sediment transport, and resource exploration, requires knowledge of the seabed's shape (oil, gas and minerals).
- **Strengthen our understanding of marine ecosystems** and marine species for the sake of our current and future food supply, as fish is a source of protein for three billion people.
- **Understanding climate change** is important because ocean bottom features such as canyons and underwater volcanoes affect vertical mixing of ocean water, ocean currents, and sea-level rise.
- **Empower people all over the world to make policy decisions**, use ocean sustainability, and conduct scientific study using comprehensive bathymetric data.

- **Provides critical inputs for navigation**, disaster predictions, oil and gas exploration, offshore wind turbine construction, fishing resources, and cable and pipeline laying.

Conclusion

The temperature, chemistry, currents, and life of the world's seas drive global processes that keep the Earth habitable for humans. The livelihoods of almost three billion people are dependent on marine and coastal biodiversity. As a result, ocean health must be considered as a global issue, and all states must work together to achieve SDG 14: To conserve and sustainably use the oceans, seas, and marine resources for sustainable development.

CLIMATOLOGY

PYQ

1. The process of desertification does not have climate boundaries. Justify with examples. 2019
2. Discuss the concept of air mass and explain its role in macro-climatic changes. 2016
3. Tropical cyclones are largely confined to South China Sea, Bay of Bengal and Gulf of Mexico. Why? 2014
4. Most of the unusual climatic happenings are explained as an outcome of the El-Nino effect. Do you agree? 2014
5. Bring out the causes for the formation of heat islands in the urban habitat of the world. 2013
6. What do you understand by the phenomenon of temperature inversion in meteorology? How does it affect the weather and the habitants of the place? 2013

Earth's Atmosphere

The atmosphere is made up of different types of gases, water vapour and dust particles. The composition of the atmosphere is not static. It changes according to the time and place.

Nitrogen and Oxygen are the two main gases of the atmosphere. 99 percent part of it is made up of these two gases. Other gases like oxygen, carbon dioxide, hydrogen, Neon, helium etc. form the remaining part of atmosphere

Structure of atmosphere

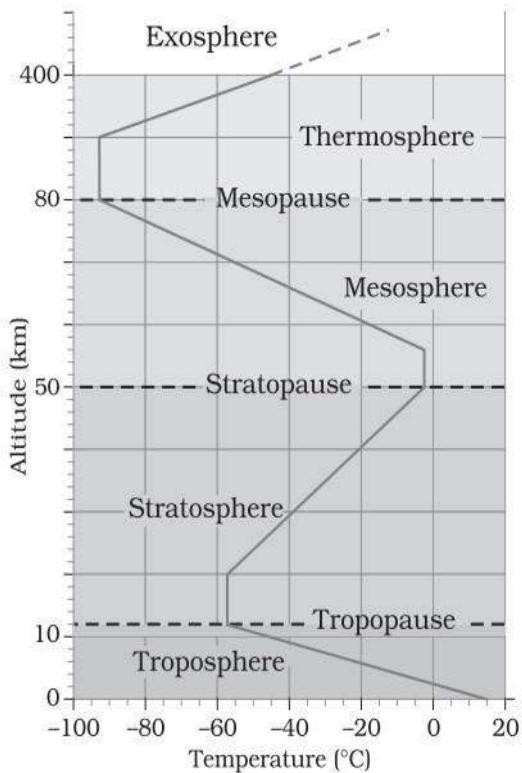
The atmosphere is comprised of layers based on temperature. These layers are the troposphere, stratosphere, mesosphere and thermosphere. A further region at about 500 km above the Earth's surface is called the exosphere.

Troposphere

- This is the lowest part of the atmosphere - the part we live in. It contains most of our weather - clouds, rain, snow.
- In this part of the atmosphere the temperature gets colder as the distance above the earth increases, by about 6.5°C per kilometre.
- The troposphere contains about 75% of all of the air in the atmosphere, and almost all of the water vapour (which forms clouds and rain).
- The top of the troposphere is called **the tropopause**. This is lowest at the poles, where it is about 7 - 10 km above the Earth's surface. It is the highest (about 17 - 18 km) near the equator.

Stratosphere

- It can be found up to 50 kilometres above the earth's surface, beyond the tropopause.
- It is responsible for a **large portion of the ozone in the atmosphere**. The absorption of ultraviolet (UV) energy from the sun by this ozone **causes the temperature to rise with height**.
- Temperatures are highest over the summer pole and lowest over the winter pole in the stratosphere.



- This layer is almost free from clouds and associated weather phenomenon, making conditions most ideal for flying aeroplanes.
 - Sometimes, cirrus clouds are present at lower levels in this layer.

The Mesosphere

- The region above the stratosphere is called the mesosphere. Here the temperature again decreases with height, reaching a minimum of about -90°C at the "mesopause".
- Most of the meteors burn up in this layer on entering from space.
- The air is so cold just below the mesopause that even the scarce water vapour can be sublimated into polar-mesospheric noctilucent clouds.

Thermosphere

- The thermosphere lies above the mesopause, and is a region in which temperatures again increase with height. This temperature increase is caused by the absorption of energetic ultraviolet and X-Ray radiation from the sun.
- **The International Space Station and satellites orbit in this layer.**
- The Kármán line, located at an altitude of 100 km within the thermosphere, is widely used to describe the border between Earth's atmosphere and outer space.

Ionosphere

- **Ionosphere is a part of the thermosphere**. It extends between 80-400 km.
- Electrically charged currents flow in the air in this sphere. Radio waves are reflected back on the earth from this sphere and due to this radio broadcasting has become possible.

Exosphere

- located above the ionosphere and extends to beyond 400 km above the earth.
- The air is extremely rarefied, and the temperature gradually increases through the layer.

Climate change and Atmosphere

- The lower and middle atmosphere affect the upper atmosphere mainly via upwardly propagating atmospheric waves. As atmospheric waves travel upwards, their amplitude increases due to the exponential decrease in atmospheric density with height.
- As a result of man-made climate change in the lower and middle atmosphere, both wave generation processes and the wave propagation conditions in the lower and middle atmosphere have changed over the past 4-5 decades.
- The increase in atmospheric CO₂ concentration is causing cooling and contraction of the upper atmosphere, which leads to lower densities at high altitudes and thereby a longer lifetime of space debris. In addition, there may be indirect effects of climate change in the lower/middle atmosphere on long-term trends in upper atmosphere density.
- **Formation of Surface level ozone:** Changes in climate can result in impacts to local air quality. Atmospheric warming associated with climate change has the potential to increase ground-level ozone in many regions
- **Uneven warming and cooling:** Ozone in the atmosphere warms the climate, while different components of particulate matter (PM) can have either warming or cooling effects on the climate.
 - For example, black carbon, a particulate pollutant from combustion, contributes to the warming of the Earth, while particulate sulfates cool the earth's atmosphere.

Solar Radiation, Heat Budget & Temperature

- The amount of solar energy received by the planet in the form of radiation is known as **insolation**.
- The sun's radiation reaches Earth in the form of **electromagnetic short waves**
- During the day, the earth absorbs shortwave radiation, and at night, it reflects the heat it receives into space as longwave radiation (mainly infrared radiation, which is nothing but heat).

Heat Budget

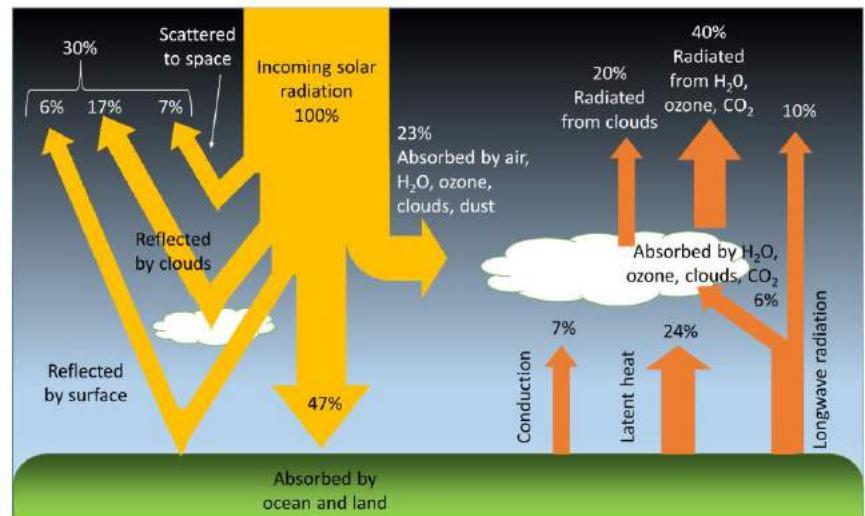
The earth absorbs some insolation (short waves) and radiates heat back into space via terrestrial radiation (longwave radiation). The world maintains a constant temperature through this input and outflow of heat, and this phenomena is known as the earth's heat budget.

Climate and Earth's Energy Budget

- The Sun doesn't heat the Earth evenly. Because the Earth is a sphere, the Sun heats equatorial regions more than polar regions.
- The atmosphere and ocean work non-stop to even out solar heating imbalances through evaporation of surface water, convection, rainfall, winds, and ocean circulation.
 - This **coupled atmosphere and ocean circulation is known as Earth's heat engine**.

Anything that increases or decreases the amount of incoming or outgoing energy disturbs Earth's radiative equilibrium; global temperatures rise or fall in response.

- These destabilizing influences are called climate forcings.
- Natural climate forcings include changes in the Sun's brightness.
 - Milankovitch cycles** (small variations in the shape of Earth's orbit and its axis of rotation that occur over thousands of years), and
 - large volcanic eruptions** that inject light-reflecting particles as high as the stratosphere.
- Man Made forcings include particle pollution (aerosols), which absorb and reflect incoming sunlight; **deforestation**; and the rising concentration of atmospheric carbon dioxide and other greenhouse gases, which decrease heat radiated to space.
- The imbalance of Earth's Energy budget leads to climate change.



Synergies between Urban Heat Island and Heat Waves

- A heat wave is a period of exceptionally high temperatures, above the typical maximum temperature, that occurs in the North-Western and South Central areas of India during the summer season.

- A record-breaking heat wave swept Northeast Asia in 2018, resulting in 71,266 hospitalisations for heat strokes in Japan. Similarly, China's Meteorological Administration was forced to issue high-temperature warnings for 33 consecutive days.
- A correlation has been discovered between a rise in extreme summer heat events in Northeast Asia and the involvement of anticyclones in the region, according to new research.
- The ground surface temperature increases during heat waves.
 - In urban areas, it may increase the released sensible heat and reduce the latent heat proportionally higher than in the rural areas, resulting in amplification of the surface temperature and causing urban heat island effect.

Urban regions experience hotter conditions compared to their natural surroundings, due to a number of factors that modulate urban climate and form '**Urban Heat Islands'**.

- The main contributing factors are changes in the surface energy budget due to increased heat storage capacity of artificial surfaces compared to natural ones, reduction of evaporative cooling, differences in convective and advective flows and increased anthropogenic heat release in urban areas.

Climate Change & Shift in Earth's Axis

Loss of water on land is changing the earth's axis of rotation, according to a new study. Ice melting and human-induced factors [such as excessive groundwater pumping] are the causes of water loss.

The Earth's axis of rotation has been rotating faster than normal since the 1990s, according to a study published in the Journal Geophysical Research Letters, due to massive melting of glaciers induced by global warming.

- According to NASA, the spin axis drifted around 10 cm every year in the 20th century. It means, in a year, polar motion exceeds 10 metres.

Finding of Study

- Because of changes in the hydrosphere, the north pole has shifted in a new eastward direction since the 1990s, according to the study (meaning the way in which water is stored on Earth).
- The average speed of drift was 17 times faster from 1995 to 2020 than it was from 1981 to 1995.
- According to the study, the fastest ice melting due to global warming was the most likely cause of the polar drift's directional change in the 1990s.
 - NASA's Gravity Recovery and Climate Experiment (GRACE) mission provided the data for the computations.
- Changes in terrestrial water storage in non glacial regions due to climate change and unsustainable groundwater consumption are two other possible causes.

Causes of this Shift

The rotation of the globe on and within the planet is affected by mass redistribution, which includes changes in soil, ice sheets, seas, and mantle movement. The key forces that contribute to mass redistribution are as follows:

- Decreasing groundwater table: Every year, millions of tonnes of groundwater are pumped out for drinking, industry, and agriculture, and the majority of it finally ends up in the sea, redistributing the planet's mass.
- Ice Melting: The most likely explanation of the polar drift's directional change in the 1990s was quicker ice melting due to global warming.
 - Water mass redistributes as glaciers melt, creating movements in the planet's axis.

The South Atlantic Anomaly

Context: Scientists from the European Space Agency (ESA) have warned that the geomagnetic field of the planet is deteriorating in several locations between Africa and South America.

- The phenomena of this fluctuation in geomagnetic field or surface magnetic field has been dubbed the 'South Atlantic Anomaly' by the European Space Agency.

What is South Atlantic Anomaly?

The South Atlantic Anomaly (SAA) is an area where Earth's inner Van Allen radiation belt comes closest to Earth's surface, dipping down to an altitude of 200 kilometres (120 mi). This leads to an increased flux of energetic particles in this region and exposes orbiting satellites to higher-than-usual levels of radiation.

- The effect is caused by the non-concentricity of Earth and its magnetic dipole.
- The SAA is the near-Earth region where Earth's magnetic field is weakest relative to an idealized Earth-centered dipole field.

The South Atlantic Anomaly is splitting, according to NASA data.

- It can be seen over South America and the Atlantic Ocean's southern reaches.
- According to recent research, SAA is growing westward and dividing into two lobes, which could weaken the magnetic field and have an impact on:
 - **Solar particles** will collide with low-earth orbit spacecraft passing through SAA, causing a short circuit and maybe irreparable damage.
 - **Instruments on the International Space Station**, which is in low Earth orbit, will also be affected.
- **SAA is caused by two characteristics of Earth's core:**
 - its magnetic axis tilt and
 - the flow of molten metals within its outer core.
- SAA degradation has so far had no obvious effects on the Earth's surface.
- **The magnetic field of the Earth works as a protective barrier**, rejecting and retaining charged particles from the Sun.
 - The Earth's magnetic field is caused by its metallic and liquid outer core, which is located around 3,000 kilometres beneath our feet.

Impact of SAA

- If a reversal occurs, the **ramifications might be severe**, causing major problems for telecommunications and satellite systems.
- It's possible that some cell phones and satellites will stop working.

Boreal Summer Intra-seasonal Oscillation

Based on the Boreal Summer Intra-Seasonal Oscillation, researchers at the Indian National Centre for Ocean Information Services (INCOIS) in Hyderabad have discovered a better technique to forecast waves.

- During the monsoon, BSISO is the transport of heat from the Indian Ocean to the western Pacific Ocean every 10-50 days (June-September).
- **It symbolises the monsoon's "active" and "break" periods**, when weeks of heavy rain give way to beautiful sunshine before the cycle begins all over again.
- Monsoon winds and, as a result, surface waves are enhanced during the active phase.

- In the worldwide monsoon system, it is one of the most notable sources of short-term climate variability.
- Compared with the related Madden-Julian Oscillation (MJO) it is more complex in nature, with prominent northward propagation and variability extending much further from the equator.

Significance of Study

- The break phase of BSISO during the monsoon season reduces the wave activity over the Northern Indian Ocean and can be utilized for offshore and coastal management activities during that time window.
- Study highlights that accurate representation of various climate modes in ocean models is very important to generate high accuracy wave forecasts up to three months in advance.

The Multidisciplinary Drifting Observatory for the Study of Arctic Climate (MOSAiC)

It is an international research expedition to study the physical, chemical, and biological processes that coupled the Arctic atmosphere, sea ice, ocean, and ecosystem.

- **The expedition was led by Germany's Alfred Wegener Institute (AWI)**, with key support from the U.S.'s Cooperative Institute for Research in Environmental Sciences (CIRES) at the University of Colorado Boulder, and the NOAA Physical Sciences Laboratory (PSL).
 - Overall, 17 nations were involved. However, India is not a member of the expedition.
- **Under the auspices of the International Arctic Science Committee(IASC)**, an international coalition of renowned arctic research institutions created the initiative.
- The scattered regional network of observational sites will be built up on the sea ice surrounding the ship icebreaker RV Polarstern throughout the year-round operation of study.
- MOSAiC's findings will help researchers better understand the regional and global repercussions of Arctic climate change and sea-ice loss, as well as improve weather and climate forecasting.

Glacial Lakes Outburst Floods

A portion of the Nanda Devi glacier broke off in Joshimath in Uttarakhand's Chamoli district, causing major flooding in parts of the state.

Glacial lakes are **Ice-dammed, moraine-dammed, and bedrock-dammed lakes**.

- These lakes are **generated when melt water from a glacier is trapped within a dammed structure**.
- Glaciers are melting and glacier lakes are growing in size and number as a result of global warming.

Regardless of the origin, a glacial lake outburst flood (GLOF) is a **sudden discharge of a considerable amount of water held in a glacial lake**.

- In India's Himalayan states, the building of moraine-dammed glacial lakes and glacial lake outburst floods (GLOF) are serious concerns.

According to recent studies, the number of glacial lakes has increased dramatically as a result of **glacier retreat induced by higher temperatures (due to global warming)**, and these lakes have the potential to inflict widespread flooding and destruction.

- A fracture in a big glacial lake was involved in the Kedarnath tragedy in 2013, for example.
- The Indus, Ganga, and Brahmaputra basins, respectively, have 352, 283 and 1,393 glacial lakes and water bodies, according to a study done by the **Central Water Commission (CWC)** between 2011 and 2015.

GLOFs are **triggered by a variety of factors**.

- **Slope migration into the lake at a breakneck pace**: Fast slope movement into the lake (slides, falls, and avalanches) causes displacement waves, which overtop the dam or trigger immediate dam breach.

- **Heavy rainfall/snowmelt and cascading** processes cause an increase in water intake into a lake (flood from a lake situated upstream)
- **Earthquake**: Dam breach and failure are the direct cause of earthquake-triggered lake outburst floods.
- **Long-term dam deterioration** occurs when the internal structure of the dam changes over time, resulting in increased hydrostatic pressure caused by basal ice melting and dam failure.
- **Black carbon**: The amount of black carbon produced by incomplete combustion of fossil fuels, wood, and other fuels is increasing, **lowering the earth's albedo and melting glaciers**.
- **Mass tourism, development interventions** such as roads and hydropower projects, and the practise of slash-and-burn farming in specific areas of the Indian Himalayan region are all examples of anthropogenic activities.

Impact of GLOFs

- **Property, infrastructure, and lives may be destroyed** or disrupted as a result of the sudden and strong flooding that occurs.
- **Impact on ocean circulation and climate**: The sudden release of a huge amount of cold freshwater into the ocean lowers the salinity of the surface layer, causing ocean circulation to change. This has an impact on the climate as well.
- **Local geomorphology altered**: GLOFs have the capacity to alter erosion-accumulation interactions and sediment dynamics, such as stream/river channel bank and depth erosion, meander shift, channel replacement and construction of new ones, and erosional terrace formation, among other things.

The **Glacial Lake Atlas of the Ganga Basin was issued by the Department of Water Resources, River Development, and Ganga Rejuvenation (DoWR, RD & GR)**.

Under the National Hydrology Project, the Ganga River Basin Atlas is published (NHP).

- The National Remote Sensing Centre (NRSC) and ISRO collaborated on the atlas under the National Hydrology Project (NHP).

Ganga River Basin

- The Ganga River basin spans India, Nepal, Tibet (China), and Bangladesh. It is also Known as the **Ganges-Brahmaputra-Meghna (GBM) River Basin**.
- **On the basis of the confluence of major rivers contributing to the system, the Ganga River basin has been divided into 11 sub basins** in this atlas, with the Yamuna entering on the right and rivers like Sarda, Ghaghara, Gandak, and Kosi joining on the left.

The Atlas's Important Findings

- For the present study, glacial lakes with a water spread area greater than 0.25 ha were mapped **using Resourcesat-2 (RS-2) Linear Imaging Self Scanning Sensor-IV (LISS-IV) satellite data**.
 - Based on its process of lake formation, location, and type of damming material, glacial **lakes are identified in nine different types**.
- **They are divided into four categories:**
 - moraine-dammed (form during periods of glacier retreat from a moraine),
 - ice-dammed (when drainage is blocked by a glacier that advances or thickens),
 - glacier erosion, and
 - other glacial lakes.

- Each glacial lake has been assigned a 12-digit alphanumeric ID as well as various properties such as hydrological, geometrical, geographical, and topographical qualities.
- Uttarakhand has 93.50 percent of the lake, with Himachal Pradesh having 6.50 percent.
- There are a total of 4,707 glacial lakes that have been identified.
 - More than half of the lakes (59.25 percent) are in the very high-altitude zone of greater than 5,000 m, and the Other Moraine Dammed Lake type dominates.
 - Glacial lakes are found in only 6 of the 11 subbasins, with the majority of them in the Kosi subbasin (51.77 percent), followed by the Ghaghara subbasin (26.77 percent).
 - The Yamuna subbasin has the fewest glacial lakes, followed by the Sarda subbasin.
 - The Glacier Ice-dammed Lake, located in the Gandak sub-basin, is the only one in the entire Ganga River basin.

Significance of the Map

- create a “comprehensive and systematic” glacial lake database for the Ganga River basin . The atlas could be used as reference for carrying out changes in the lakes over time, the spatial extent (expansion/shrinkage), and formation of new lakes.
- The information on glacial lakes including their type, hydrological, topographical, and associated glaciers are useful in identifying the potential critical glacial lakes and consequent GLOF (Glacial Lake Outburst Flood) events.
- The atlas can also be used in conjunction with glacier data to study the retreat of glaciers and the influence of climate change.
- The atlas can be used by central and state disaster management authorities for disaster mitigation planning and related programmes.

Cryosphere and Climate change

The Intergovernmental Panel on Climate Change (IPCC) Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC) states that “over the last decades, global warming has led to widespread shrinking of the cryosphere, with mass loss from ice sheets and glaciers, reduction in snow cover, and Arctic sea ice extent and thickness, and increased permafrost temperatures”.

Significance of Cryosphere

- It acts like a **highly reflective blanket(highest albedo)**; the cryosphere protects Earth from getting too warm.
- Snow and ice reflect more sunlight than open water or bare ground. Changes in snow and ice cover affect air temperatures, sea levels, ocean currents, and storm patterns all over the world.

Decline in Arctic Sea Ice

The effects of global warming can be observed most dramatically in the Arctic region, which is warming twice as rapidly as the global average. The Arctic ice cap is rapidly melting, and the volume of Arctic sea ice has decreased by up to 75%.

Impact of Melting Arctic Ice

- **Sea levels, salinity levels**, and current and precipitation patterns will all be affected by the loss of ice and warming waters.
 - As the polar jet stream shifts, it will result in more **harsh winters**.
- **Coastal community on risk:** Since 1900, the global average sea level has increased by around 7–8 inches, and the situation is worsening.
- **Release of Methane:** **Permafrost** (permanently frozen ground) in the Arctic region accumulates a substantial amount of methane, a greenhouse gas that contributes to climate change.

- **Impact on Food security:** Polar vortexes, increasing heat waves, and meteorological unpredictability induced by ice loss are already wreaking havoc on crops that are vital to global food systems.
- **Temperature Rise:** The loss of billions of tonnes of ice from Earth's frozen spaces is likely to increase global temperatures by an additional 0.4 degrees Celsius, according to research.

Why quick melt and slow refreeze?

- Variations in water temperatures and weather can affect the Arctic sea ice.
- Starting in May, warm air over Siberia led to rapid melting of ice in the East Siberian and Laptev seas.
- With large expanses of dark, ice-free water, the ocean was exposed to more heat than usual in the summer, which led to more melting.
- Until that heat escaped into the atmosphere, sea ice could not regrow, thus delaying the Arctic Ocean's refreeze.

"With continued global warming, it becomes more and more likely that we cross tipping points. "If the Paris Agreement is fulfilled we can avoid many of the strongest and potentially irreversible impacts on Earth's ice masses, the global climate and humanity."

GEOGRAPHICAL PERSPECTIVE TO DISASTERS IN INDIA

PYQ

1. Bring out the causes for more frequent landslides in the Himalayas than in Western Ghats. 2013
2. Major cities of India are becoming more vulnerable to flood conditions. Discuss. 2016
3. Mumbai, Delhi and Kolkata are the three mega cities of the country but the air pollution is much more serious problem in Delhi as compared to the other two. Why is this so? 2015
4. In what way can flood be converted into a sustainable source of irrigation and all weather inland navigation in India? 2017
5. Account for the huge flooding of million cities in India including the smart ones like Hyderabad and Pune. Suggest lasting remedial measures. 2020
6. Examine the status of forest resources of India and its resultant impact on climate change. 2020

Introduction:

- India has been vulnerable, in varying degrees, to a large number of natural, as well as, human-made disasters on account of its unique geo-climatic and socio-economic conditions.
- India is vulnerable to a wide range of natural hazards, particularly flooding, cyclones, drought, extreme heat waves, landslides, wildfire, and earthquakes.
- The DM Act 2005 uses the following definition for disaster: "Disaster" means a catastrophe, mishap, calamity or grave occurrence in any area, arising from natural or manmade causes, or by accident or negligence which results in substantial loss of life or human suffering or damage to, and destruction of, property, or damage to, or degradation of, environment and is of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area."

Due to vulnerability of different kinds of disasters, it is said that India is a disaster prone country, the reasons are:

According to the National Disaster Management Authority,

1. 85% of land vulnerable to single or multiple disasters
2. About 59% of the land area is vulnerable to earthquakes,
3. 12% is flood prone,
4. 8% is vulnerable to cyclones and
5. 70% of the land under cultivation is drought prone
6. 57% of area lies in high seismic zones

Hazard and Disaster:

- **Hazard** is a condition/event that has potential for causing injury/ loss of life or damage to property/environment.
- **Disaster** is an event that occurs suddenly/unexpectedly in most cases and disrupts the normal course of life in affected areas; results in loss or damage to life property or environment and is beyond the coping capacity of the local affected population/society and therefore requires external help.
- **Difference between a hazard and a disaster**

Hazard	Disaster
<p>1. A hazard is a dangerous physical condition or event.</p> <p>2. Earthquakes, floods, volcanic eruptions, landslides, droughts etc are called natural hazards before they cause loss of life and damage to property.</p> <p>3. Small number of people are affected.</p>	<p>1. A disaster disrupts the normal function of the society caused by a hazard.</p> <p>2. It causes damage to property and loss of life but it disrupts the opportunities of employment also.</p> <p>3. A large number of people are affected by it.</p>

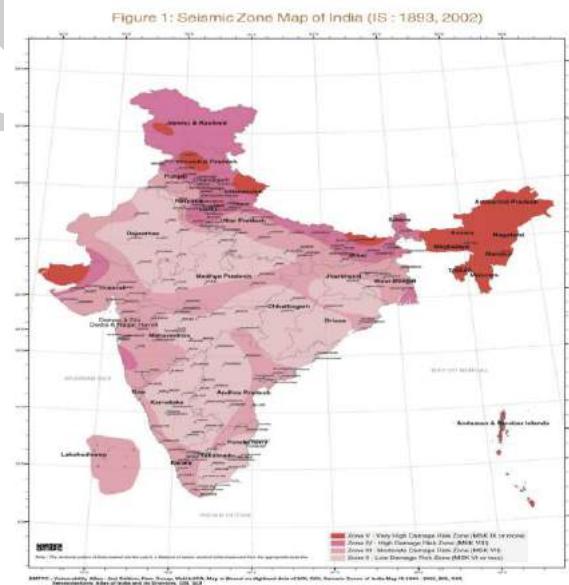
4. It may cause injury, loss of life or damage of property. 5. Earthquakes, floods, volcanoes, tsunami, landslide, drought etc. are natural hazards	4. It causes widespread loss to life and property. 5. It affects the society to such an extent that external aid becomes necessary to compensate for the losses.
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Classification of disaster

Atmospheric	Terrestrial	Aquatic	Biological
<ul style="list-style-type: none"> ● Blizzards ● Thunderstorms ● Lightning ● Tornadoes ● Tropical Cyclone ● Drought ● Hailstorm ● Frost, Heat Wave or Loo. ● Cold Waves, etc. 	<ul style="list-style-type: none"> ● Earthquakes ● Volcanic Eruptions ● Landslides ● Avalanches ● Subsidence ● Soil Erosion 	<ul style="list-style-type: none"> ● Floods ● Tidal Waves ● Ocean Currents ● Storm Surge ● Tsunami 	<ul style="list-style-type: none"> ● Plants and Animals as colonisers (Locusts, etc.). Insects infestation— fungal, bacterial and viral diseases such as bird flu, dengue, etc.

Natural Disaster And Hazard in India**A : EARTHQUAKE****Introduction:**

- An earthquake is the shaking of the surface of the Earth resulting from a sudden release of energy in the Earth's lithosphere that creates seismic waves.
- In Indian context, Movement of Indian plate is being constantly obstructed by the Eurasian plate resulting in excessive accumulation of energy that ultimately leads to the sudden release of energy causes earthquakes along the Himalayan arch
- India's high earthquake risk and vulnerability is evident from the fact that about 59 per cent of India's land area could face moderate to severe earthquakes.

**India and Earthquake:**

- During the last 15 years, the country has experienced 10 major earthquakes that have resulted in over 20,000 deaths.
- The entire Himalayan belt is susceptible to great earthquakes of magnitude more than 8.0. The main cause of earthquakes in these regions is due to the movement of the Indian plate towards the Eurasian plate at the rate of about 50 mm per year.
- Besides the Himalayan region and the Indo-Gangetic plains, even the peninsular India is prone to damaging earthquakes as clearly illustrated by the Koyna (1967), Latur (1993), and the Jabalpur (1997) earthquakes.

Earthquake prone areas:

<https://onlyias.com>

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info@onlyias.com /+91-7007931912

Join IDMP: dpp.onlyias.in

The Bureau of Indian Standards has classified regions in India into four seismic zones on the basis of historical seismic activity. These are zones II, III, IV and V. Among these, Zone V is the most seismically active region and zone II is the least active.

- **Zone V:** Entire North-eastern India, parts of Jammu and Kashmir and Himachal Pradesh, Uttarakhand, Rann-of Kutch in Gujarat, parts of North Bihar and Andaman & Nicobar Islands.
- **Zone-IV:** Remaining parts of Jammu and Kashmir and Himachal Pradesh. Delhi-NCR region, Sikkim, northern parts of Uttar Pradesh, Bihar and West Bengal, parts of Gujarat and small portions of Maharashtra near the west coast and Rajasthan.
- **Zone III:** Goa, Kerala, Lakshadweep, remaining parts of Uttar Pradesh, Gujarat and West Bengal, parts of Punjab, Rajasthan, Madhya Pradesh, Bihar, Jharkhand, Chhattisgarh, Maharashtra, Orissa, Andhra Pradesh, Tamilnadu and Karnataka.
- The remaining portion of the country falls under zone II.

Seismic Zones	% of Geographical Area
II	41.40
III	30.40
IV	17.30
V	10.90
	58.6%

Socio environmental consequences of earthquakes:

- **Fear and horror:** The idea of earthquakes is often associated with fear and horror due the scale, magnitude and suddenness at which it spreads on the surface of the earth without discrimination.
- **Calamity:** It becomes a calamity when it strikes the areas of high density of population.
- **Damages and destruction:** It not only damages and destroys the settlement, infrastructure, transport and communication networks, industries and other developmental activities but also robs the population of their material and socio-cultural gains that they have preserved over generations.
 - It renders them homeless, which puts an extra pressure and stress, particularly on the weak economy of developing countries.

Impact of Earthquake

- **Human loss** - Duration of tremors of earthquake is normally of only a few seconds, but thousands of people may die in this short period 563 earthquakes, including related tsunamis, accounted for 56% of the total deaths or 747,234 lives lost between 1998 to 2017.
- **Structural Damage:** According to the World bank 10% of damage occurs to infrastructure due to earthquakes. Dams on river collapse, resultant floods cause havoc. The earthquake in 1967 in Koyna damaged the Dam
- **Surface Rupture & Ground Displacement:** The primary earthquake hazard is surface rupture. It can be caused by vertical or horizontal movement on either side of a ruptured fault. Ground displacement, which can affect large land areas, can produce severe damage to structures, roads, railways and pipelines.
- **Economic impact:** The total loss of public and private property was estimated at 4.97 billion USD according to the World Bank and the percentage loss in terms of GDP was 1% of India's GDP of India.
- **Changes in river courses:** Sometimes river channels are blocked or their courses are changed due to the impact of the earthquake. eg. Brahmaputra river, Indus River.
- **Landslides:** Earthquakes can trigger landslides and mudslides, especially in areas with water-soaked soils.e.g. Malin landslide, Maharashtra, Kedarnath landslide, Uttarakhand.
- **Liquefaction:** The shaking from an earthquake can turn loose soil into a liquid during an earthquake.
- **Tsunamis:** An earthquake generates a tsunami, which is actually a series of very long waves. Large tsunamis which travel to the ocean floor to the surface are dangerous to human health, property, and infrastructure. e.g. 2004 Indian Ocean earthquake and tsunami.
- **Fires:** Earthquake fires start when electrical and gas lines are dislodged due to the earth's shaking.

Theory of emergence of a fault line: some earth scientists have come up with a theory of emergence of a fault line and energy build-up along the fault line represented by the river Bhima (Krishna) near Latur and Osmanabad (Maharashtra) and the possible breaking down of the Indian plate.

Earthquake swarm:

- The **Palghar district in northern Maharashtra** has been witnessing unusual tremors as an ‘earthquake swarm’ which is a series of low magnitude earthquakes that occur in a localised region over a period of time.
- Similarly earthquakes swarms were recorded in the Rampur area of Himachal Pradesh. This Himalayan swarm was later attributed to low strength of the earth’s crust in the area which could not hold the tectonic energy.

Koyna earthquake: The Koyna earthquake was human-made and was caused by the huge Koyna dam completed in 1962. Such an earthquake can occur through the process of Reservoir Induced Seismicity (RIS)

Current developments:

Earthquake in Manipur:

- According to the United States Geological Survey (USGS) an earthquake of magnitude 4.9 on the Richter scale hit Manipur.
- The earthquake occurred in Manipur’s Ukhrul, at a distance of 38 km from Sikhong Sekmai.
- The tremors of the earthquake that hit at a depth of 59.7 km were felt in both India and Myanmar

Earthquake in Gujarat:

- An earthquake of magnitude 4.3 was recorded in and around Jamnagar city of Gujarat.
- This earthquake hit 14 km South-South-West of Jamnagar city at a depth of 14 kms.

Earthquake in Assam:

- The Assam earthquake struck 11 km away from Dhekiajuli, Assam, with a magnitude of 6.0 and a Richter scale magnitude of 6.4.
- The earthquake struck at a depth of 34 km, 140 km north of the main city of Guwahati.

Way Forward:

- **Building codes:** Re-framing buildings' codes, guidelines, manuals and byelaws and their strict implementation.
- **Public utilities:** Making all public utilities like water supply systems, communication networks, electricity lines etc. earthquake-proof.
- **Research and development:** Supporting R&D in various aspects of disaster mitigation, preparedness and prevention and post-disaster management.
- **Education:** Evolving educational curricula in architecture and engineering institutions and technical training in polytechnics and schools to include disaster related topics.
- **Literature:** Preparation of disaster related literature in local languages with dos and don'ts for construction.
- **Community participation:** Getting communities involved in the process of disaster mitigation through education and awareness.
- **Role of NGO:** Networking of local NGOs working in the area of disaster management

Conclusion:

"It is not the disaster, but the lack of preparedness to disaster that kills". The solution to minimise the loss of lives and properties is the effective preparedness against the earthquake. Thus, disaster preparedness is one of the most vital components in disaster management. People's participation, cooperation and awareness among all stakeholders will help to reduce disaster.

OnlyIAS Nothing Else

B : Cyclones

Introduction:

- The major natural disaster that affects the coastal regions of India is cyclones and as India has a coastline of about 7516 kms, it is exposed to nearly 10 percent of the world's tropical cyclones.
- Tropical cyclones are intense low-pressure areas confined to the area lying between 30° N and 30° S latitudes, in the atmosphere around which high velocity winds blow.
- The air circulates inward in an anticlockwise direction in the Northern hemisphere and clockwise in the Southern hemisphere.

Initial conditions for the emergence of a tropical cyclone are:

- Large and continuous supply of warm and moist air that can release enormous latent heat.
- Strong Coriolis force that can prevent filling of low pressure at the centre (absence of Coriolis force near the equator prohibits the formation of tropical cyclone between 0 - 5 latitude)
- Unstable condition through the troposphere that creates local disturbances around which a cyclone develops
- Absence of strong vertical wind wedge, which disturbs the vertical transport of latent heat.

Classification of Tropical Cyclones:

Table 1.4 Indian Classification of Cyclonic Disturbances in the North Indian Ocean (Bay of Bengal and Arabian Sea)

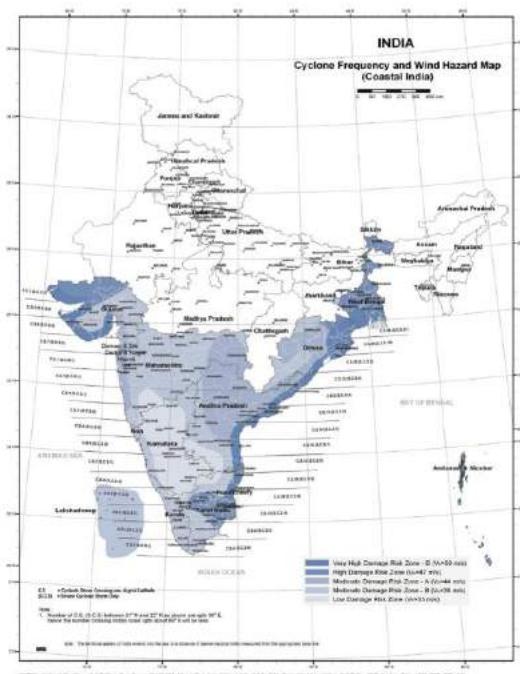
Type	Wind Speed in km/h	Wind Speed in Knots
Low Pressure area	Less than 31	Less than 17
Depression	31–49	17–27
Deep Depression	50–61	28–33
Cyclonic Storm	62–88	34–47
Severe Cyclonic Storm	89–118	48–63
Very Severe Cyclonic Storm	119–221	64–119
Super Cyclone	222 or more	120 or more

Source: India Meteorological Department.

Occurrence of cyclones:

- In India, most of the cyclones occur in the post monsoon season, i.e. from October to December or in the pre-monsoon season from April to May.
- The lifespan of a cyclone is generally from 7 to 14 days.

Figure 1 (a): Cyclone Frequency and Wind Hazard Map



Location:

- About 71 percent of this area is in ten states (Gujarat, Maharashtra, Goa, Karnataka, Kerala, Tamil Nadu, Puducherry, Andhra Pradesh, Orissa and West Bengal).
- The islands of Andaman, Nicobar and Lakshadweep are also prone to cyclones. On an average, about five or six tropical cyclones form in the Bay of Bengal and Arabian sea and hit the coast every year. Out of these, two or three are severe.

Impact of cyclones :

- Human loss:** Cyclones, which are responsible for much loss of life, damage to property and deterioration of day to day life.
- Economic impact:** Impacts of cyclones cause direct economic losses such as loss in asset value, reduction in investments which is a socioeconomic impact of a disaster.
- Food scarcity:** Food scarcity is the main impact of cyclones as they lose their agricultural supplies.
- Livelihood:** Cyclones mostly affect coastal districts. Several people in coastal villages who depended only on fishing had lost access to food and clean drinking water as fishing was prohibited.

- **Structural damage:** Damage to infrastructures such as roads, bridges, revetment results in loss to both public and Government.
- **Floods:** Cyclones may result in heavy rainfall and floods which is the next devastation to the environment. Floods caused by the cyclone can cause waterlogging in unwanted places which causes many diseases.
- **Agricultural damage:** Devastation of crops may result in reduced income for farmers, increased prices for food, unemployment, increased crimes which in turn human populations are at higher level of risk.
- **Sea level:** Abnormal rise in sea level caused by cyclones is known as storm surge.
- **Inequality:** The impact of a natural disaster may also cause inequalities. The poor, who suffer from income fluctuations, and also have limited access to financial services, in the aftermath of a disaster, may be more prone to scarcity.

Very few tropical cyclones during southwest monsoon season

- The southwest monsoon is characterised by the presence of strong westerly winds in the lower troposphere (below 5 km) and very strong easterly winds in the upper troposphere. This prevents upward movement of air.
- Also the potential zone for the development of cyclones shifts to North Bay of Bengal during southwest monsoon season.
- During this rainy season, the low pressure system upto the intensity of depressions form along the monsoon trough, which extends from northwest India to the north Bay of Bengal.
- The depression forming over this area crosses Orissa-West Bengal coast in a day or two. These systems have shorter oceanic stay which is also one of the reasons for their non-intensification into intense cyclones.

Fewer cyclones over Arabian Sea compared to Bay Of Bengal:

- The Arabian sea is colder than the Bay of Bengal, hence the tropical cyclone generated is weak and many fades away before reaching the characteristic level.
- The Arabian sea is more enclosed compared to Bay of Bengal which is extensively connected to the north pacific.
- For tropical cyclones a wide sea area with warm water is necessary to provide sufficient condensation force. The frequency of typhoons observed in north pacific shows its influence on Bay of Bengal and more cyclones are found here.
- Location of Arabian sea: Tropical cyclones normally move from east to west. Bay of Bengal has wide area but Arabian sea has geographical constraint.

Recently, The Arabian Sea is one of the fastest warming basins across the global oceans.

One of the reasons for cyclones in the Arabian Sea is because of ocean warming, rapid ocean warming.

Recent Current development :

Super Cyclonic Storm Amphan :

- Cyclone Amphan was a powerful and catastrophic tropical cyclone that caused widespread damage in Eastern India, specifically West Bengal, Odisha and in Bangladesh in May 2020.
- It was the strongest tropical cyclone to strike the Ganges Delta since Sidr of the 2007 season and the first super cyclonic storm to have formed in the Bay of Bengal since the 1999 Odisha cyclone.
- It was also the fourth super cyclone that hit West Bengal and Kolkata since 1582, after 1737, 1833 and 1942, as well as being one of the strongest storm to impact the area.

Cyclone Tauktae :

- Extremely Severe Cyclonic Storm Tauktae was a powerful, deadly and damaging tropical cyclone in the Arabian Sea that became the strongest tropical cyclone to make landfall in the Indian state of Gujarat since the 1998 Gujarat cyclone.
- It is one of the strongest tropical cyclones to ever affect the west coast of India and first extremely severe cyclonic storm of the 2021 North Indian Ocean cyclone season.

Cyclone Nisarg

- Severe Cyclonic Storm Nisarga was the strongest tropical cyclone to strike the Indian state of Maharashtra in the month of June since 1891.
- It was also the first cyclone to impact Mumbai since Phyan of 2009.

- Nisarga originated as a depression in the Arabian Sea and moved generally towards the coastline of north Maharashtra and south Gujarat.

Cyclone Nirav :

- Very Severe Cyclonic Storm Nivar was a tropical cyclone which brought severe impacts to portions of Tamil Nadu and Andhra Pradesh.
- Nivar originated from a disturbance in the Intertropical Convergence.

Way Forward:

- **Construction of cyclone shelter:** The cyclone shelters should be designed for multi-purpose use such as school buildings, community centers, or any other public utility buildings so as to ensure that these buildings act as resistance to cyclones.
- **Construction of canals and embankments for improved drainage:** A canal network in the coast is an effective tool of water management. Besides improvement to minor drains in the coastal areas may be considered for effective drainage of water.
- **Shelterbelt plantation:** Shelterbelts are barriers of trees that are planted to reduce wind velocities and prevent wind erosion. Main objective of windbreaks and shelterbelts is to protect the human habitations and agricultural crops.
- **Construction of missing road links:** Effective road connectivity ensures fast deployment of men, materials and machinery to affected areas. It helps in ensuring speedy evacuation of people from vulnerable places to safer areas in the face of an impending disaster threat.
- **Capacity building :** While the hazards due to tropical cyclones cannot be reduced, mitigation strategies to reduce their impacts can be devised.
- **Improvement of on-shore warning system:** Early reliable warning is one of the important short term mitigation measures that can reduce the severity of the cyclone related disasters if acted upon timely.
- **Retrofitting of vital installations:** Roads/culverts/bridges in the cyclone prone areas need to be maintained well. If they are in a bad shape their repair and strengthening work also needs to be given utmost attention.
- **Awareness generation for cyclone risk mitigation:** The public awareness programme is an important component of disaster risk management. Involvement of communities under threat is essential for the success of any disaster risk reduction programme.
- **Approach:** Thus a multi-pronged approach is needed to mitigate the risk of tropical cyclones, which shall be certainly helpful for minimal loss of life and resources.

Conclusion: Tropical cyclones are natural phenomena which India faces frequently. With the advent of climate change, tropical cyclones are developing more frequently and accompanied by increased intensity. Regardless of state support and administrative help, people themselves have to step up to create local solutions using their own practices. People's participation, cooperation and awareness among all stakeholders will help to reduce disaster.

C. Drought:

Introduction:

- The term 'drought' is applied to an extended period when there is a shortage of water availability due to inadequate precipitation, excessive rate of evaporation and over-utilisation of water from the reservoirs and other storages, including the groundwater.
- According to the Union Agriculture and Cooperation Ministry's Drought Crisis Management Plan document 68 percent of the country is prone to drought with nearly 33 per cent area having a chronic drought problem while another 35 per cent is drought-prone

Types of Droughts

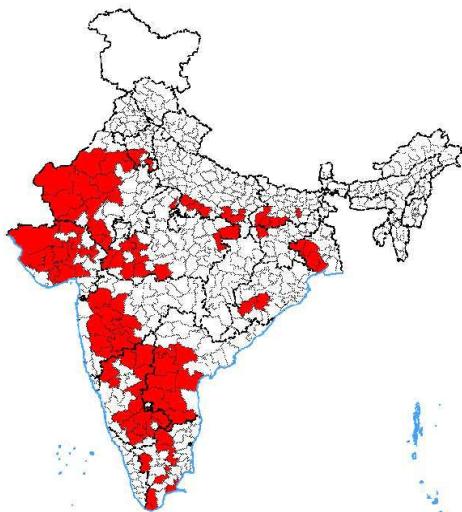
- **Meteorological Drought :** It is a situation when there is a prolonged period of inadequate rainfall marked with mal-distribution of the same over time and space.
- **Agricultural Drought :** It is also known as soil moisture drought, characterised by low soil moisture that is necessary to support the crops, thereby resulting in crop failures.
- **Hydrological Drought :** It results when the availability of water in different storages and reservoirs like aquifers, lakes, reservoirs, etc. falls below what the precipitation can replenish.

- **Ecological Drought :** When the productivity of a natural ecosystem fails due to shortage of water and as a consequence of ecological distress, damages are induced in the ecosystem

Causes of drought

- Uneven distribution of rainfall over different parts of the country.
- Low average annual rainfall of 750mm over 33% of cropped area heightens susceptibility to drought.
- Over-exploitation of ground water and sub-optimum conservation of surface water leading to inadequate water availability for irrigation.
- Limited irrigation coverage and poor irrigation techniques: Net irrigated area in the country is less than 50%. The impact of drought on account of complete dependence of agriculture in such areas on rainfall

India can be divided into the following regions:



- **Extreme Drought Affected Areas :** Most parts of Rajasthan, particularly areas to the west of the Aravali hills and Kachchh regions of Gujarat fall in this category.
- **Severe Drought Prone Area :** Parts of eastern Rajasthan, Madhya Pradesh, Maharashtra, Andhra Pradesh, Karnataka Plateau, Tamil Nadu, Jharkhand and Odisha
- **Moderate Drought Affected Area :** Rajasthan, Haryana, Uttar Pradesh, Gujarat, Maharashtra, Jharkhand and Tamil Nadu.
- The remaining parts of India can be considered either free or less prone to drought.

Impact of drought :

- **Socio-economic:** Droughts cause scarcity of food and water, People die of hunger, malnutrition and epidemics and Impact on the health of people.
- **Economic:** Agricultural contributions to the Gross Domestic Product (GDP) dipped by 3.1 per cent and agricultural income losses were estimated at Rs 39,000 crore.
- **Agricultural :** Crops fail due to scarcity of water. Severe droughts in rainfed areas have reduced agricultural production by 20 to 40 per cent.
- **Employment:** Farmers are deprived of their employment .Nearly 50 per cent of the rural workforce is concentrated in drought prone districts.
- **Poverty:** Drought and poverty are interconnected with millions of very poor people living in drought-prone areas
- **Migration:** People are forced to migrate from their area of residence in the pursuit of food, water, green fodder and employment.

Southern India drought:

- A severe drought that hit southern India during 2016-2018 was the worst to hit the region over the past 150 years and was associated with a deficit in the northeastern monsoon.
- Drought conditions linked to northeastern monsoonal rainfall across southern India are associated with cool phases of the tropical Indo-Pacific Ocean. Cool phases of the Pacific Ocean are known as La Niña.

Way Forward:

- **Suitable farming methods for arid areas :** By adopting the following methods it is possible to mitigate the intensity of drought. The methods are: Production of coarse and hardy cereals; conservation of soil moisture by deep ploughing, storing water behind small dams, collecting water in ponds and tanks and use of sprinklers for irrigation.
- **Sowing drought resistant crops:** By sowing drought resistant crops of cotton, Moong, pearl millet, wheat etc, the impact of drought could be mitigated to a certain extent.

- **Rain water harvesting :** Collection of each and every drop of rain could help in coping with the drought. By making high bunds around the fields, adoption of terrace cultivation, planting trees on the bunds of fields, the use of rainwater can be maximised.
- Water can also be conserved by taming the irrigation canals with mortar and bricks.
- Small quantity of water can irrigate a comparatively larger area by using a drip irrigation method.

Conclusion: Government needs to invest in Research and Development projects to invent new techniques for effective water management in our country. Climate change will potentially be increasing the frequency of events like droughts. Effective implementation of medium and long term solutions will help mitigate the impact of droughts.

D. Landslides:

Introduction:

- Landslides are simply defined as the mass movement of rock, debris or earth down a slope and have come to include a broad range of motions whereby falling, sliding and flowing under the influence of gravity dislodges earth material
- Landslides are among the major hydro-geological hazards that affect large parts of India covering about 15 % of the landmass.
- Landslides occur in the hilly regions of India such as the Himalaya, North-East India, the Nilgiris, Eastern Ghats and Western Ghats. It is estimated that 30 percent of the World's landslides occur in the Himalayan ranges.

Causes of landslides

- **Heavy rain :** Heavy rain is the main cause of landslides.
- **Deforestation :** Deforestation is another major cause of landslides. Trees, bushes and grasses keep the soil particles compact. Mountain slopes lose their protective cover by felling of trees. The rain water flows on such slopes with unimpeded speed.
- **Earthquakes and volcanic explosions :** Earthquake is a common feature in the Himalaya. Tremors destabilize the mountains and the rocks tumble downwards. Volcanic explosions also trigger landslides in the mountainous areas.
- **Building of roads:** During the process of the construction of the road, a large amount of rocks and debris has to be removed. This process dislodges the rock structure and changes the angle of slopes. Consequently landslides are triggered.
- **Shifting agriculture :** In the North Eastern part of India, the number and frequency of landslides has increased due to the practice of shifting agriculture.
- **Construction of houses and other buildings :** For giving shelter to the ever-increasing population and promotion of tourism, more and more houses and hotels are being built. In building processes large amounts of debris are created. This causes landslides.

Landslide Vulnerability Zones

India has been divided into a number of zones.

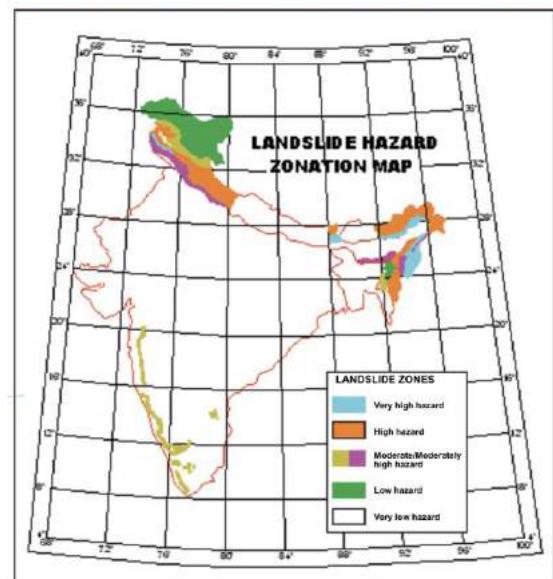
- Very High Vulnerability Zone : Highly unstable, relatively young mountainous. high rainfall regions with steep slopes in the Western Ghats and north-eastern regions, along with areas that experience frequent ground-shaking due to earthquakes.
- High Vulnerability Zone : All the Himalayan states and the states from the north-eastern regions except the plains of Assam are included in the high vulnerability zones.
- Moderate to Low Vulnerability Zone : Areas that receive less precipitation, rain shadow areas in the Western and Eastern Ghats.
- Other Areas : The remaining parts of India.

Impact of landslide

- **Degrading of environment :** Landslides are degrading the environment of mountains. Natural beauty is diminishing.
- Loss of Lives and property

- Flooding in rivers is increasing.
- **Restricts Movement:** The mud, rocks, and debris moving down the slope create a barrier on critical transportation routes like highways, railway lines, etc. This restricts the movement of goods and people.
- **Infrastructural Damage:** Several houses, buildings, roads, and other infrastructure get damaged whenever a landslide occurs.
- **Economic Losses:** A significant amount is spent on reconstructing the lost infrastructure, rehabilitating the masses, and providing relief support to the impacted people.
- **Sources of water are drying up:** When landslides occur on the slopes of a river valley, the sliding mass may reach the bottom of the valley and cause partial or complete blockage of the river channel. It may impair the availability of water for nearby people.

Figure 1.2: Landslide Hazard Zonation Map of India (Prepared by GSI)



Way Forward:

- **Afforestation:** Trees and brushes help in binding the soil particles.
- **New technology in road construction:** Roads should be constructed in such a way that a lesser amount of debrisses is generated.
- **Banning:** Ban on quarrying of stones and mining of minerals
- **Forest use:** Instead of exploitation of forests, they should be used scientifically.
- **Crop replacement:** Permanent crops like orchards of fruits should replace the seasonal or annual drops.
- **Water control:** By controlling the surface flow of water, seepage of water should be minimised.
- **Retaining walls:** It can be built on mountain slopes to stop land from slipping.
- **Mapping:** Hazard mapping should be done to locate areas commonly prone to landslides.

Conclusion:

Landslides are one among the other natural hazards, which cannot eliminate completely but preparedness for hazards and suitable warning systems can minimize the losses. By above measures we can mitigate the landslides to some extent but disaster preparedness is also very important especially incase of unavoidable disaster events. Collective participation and awareness among people can even contribute towards its mitigation.

E. Heat wave

Introduction:

- The World Meteorological Organization defines a heat wave as five or more consecutive days of prolonged heat in which the daily maximum temperature is higher than the average maximum temperature by 5 °C.
- A heat wave is a condition of air temperature which becomes fatal to the human body when exposed.
- Higher daily peak temperatures and longer, more intense heat waves are becoming increasingly frequent globally due to climate change.

Criterion for declaring heat waves in India.

- Heat wave is considered if the maximum temperature of a station reaches at least 40°C or more for Plains and at least 30°C or more for Hilly regions.
- Based on Departure from Normal Heat Wave: Departure from normal is 4.50°C to 6.40°C. Severe Heat Wave: Departure from normal is >6.4°C
- When actual maximum temperature $\geq 45^{\circ}\text{C}$. Severe Heat Wave: When actual maximum temperature $\geq 47^{\circ}\text{C}$
- If the above criteria met at least in 2 stations in a Meteorological subdivision for at least two consecutive days and it declared on the second day.
-

Favorable conditions for Heat waves.

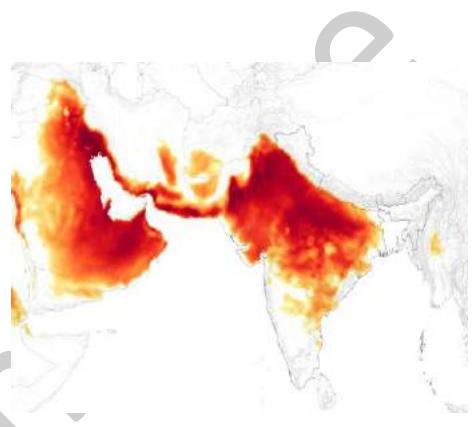
- Transportation / Prevalence of hot dry air over a region.
- Absence of moisture in the upper atmosphere
- The sky should be practically cloudless
- Large amplitude anticyclonic flow over the area.

Occurrence of heat wave :

It is occurring mainly during March to June and in some rare cases even in July. The peak month of the heat wave over India is May.

Heat wave prone states:

- Heat waves generally occur over plains of northwest India, Central, East & north Peninsular India
- It covers Punjab, Haryana, Delhi, Uttar Pradesh, Bihar, Jharkhand, West Bengal, Odisha, Madhya Pradesh, Rajasthan, Gujarat, parts of Maharashtra & Karnataka, Andhra Pradesh and Telangana. Sometimes it occurs over Tamilnadu & Kerala also.
- Maximum temperatures more than 45°C are observed mainly over Rajasthan and Vidarbha region in the month of May.
- Region wise analysis shows that the maximum count of heat wave events has been detected in northwest (30 percent) followed by central northeast (28 per cent) and central west (19 per cent) regions, whereas least over hilly (1 percent)



Impact of Heat Waves:

- **Risk of Wildfires:** The heat waves act as fuel to wildfires, which destroys a lot of land area every year.
- **Prevents Cloud Formation:** The condition also prevents clouds from forming, allowing for more radiation from the sun to hit the ground.
- **Heat Strokes and Sudden Fatalities:** The very high temperatures or humid conditions pose an elevated risk of heatstroke or heat exhaustion.
- **Health problems:** Older people and people with chronic illness such as heart disease, respiratory disease, and diabetes are more susceptible to heatstroke, as the body's ability to regulate heat deteriorates with age.
- **Effect on Vegetation:** The trapping of heat can also damage crops, dry out vegetation and result in droughts.
- **Increased Energy Demands:** The sweltering heat wave also leads to rise in energy demand, especially electricity, leading to pushing up rates.

Way forward:

- **Early warning system:** Establish Early Warning System and Inter-Agency Coordination to alert residents on predicted high and extreme temperatures to various government agencies especially for health.
- **Capacity building:** Capacity building / training programme for health care professionals at local level to recognize and respond to heat-related illnesses, particularly during extreme heat events so they can effectively prevent and manage heat - related medical issues to reduce mortality and morbidity.
- **Awareness:** Public Awareness and community outreach - Disseminating public awareness messages on how to protect against the extreme heat
- **Collaboration with non government and civil society:** Collaboration with non-governmental organizations and civil society organizations to improve bus stands, building temporary shelters, wherever necessary, improved water delivery systems in public areas and other innovative measures to tackle Heat wave conditions.

Conclusion:

Human-induced climate change has contributed to changing patterns of extreme weather across the globe, from longer and hotter heat waves to heavier rains. Intensity and frequency of heat waves can be reduced by creating awareness among people and disaster preparedness measures to mitigate the Impact of heat waves.

F: Forest fire :

Introduction:

- Forest fire may be defined as an unclosed and freely spreading combustion that consumes the natural fuels. Combustion is another word for fire. When a fire burns out of control it is known as WildFire.
- Fire is a good servant but a bad master” the saying is true for forest fire too.
- Limited and controlled forest fires have been very useful and essential for healthy forest growth.
- But uncontrolled forest fire may engulf and destroy healthy thick forest cover within no time.

Classifications of forest fire depending upon their nature and size

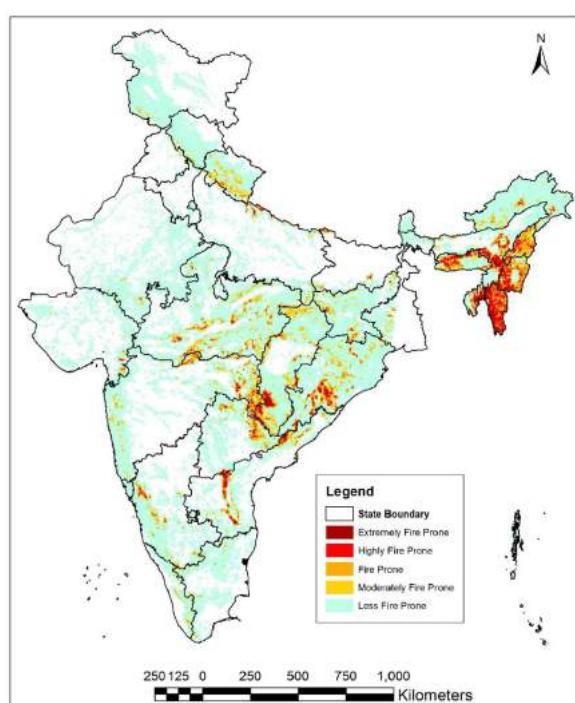
- **Surface fires:** Surface fire is the most common forest fires that burn undergrowth and dead material along the floor of the forest.
- **Underground fires:** The fires of low intensity, consuming the organic matter beneath and the surface litter of forest floor
- **Ground fires:** This fire burns root and other material on or beneath the surface i.e. burns the herbaceous growth of forest floor.
- **Crown fires:** Crown fires are the most unpredictable fires that burn the top of trees and spread rapidly by wind.

Causes of Forest fire

- **Natural causes-** Many forest fires start from natural causes such as lightning which set trees on fire. However, rain extinguishes such fires without causing much damage. High atmospheric temperatures and dryness (low humidity) offer favourable circumstances for a fire to start.
- **Man made causes-** Fire is caused when a source of fire like naked flame, cigarette or bidi, electric spark or any source of ignition comes into contact with inflammable material. More than ninety five percent of forest fires are anthropogenic.

Forest prone to fire :

- As of 2019, about 21.67% (7,12,249 sq km) of the country's geographical area is identified as forest, according to the India State of Forest Report 2019.
- Forests of the Northeast and central India regions are the most vulnerable areas to forest fires.
- Forests in Assam, Mizoram and Tripura have been identified as 'extremely prone' to forest fire.
- States with large forest areas under the 'very highly prone' category include Andhra Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Odisha, Maharashtra, Bihar and Uttar Pradesh.



Impact of forest fires:

Environmental:

- loss of valuable timber resources
- degradation of water catchment areas resulting in loss of water.
- loss of biodiversity and extinction of plants and animals
- loss of wildlife habitat and depletion of wildlife
- loss of natural regeneration and reduction in forest cover
- global warming
- Loss of carbon sink resource and increase in percentage of CO₂ in atmosphere

- soil erosion affecting productivity of soils and production
- ozone layer depletion

Health:

- change in the microclimate of the area with unhealthy living conditions
- health problems leading to diseases

Livelihood:

- loss of livelihood for tribal people and the rural poor, as approximately 300 million people are directly dependent upon collection of non-timber forest products from forest areas for their livelihood.

Way forward:

- **Fire fighting reservoirs:** Water is still the main way to extinguish forest fires. Therefore in large, contiguous and fire endangered forested areas it is necessary to have, or build and maintain, a fire fighting water supply system within suitable water courses or to create artificial reservoirs for water extraction.
- **Infrastructure:** In order for fire engines to reach a forest stand it is important that the roads can bear heavy vehicles.
- **Machinery and equipment:** Maintaining appropriate fire-fighting tools and machinery is necessary to tackle forest fire.
- **Forest Fire Monitoring:** Using forest fire observation systems, the number of forest fires has not reduced but their extent has reduced.
- **Aerial Surveillance:** Aerial surveillance flights are a possible means to detect forest fires at an early stage during times of high fire risk.
- **Communication equipment:** Forest fires can only be quickly and successfully fought with functioning communication between the fire service and forest authority operational teams.
- **Cooperation and joint exercises:** Collaboration between forest owners, the administration and different branches of the fire and emergency services is of special importance when it comes to forest fires.

Conclusion:

Forest fires are usually seasonal. They usually start in the dry season and can be prevented by adequate precautions. The best way to control a forest fire is therefore, to prevent it from spreading, which can be done by creating firebreaks in the shape of small clearings of ditches in the forest.

Recent forest fires:

- Uttarakhand, Himachal Pradesh (Kullu Valley), Nagaland-Manipur border (Dzukou Valley), Nainital and Simlipal National Park in Odisha saw a major fire in 2021
- Uttarakhand and Himachal Pradesh are the two states that witness the most frequent forest fires annually.
- In Uttarakhand, the lack of soil moisture too is being seen as a key factor. In two consecutive monsoon seasons (2019 and 2020), rainfall has been deficient by 18% and 20% of the seasonal average, respectively
- In Odisha, which saw a major fire in Simlipal forest, villagers are known to set dry leaves to fire in order to collect mahua flowers, which go into preparation of a local drink.

Floods :**Introduction:**

- India is highly vulnerable to floods. Out of the total geographical area of 329 million hectares (mha), more than 40 mha is flood prone.
- Floods are a recurrent phenomenon, which cause huge loss of lives and damage to livelihood systems, property, infrastructure and public utilities.

Flood distribution in India

- India's high-risk vulnerability is highlighted by the fact that 40 million hectares out of the geographical area of 3290 lakh hectares are prone to floods, which is 12%.
- State-wise study shows that about 27% of the flood damage in the country is in Bihar, 33% in Uttar Pradesh and Uttarakhand, and 15% in Punjab and Haryana.
- The middle and lower courses of North Indian rivers such as Ganga, Brahmaputra, Kosi, Damodar, Mahanadi, etc. Are prone to floods due to very low gradients.

- Peninsular rivers are mature and have hard rock beds, so they have shallow basins. This makes them prone to flooding.

The causes of flood in India:

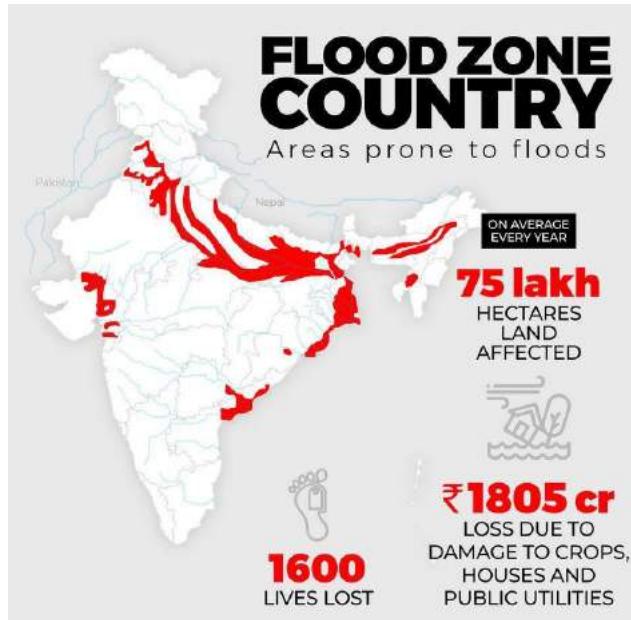
- Heavy rainfall :** Heavy rain in the catchment area of a river causes water to overflow its banks, which results in the flooding of nearby areas.
- Sediment deposition :** River beds become shallow due to sedimentation. The water carrying capacity of such rivers is reduced. As a result the heavy rain water overflows the river banks.
- Deforestation :** Vegetation hampers the flow of water and forces it to percolate in the ground. As a result of deforestation, the land becomes obstruction free and water flows with greater speed into the rivers and causes floods.
- Cyclone :** Cyclone generated seawaves of abnormal height spreads the water in the adjoining coastal areas. In October 1994 Orissa cyclone generated severe floods and caused unprecedented loss of life and property.
- Interference in drainage system:** Drainage congestion caused by badly planned construction of bridges, roads, railway tracks, canals etc. hampers the flow of water and the result is flood.
- Change in the course of the river:** Meanders and change in the course of the river cause floods.
- Tsunami :** Large coastal areas are flooded by rising sea water, when a tsunami strikes the coast.

Flood prone areas :

- Assam, West Bengal and Bihar are among the high flood prone states.
- Apart from these, most of the rivers in the northern states like Uttar Pradesh and Punjab are also vulnerable to frequent floods.
- States like Rajasthan, Gujarat, Haryana and Punjab are also getting inundated in recent years due to flash floods. This is partly because of the pattern of monsoon and partly because of blocking of most of the streams and rivers by human activities.
- Sometimes TamilNadu experiences flooding during November-January due to retreating monsoon.

Impact of floods :

- Casualties:** Human and livestock death due to drowning, serious injuries and outbreak of epidemics like diarrhea, cholera, jaundice or viral infections are common problems faced in flood affected areas. Even wells, other sources of drinking water get submerged resulting in acute shortage of safe drinking water during floods. Consequently, often people are forced to drink contaminated flood water, which may cause serious diseases.
- Structural damage:** During floods mud huts and buildings built on weak foundations collapse endangering human lives and property. Damage may also be caused to roads, rail, dams, monuments, crops and cattle. Floods may uproot trees and may cause landslides and soil erosion.
- Material loss:** Household articles including eatables, electronic goods, beds, clothes, furniture get submerged in water and get spoiled. All materials mounted on ground e.g. food stock, equipment, vehicles, livestock, machinery, salt pan and fishing boats can be submerged and spoiled.
- Utilities damage:** Utilities such as water supply, sewerage, communication lines, power-lines, transportation network and railways are put at risk. Crop loss Apart from the loss of human and cattle life, floods cause severe devastation of standing agricultural crops. Flood water spoils the stored food-grains or harvested crops. Floods



may affect soil characteristics and may turn them infertile due to the erosion of the topsoil or in coastal areas agricultural lands may turn saline due to flooding by sea water.

Way Forward:

- **Reservoirs :** By constructing reservoirs in the course of rivers could store extra water at the time of flood. Such measures adopted till now however, have not been successful. Dams built to control floods of Damodar could not control the flood.
- **Embankments :** By building flood protection embankments, flood water can be controlled from overflowing the banks and spreading in nearby areas. Building of embankments on Yamuna, near Delhi, has been successful in controlling the flood.
- **Afforestation :** The fury of flood could be minimized by planting trees in catchment areas of rivers.
- **Restoration of original drainage system :** Drainage system is generally choked by the construction of roads, canals, railway tracks etc. Floods could be checked if the original form of drainage system is restored.

Conclusion:

India is vulnerable to annual flooding because of its geographical location and it causes huge damage to life and property. A Flood is a natural phenomenon, it cannot be fully controlled. However, the government can mitigate the risks posed by floods to a greater extent by taking appropriate steps.

INDIAN CLIMATE

PYQ

1. Why is Indian Regional Navigational Satellite System (IRNSS) needed? How does it help in navigation? 2018
2. How far do you agree that the behavior of the Indian monsoon has been changing due to humanizing landscapes? Discuss. 2015
3. What characteristics can be assigned to monsoon climate that succeeds in feeding more than 50 percent of the world population residing in Monsoon Asia? 2017
4. In spite of adverse environmental impact, coal mining is still inevitable for development." Discuss 2017
5. The recent cyclone on the east coast of India was called "Phailin". How are the tropical cyclones named across the world? 2013
6. There is no formation of deltas by rivers of the Western Ghat. Why? 2013

Introduction:

- Climate plays a very significant role in the physical environment of human beings. In a country like India climatic characteristics do play a dominant role in affecting the economic pattern, way of life, mode of living, food preferences, costumes and even the behavioural responses of the people.
- **Indian climate:** Climate is the aggregate of the atmospheric condition involving heat, Moisture and air movement. The climate of India is described as the 'Tropical type monsoon' indicating the impact of its location in the tropical belt and the monsoon wind.
- **Weather patterns:** In India Weather patterns are strongly variable: epochal droughts, heat waves, floods, cyclones, and other natural disasters are sporadic, but have displaced or ended millions of human lives. Such climatic events are likely to change in frequency and severity as a consequence of human-induced climate change.
- **Sea level rise:** On-going and future vegetative changes, sea level rise and inundation of India's low-lying coastal areas are also attributed to global warming.
- **Physiography:** Although a sizable part of the country lying north of the Tropic of Cancer falls in the northern temperate zone, the shutting effects of the Himalayas and the existence of the Indian Ocean in the south have played significant roles in giving India a distinctive climatic characteristic.

The factors influencing the climate of India are given below:

- **Reversal of winds:** Reversal of wind system with the change of season in a year. During the Winter season wind generally blow from north-east to southwest direction and in the Summer season, it completely reverses
- **Seasonal and Variation of rainfall:** 80% annual rainfall is obtained in the latter part of the summer whose duration is from 1-5month. Cherrapunji has received in a single day an amount equal to 10 years of rainfall at Jaisalmer, Rajasthan.
- **Diversity of Indian Climate:** These are caused by Difference in the location, altitude, distance from the sea and General reliefs condition at different places.
- **Impact of High and Low pressure over the land :** Due to the low temperature high pressure area is formed and vice versa. Ex- intense heating of the land in summer season to formation of the thermally induced low pressure cell over the north western part of the country.
- **Plurality of seasons:** The Indian climate is characterised by constantly changing weather conditions. There are three main seasons but on broader consideration their number goes to six a year (winter, fall of winter, spring, summer, rainy and autumn).
- **Characterised by Natural Calamities:** Due to its peculiar weather conditions especially rainfall variability during rainy seasons has made Indian climate more prone to natural calamities like floods, droughts, famines and even epidemics.

Factors Determining the Climate of India India's climate is controlled by a number of factors which can be broadly divided into two groups –

A. Factors Related to Location and Relief Latitude: The tropical zone being nearer to the equator, experiences high temperatures throughout the year with small daily and annual range. Area north of the Tropic of Cancer being away from the equator, experiences extreme climate with a high daily and annual range of temperature.

- **The Himalayan Mountains :** The cold and chilly winds that originate near the Arctic Circle are obstructed by the Himalayas and give a distinctive taste to the climate of India.
- **Distribution of Land and Water:** As compared to the landmass, water heats up or cools down slowly. This differential heating of land and sea creates different air pressure zones in different seasons in and around the Indian subcontinent.
- **Distances from the Sea:** With a long coastline, large coastal areas have an equable climate. Areas in the interior of India are far away from the moderating influence of the sea. Such areas have extremes of climate. Ex- The Konkan coast has moderate temperature but Kanpur and Amritsar are affected with extreme temperature.
- **Altitude:** Temperature decreases with height, as air ascends it loses its temperature due to Normal Lapse Rate.
- **Relief:** The physiography or relief of India also affects the temperature, air pressure, direction and speed of wind and the amount and distribution of rainfall.

B. Factors Related to Air Pressure and Wind

- **Distribution of air pressure and winds** on the surface of the earth.
- **Upper air circulation** caused by factors controlling global weather and the inflow of different air masses and jet streams.
- Inflow of **western cyclones** generally known as disturbances during the winter season and tropical depressions during the south-west monsoon period into India, creating weather conditions favourable to rainfall.

So, These factor have different mechanism with reference to winter and summer season of the yearly separately:

1. Weather condition in winter season
2. Weather condition in summer season

Weather condition in winter season :

Surface pressure and wind :	During Winter, High pressure area is built in Central and west Asia which gives rise to the flow of air at the low level from the north towards the Indian subcontinent. These continental winds come in contact with trade winds over north-western India. Now, the contact zone is not stable thus bringing the entire North-western India the influence of the North-Westerly winds
Jet stream and upper air circulation :	During the winter season the upper air westerly jet streams are positioned in Asia. These are bifurcated in two branches due to the Tibetan Himalayan obstruction. North branch blows north of the Himalayas and the Tibetan Plateau. Southern branch blows south of the mighty mountains. In winter the subtropical westerly jet stream brings rain to the western part of India.
Western Cyclonic Disturbance and Tropical Cyclones:	The western cyclonic disturbances are weather phenomena of the winter months brought in by the Westerly flow from the Mediterranean region. They usually influence the weather of the north and north-western regions of India. It brings little rain in the winter month which is good for the wheat crops. Tropical cyclones occur during the monsoon as well as in October -November, and are part of the easterly flow. These disturbances affect the coastal regions of the country. These tropical cyclones have very high wind velocity and heavy rainfall and hit the Tamil Nadu, Andhra Pradesh and Orissa coast

Weather condition in summer season:

Surface pressure and wind:	In summer, Sun shifts northward then wind circulation over the sub-continent undergoes a complete reversal at both. This is caused by Low pressure belt nearer the surface, Termed as ITCZ
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	(InterTropical convergence Zone) shift northwards in the month of July. So, this time, the westerly jet stream withdrew from the Indian region.
Jet stream and upper air circulation :	An easterly jet stream flows over the southern part of the Peninsula in June, and has a maximum speed of 90 km per hour In August; it is confined to 15 Degree North latitude, and in September up to 22 Degree North latitudes. The easterlies normally do not extend to the north of 30 Degree North latitude in the upper atmosphere.
Western cyclonic disturbance and Tropical cyclone:	The easterly jet stream steers the tropical depressions into India. These depressions play a significant role in the distribution of monsoon rainfall over the Indian subcontinent. The tracks of these depressions are the areas of highest rainfall in India. The frequency at which these depressions visit India, their direction and intensity, all go a long way in determining the rainfall pattern during the southwest monsoon period.

INDIAN MONSOON

- The term monsoon is derived from the Arabic word ‘Mausam’ meaning ‘season’. It is characterized by seasonal reversal of wind direction at regular intervals.
- Although the monsoon is a global phenomenon influenced by a variety of factors not yet completely understood, the real monsoon rains cover mainly the South Asian region, represented by India, Myanmar, Sri Lanka, Bangladesh, Bhutan and parts of SouthEast Asia.

THERMAL CONCEPT OF INDIAN MONSOON

- According to this Thermal theory (Halley's Theory of Origin of Monsoon), the differential heating of land and sea at the time when the sun makes an apparent northward movement is the main cause of the Indian monsoonal regime.

Two factors are mainly responsible for this very strong development of monsoons:

- Vast size of the Indian subcontinent and adjacent seas.
- Very high and extensive mountain systems of the Himalayas.

MECHANISM OF HALLEY'S THEORY OF ORIGIN OF MONSOON

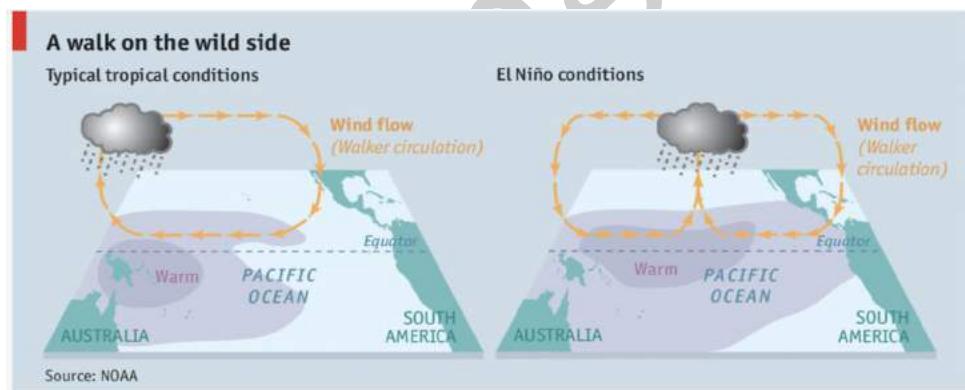
- According to the thermal concept, during the period following the **Vernal Equinox (March 22)**, the sun starts its apparent northward shift. As a result, the areas lying north of the equator (tropics and subtropics) get a progressive high incidence of solar radiation.
- The effect of this phenomenon on the Indian subcontinent is seen in the form of intense heating of the vast northern plains and the adjoining highlands. As a result, a massive low pressure belt is formed extending from the Punjab plains in the north-west to the Bengal delta in the east.

ORIGIN OF INDIAN MONSOON

Indian Monsoon depends on the Differential heating of sea and land but alone it can't produce the Monsoon circulation. Apart from, it depends on the Following Concept:

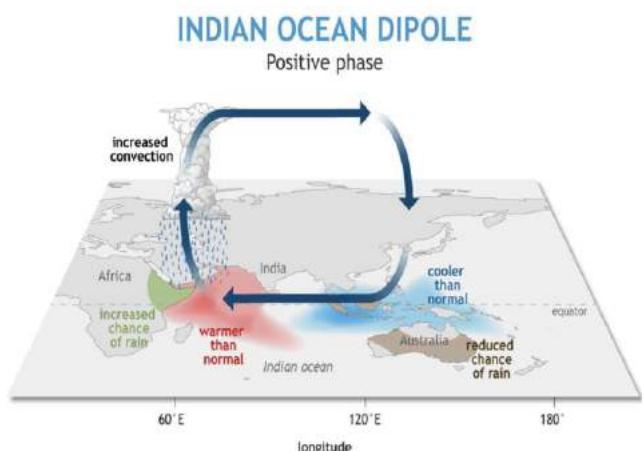
- **Role of jet stream:**
 - **Burst of monsoon:** It depends upon the upper air circulation which is dominated by SubTropical Jet Streams (STJ). The south west monsoon coming in India is related to the tropical easterly stream. It blows between 8 degree- 35 degree North latitudes.
 - **North east monsoon:** The winter monsoon is related to the subtropical westerly Jet Stream which blows between 20 degree and 35 degree latitudes in both hemispheres.
- **Role of Himalaya and Tibet plateaus:**
 - **Air circulation:** Tibet plateau plays a crucial role in initiating the monsoon circulation. Heating of these areas leads to a clockwise air circulation in the middle troposphere .
 - **Two-wind streams originate from this area.**

- **First stream:** These wind streams blow southward and develop into the tropical easterly jet stream (TEJ).
- **Second stream:** It blows in an opposite direction towards the North Pole and becomes the westerly jet stream over Central Asia.
- **Role of El Nino/Southern Oscillation**
 - **Sea surface temperature:** El Nino/Southern Oscillation and La Niña - Both terms refer to large-scale changes in sea-surface temperature across the eastern tropical Pacific and the most powerful phenomenon of the Earth. These are best known for altering the climate across more than half of the planet that also impact the weather patterns of India.
 - **Impact on Indian monsoon :**
 - **El Nino:** During winter El Niño causes warm conditions over the Indian subcontinent and during summer, it leads to dry conditions and deficient monsoon.
 - **La Niña:** It results in better than normal monsoon in India.
- **Role of Walker circulation:**
 - The Walker circulation is the result of a difference in surface pressure and temperature over the western and eastern tropical Pacific Ocean.
 - **Indian Ocean:** In this region air descends down at a high pressure zone from where surface winds blow as Southwest monsoon towards the Indian sub-continent in summers.
 - **Impact on La Niña :** During La-Nina, the Indian ocean branch of the walker cell gets strengthened and surface winds are more intense. La-Nina condition is generally associated with good monsoon.
 - **Impact on El Niño:** During the appearance of El-Nino or negative SOI, the surface winds or Southwest monsoon winds are weaker than normal conditions



Indian Ocean dipole:

- The Indian Ocean Dipole (IOD) is defined by the difference in sea surface temperature between two areas a western pole in the Arabian Sea (western Indian Ocean) and an eastern pole in the eastern Indian Ocean south of Indonesia.
- **Positive Indian Ocean dipole:** The Arabian Sea is much warmer and eastern Indian Ocean around Indonesia becoming colder and dry. Positive IOD results in more cyclones than usual in the Arabian Sea.
- **Negative Indian Ocean dipole:** The reverse happens making Indonesian much warmer and rainier. Negative IOD results in stronger than usual cyclogenesis in Bay of Bengal. Cyclogenesis in the Arabian Sea is suppressed.



NATURE AND IMPORTANT ASPECTS OF MONSOON

Systematic studies of the causes of rainfall in the South Asian region help to understand the causes and salient features of the monsoon, particularly some of its important aspects, such as:

- The onset of the monsoon.

- Rain-bearing systems (e.g. tropical cyclones) and the relationship between their frequency and distribution of monsoon rainfall - Arabian Sea Branch and Bay of Bengal Branch.
- Break in the monsoon.
- Retreat in Monsoon

THE ONSET OF THE MONSOON :-

- Differential heating of land and sea during the summer months is the mechanism which sets the stage for the monsoon winds to drift towards the subcontinent. This causes the formation of an intense low pressure in the north-western part of the subcontinent. So low pressure cells attract the southeast trade across the equator.
- The shift in the position of the ITCZ is also related to the phenomenon of the withdrawal of the westerly jet stream and emergence of the easterly jet stream which are responsible for the burst of the monsoon in India.

Factors influencing the onset on Southwest Monsoon:

- **Low pressure belt system** : The low-pressure area or depression in the Bay of Bengal during the last days of May or the beginning of June. There are such systems in the Arabian Sea as well around the same time which results in onset over the mainland.
- **Cyclonic vortex**: 'Cyclonic Vortex' is another factor which appears in the Southeast Arabian Sea, off Kerala and Lakshadweep region. They also shift along the west coast to push the monsoon current.
- **Trough Formation**: The formation of 'trough' off the west coast due to temperature differential between land and sea. This situation could be for a mild start and weak progress.
- **Cross equatorial winds**: cross-equatorial flow, wherein the trade winds from the Southern Hemisphere crossover to the Northern Hemisphere can bring a strong monsoon surge towards the Indian mainland.

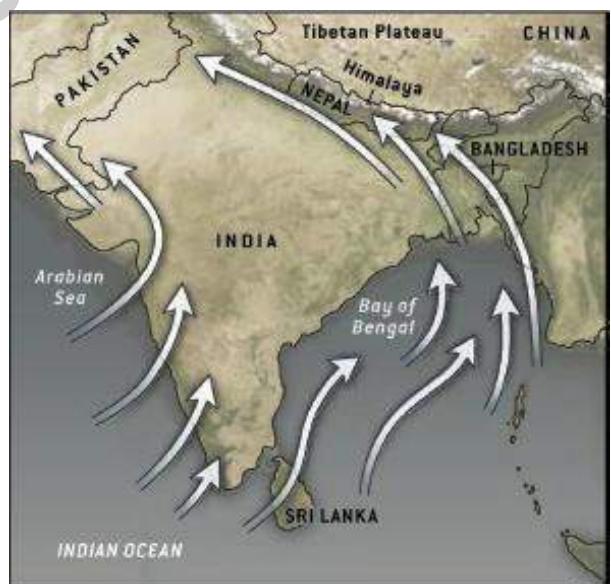
RAIN-BEARING SYSTEMS

- The southwest monsoon splits into two branches, the Arabian Sea Branch and the Bay of Bengal Branch near the southernmost end of the Indian Peninsula.

1. The Arabian Sea branch

The Arabian Sea branch of the southwest monsoons is divided into three distinct streams on arriving in the mainland of India.

- **The first stream** strikes the west coast of India and gives extremely heavy rainfall of over 250 cm. It strikes perpendicular to Western Ghats causing plentiful Orographic Rainfall (400 to 500 cm annual rainfall on the windward side). Rainfall is drastically reduced to about 30-50 cm on the leeward side of the crest.
- **The second stream** enters Narmada - Tapi troughs (narrow rift valley) and reaches central India.
- **The third stream** moves parallel to the Aravalli Range without causing much rainfall.



2. The Bay of Bengal Branch

The Bay of Bengal Branch of the southwest monsoon is divided into two distinct streams.

- **The first stream** crosses the Ganga - Brahmaputra delta and reaches Meghalaya. Here the orographic effect results in intense rainfall. Cherrapunji receives an annual rainfall of 1,102 cm, and Mawsynram records higher annual rainfall of 1,221 cm.
- **The second stream** of the Bay of Bengal branch moves along Himalayan foothills as they are deflected to the west by the Himalaya and brings widespread rainfall to Ganga plain.

BREAK IN THE MONSOON.

- During the south-west monsoon period after having rains for a few days, if rain fails to occur for one or more weeks, it is known as break in the monsoon. These dry spells are quite common during the rainy season.

RETREAT IN MONSOON

- In simple words, retreating means withdrawal. So, withdrawal of south-west monsoon winds from skies of north India during months of October and November is known as retreating monsoon. The withdrawal is gradual and takes about three months.

Recent developments:

Indian Ocean dipole and Indian monsoon:

- Positive Indian Ocean dipole:** Studies have shown that a positive IOD year sees more than normal rainfall over central India and it also results in more cyclones than usual in the Arabian Sea.
- Negative Indian Ocean dipole:** It complements El Niño leading to severe drought and results in stronger than usual cyclogenesis (Formation of Tropical Cyclones) in Bay of Bengal. Cyclogenesis in the Arabian Sea is suppressed during this time.

La Niña and Indian monsoon :

- La Niña is the large-scale cooling of ocean surface temperatures in the central and eastern equatorial Pacific Ocean, together with changes in the tropical atmospheric circulation, namely winds, pressure and rainfall.
- Impact on Monsoon:**
 - More Rainfall:** While La Niña conditions enhance the rainfall associated with the Southwest monsoon, it has a negative impact on rainfall associated with the Northeast monsoon.
 - Cyclone Formation:** During La Niña years, the synoptic systems — low pressure or cyclones — formed in the Bay of Bengal remain significantly to the north of their normal position.
 - Less Rainfall :** Besides, instead of moving westwards, these systems recurve. As they lie to the north of their normal position, not much rainfall occurs over southern regions like Tamil Nadu

No cyclones during main monsoon months like July and August:

- Conditions for tropical cyclone:**
 - Warm Ocean waters (of at least 26.5°C throughout sufficient depth at least on the order of 50 m).
 - Relatively moist layers near the height of 5 km.
 - Non- negligible amount of Coriolis force pre-existing near surface disturbance.
 - Low values of vertical wind shear between the surface and upper troposphere.
- Surface winds:** In July and August winds on the surface are westerly/south-westerly to the south of monsoon trough and south easterly/ easterly to its north and are generally stronger over the seas than the Land areas.
- Upper Air circulation:** The upper winds are westerly/south-westerly to the south and south easterly/ Easterly to the north of this trough region. Westerly winds increase with height and reach a maximum speed of 20-25 knots between 900 to 800 hPa levels. Easterly winds strengthen with height from 200 hPa reaching a maximum at 100 hPa. Speeds are between 60 to 80 knots over peninsula at 150 /100 hPa level or even at lower height (around 200 hPa) in the southern latitude.
- Wind shear:** This results in high values of vertical wind shear which is unfavourable for Tropical cyclogenesis. So, we don't get cyclones during the main monsoon months like July and August.

INDIAN CLIMATE –SEASONS

The climatic conditions of India can best be described in terms of an annual cycle of seasons. The meteorologists recognise the following four seasons:

- The cold weather season
- The hot weather season
- The southwest monsoon season
- The retreating monsoon season.

Seasons are a special feature of the Indian climate. Temperature, pressure, wind direction and the amount and duration of rain varies from one season to the other. Meteorologists identify four seasons in India.

1. THE COLD WEATHER SEASON

- Duration:** Mid-November to February

- **General Characteristic :** Clear sky, pleasant weather, low temperature, low humidity, high range of temperature, cool and slow north-east trade winds.
- **Temperature :** The diurnal range of temperature, especially in interior parts of the country, is very high. The isotherm of 20°C runs roughly parallel to the Tropic of Cancer. Some parts of Kerala and Tamil Nadu typically experience temperatures near 30°C. The mean minimum temperature is about 5°C over north-west India and 10°C over the Gangetic plains.
- **Wind Disturbance:** High pressure over north-western India. Winds blow from northwest to southeast. Around four or five westerly Disturbances are carried by westerly jet streams.
- **Rainfall :** The retreating winter monsoons pick up some moisture while crossing the Bay of Bengal and cause winter rainfall in Tamil Nadu, south Andhra Pradesh, south-east Karnataka and south-east Kerala (Usually in the first weeks of November). The western disturbances also cause a little rainfall in north-west India

Recent development:

Dropped in Delhi temperature:

- Temperature in New Delhi dropped to 4.1 degrees Celsius, the lowest during the season this year. The dip was five degrees below the normal temperature for this time of the year, according to the India Meteorological Department (IMD).
- Factors causing the dip in Delhi's temperature:
 - **Snowfall:** There has been a significant amount of snowfall over the past few days in states falling in the western Himalayan range — Jammu & Kashmir, Himachal Pradesh and Uttarakhand
 - **Western disturbance:** In winters, whenever an active Western Disturbance passes through the western Himalayan region, it leads to a dip in temperatures across northwest India.
 - **Cloud cover:** The lack of cloud cover also leads to higher radiation from the Earth's surface into the atmosphere at night time.
 - **La Niña :** under the influence of an active La Niña climate pattern, temperatures across the globe have been dipping.

2. THE HOT WEATHER SEASON

- **Duration :** April, May, June
- **General Characteristic :** High temperature and low humidity are the chief characteristics. Also seen as Dust storm and dryness.
- **Temperature:** In March, the highest temperatures occur in the southern parts (40-45°C). In April the highest temperature of about 45°C is recorded in the northern parts of Madhya Pradesh. In May the highest temperature shifts to Rajasthan where temperatures as high as 48°C may be recorded. The diurnal range of temperature is also very high. It may be as high as 18°C in some parts.
- **Wind Disturbance:** Low pressure over north-western part of India and high pressure over southern parts of Bay of Bengal. ITCZ shifts to Ganges plain. Wind direction varies from one part of India to the other. Dust storms are frequently experienced in the afternoon in northern plains.
- **Rainfall:** Completely dry Season. Dust storms and thunderstorms provide some rainfall. Eastern regions receive more rainfall comparatively.

Recent development:

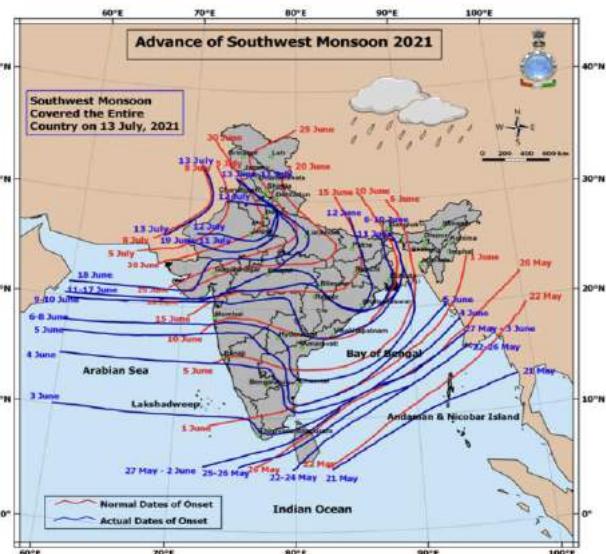
Rise in Indian temperature:

- India's average temperature had risen by 0.7 degrees Celsius from 1901-2018.
- This rise is primarily due to global warming caused by greenhouse gas (GHG) emissions.
- India's average temperature will rise by almost 4.4 degrees Celsius by 2100, compared to the recent past (1976-2005).
- The frequency of summer heatwaves is projected to increase by two-three times, while the duration of these heat waves is expected to double (both relative to the baseline period of 1976-2005).
- Delhi set a new maximum record of 48 degrees Celsius, while Churu in Rajasthan hit 50.8 degrees Celsius. On 26 May this year, Delhi hit 47.8 degrees Celsius, while Churu again recorded a high of 50 degrees Celsius as another heat wave swept through north and central India.

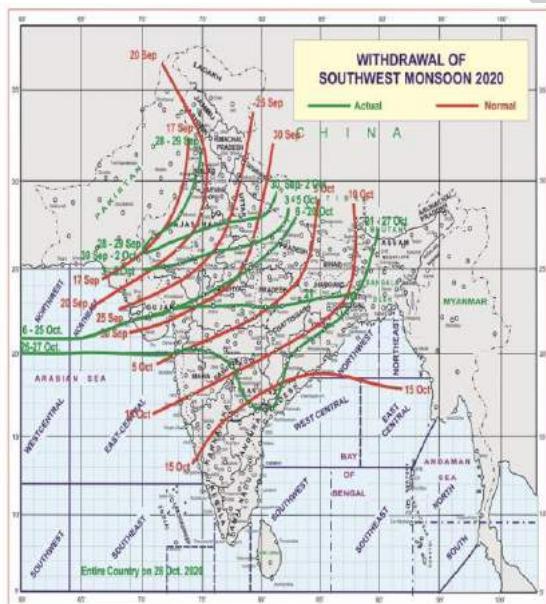
3. THE SOUTHWEST MONSOON SEASON

Duration : June – September

- **General Characteristic:** South West Monsoon Season is also known as hot-wet season. Sudden onset is an important feature of South West Monsoons. With the onset of monsoons, temperature falls drastically and humidity levels rise.
 - **Temperature:** Sudden onset of South West Monsoons leads to significant fall in temperature (3° to 6°C). The temperature remains less uniform throughout the rainy season. The temperature rises in September with the cease of south-west monsoons. Other parts of Northwest India also have temperatures above 30°C
 - **Wind Disturbance:** Over the peninsular region, due to pressure gradient between north and south, winds blow in a southwest to northeast direction from Arabian sea and Bay of Bengal. Their direction undergoes a change in the Indo-Gangetic plain where they move from east to west.
 - **Rainfall:** The average rainfall over the plains of India in this season is about 87 per cent. The advance of the monsoon is much faster in the Bay of Bengal than in the Arabian Sea. The monsoons advance quickly accompanied with a lot of thunder, lightning and heavy downpour. This sudden onset of rain is termed as monsoon burst.



4. THE RETREATING MONSOON SEASONAL

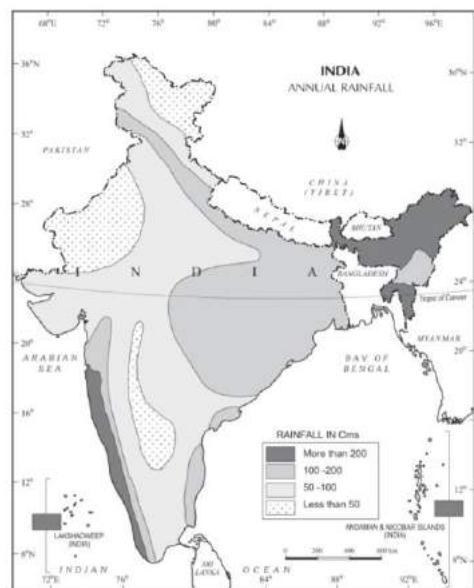


- **Duration:** October - November
 - **General Characteristic:** Monsoon winds are retreating gradually and sudden rise of temperature with October heat.
 - **Temperature:** With the retreat of the monsoons, the clouds disappear and the sky becomes clear. The day temperature starts falling steeply. The diurnal range of temperature increases due to lack of cloud cover.
 - **Wind Disturbance:** As the monsoons retreat, the monsoon trough weakens and gradually shifts southward. Consequently, the pressure gradient is low. Unlike the southwest monsoon, the onset of the north monsoon is not clearly defined. The direction of winds over large parts of the country is influenced by the local pressure conditions.
 - **Rainfall:** October-November is the main rainy season in Tamil Nadu and adjoining areas of Andhra Pradesh to the south of the Krishna delta as well as a secondary rainy period for Kerala. The retreating monsoons absorb moisture while passing over the Bay of Bengal and cause this rainfall.

Distribution of rainfall

The distribution of rainfall in any region is mostly influenced by the relief features on the surface of the Earth and the direction of the rain-bearing winds in that region. Another important factor which influences the distribution of annual rainfall in India is the path followed by the cyclonic depressions. The region located on the windward side of mountains, hills or plateaus receives comparatively more rainfall than the leeward side.

- Rainfall patterns:** As we move from Meghalaya to Haryana or Punjab in the Northern plains, the rainfall decreases and In peninsular India, rainfall decreases from coast to interior parts similarly in North-East India, the rainfall increases with altitude.
- Maximum and Moderate Rainfall:** Maximum rainfall (above 200 cms) in India occurs in the western coast, sub Himalayan regions of north-east and Garo, Khasi and Jaintia hills of Meghalaya and Moderate rainfall (100-200cm) occurs in some parts of the Western Ghats, West Bengal, Odisha and Bihar and many states.
- Low and inadequate rainfall:** Low rainfall (60 to 100cm) occurs in parts of Uttar Pradesh, Rajasthan, and interior Deccan plateau and Inadequate rainfall (Less than 60cm) occurs in western part of Rajasthan and Gujarat, Ladakh and south central part receives a rainfall of less than 20cm.



Recent development:

Changing Rainfall Pattern in the Country

India Meteorological Department (IMD) has carried out an analysis of observed monsoon rainfall variability and changes of 28 States & 8 Union Territory at State and District levels based on the IMD's observational data of recent 30 years (1989- 2018) during the Southwest monsoon season from June-July-August-September (JJAS).

- The highlights of the report are as follows:
 - Decrease in Rainfall:** Five states viz., Uttar Pradesh, Bihar, West Bengal, Meghalaya and Nagaland have shown significant decreasing trends in southwest monsoon rainfall during the recent 30 years period (1989-2018).
 - State wise pattern:** The annual rainfall over these five states along with the states of Arunachal Pradesh and Himachal Pradesh also show significant decreasing trends. Other states do not show any significant changes in southwest monsoon rainfall during the same period.
 - District wise pattern:** Considering district-wise rainfall, there are many districts in the country, which show significant changes in southwest monsoon and annual rainfall during the recent 30 years period (1989-2018).
 - Increase in Rainfall:** With regard to the frequency of heavy rainfall days, significant increasing trend is observed over Saurashtra & Kutch, South-eastern parts of Rajasthan, Northern parts of Tamil Nadu, Northern parts of Andhra Pradesh and adjoining areas of Southwest Odisha, many parts of Chhattisgarh, Southwest Madhya Pradesh, West Bengal, Manipur & Mizoram, Konkan & Goa and Uttarakhand.

KOEPPEN'S CLASSIFICATION OF CLIMATIC REGIONS OF INDIA

- Koeppen identified a close relationship between the distribution of vegetation and climate. Koeppen's Classification of Climatic Regions of India is an empirical classification based on mean annual and mean monthly temperature and precipitation data.
- Koppen climatic groups are subdivided into types, designated by small letters, based on seasonality of precipitation and temperature characteristics.

Climate Classification	Climate Region
Monsoon type with short dry season (Amw)	The western coastal region south of Goa experiences this type of climate.
Monsoon type with dry season in summers (AS)	The region of this type of climate extends along the coromandel coast

Tropical Savanna type (Aw)	Almost the entire peninsular region except for some coastal parts experiences this type of climate.
Semi-arid steppe climate (BShw)	This climatic region includes the interior parts of the peninsular plateau and some parts of Gujarat , Rajasthan, Haryana, Punjab and Jammu & Kashmir.
Hot desert type (BWhw)	This type of climate is found only in the western part of Rajasthan
Monsoon type with dry winters (Cwg)	Largely Northern plains of India experience this type of climate.
Cold-humid winter type with short summer (Dfc)	This climate is characterized by a short summer season. This region covers the north-eastern parts of India.
Polar type (E)	This type of climate is experienced in Jammu & Kashmir and the neighbouring mountain ranges.

Monsoon and Economic life of India:

- **Livelihood :** Monsoon is that axis around which revolves the entire agricultural cycle of India. It is because about 64 per cent people of India depend on agriculture for their livelihood and agriculture itself is based on southwest monsoon.
- **Crop production:** Except the Himalayas all the parts of the country have temperatures above the threshold level to grow the crops or plants throughout the year. Regional variations in monsoon climate help in growing various types of crops.
- **Uneven Rainfall:** Variability of rainfall brings droughts or floods every year in some parts of the country.
- **Agriculture:** Agricultural prosperity India depends very much on timely and adequately distributed rainfall. If it fails, agriculture is adversely affected particularly in those regions where means of irrigation are not developed.
- **Benefits to crops:** Winter rainfall by temperate cyclones in north India is highly beneficial for rabi crops.
- **Climatic variation:** Diverse Regional climatic variation in India is reflected in the vast variety of food, clothes and house types.

Monsoonal unity of India:

- **Lifestyle and economic activities:** The seasonal alteration of the wind systems and weather conditions provide a rhythmic cycle of seasons affects the life styles and economic activities of the people throughout India.
- **Monsoon arrival:** The Indian landscape, its animal and plant life, its entire agricultural calendar and the life of the people, including their festivities, revolve around this phenomenon. Year after year, people of India from north to south and from east to west, eagerly await the arrival of the monsoon.
- **Agriculture:** These monsoon winds bind the whole country by providing water to set the agricultural activities in motion.
- **River :** The river valleys which carry this water also unite as a single river valley unit.

Recent development:

Monsoon Mission

- **Vision of Mission :** Monsoon Mission is a national programme launched by the Ministry of Earth Sciences (MoES) with a vision to develop state-of-the-art dynamical prediction systems for the monsoon rainfall in different time scales.
- **Research and development:**

- The mission supports focused research by national and international research groups with definitive objectives and deliverables to improve models in the short, medium, extended and seasonal range scales through setting up of a framework for generating dynamical forecasts and improving skill of forecasts.
- It also supports observational programs which will help the better understanding of the atmospheric processes related to monsoon.
- **The main objectives of this mission are:**
 - To improve Seasonal and Intra-seasonal Monsoon Forecast
 - To improve Medium Range Forecast.
- **Institutions :** Indian Institute of Tropical Meteorology (IITM), Pune, India Meteorological Department (IMD), Indian National Centre for Ocean Information Services (INCOIS), Hyderabad and National Centre for Medium Range Weather Forecast (NCMRWF), Noida are the major participating institutions in Monsoon Mission.

Assessment of climate change over the Indian region: A report of the Ministry of Earth Sciences (MoES), Government of India

- **Temperature Rise Over India**
 - **Rise in temperature:** India's average temperature has risen by around 0.7°C during 1901–2018. By the end of the twenty-first century, average temperature over India is projected to rise by approximately 4.4°C relative to the recent past (1976–2005 average)
 - **Reason :** This rise in temperature is largely on account of GHG-induced warming, partially offset by forcing due to anthropogenic aerosols
- **Indian Ocean Warming**
 - **Sea surface temperature** of the tropical Indian Ocean has risen by 1°C on average during 1951–2015, markedly higher than the global average SST warming of 0.7°C, over the same period.
- **Changes in Rainfall**
 - **Decrease in Rainfall:** The summer monsoon precipitation (June to September) over India has declined by around 6% from 1951 to 2015, with notable decreases over the Indo-Gangetic Plains and the Western Ghats.
 - **Reason :** There is an emerging consensus, based on multiple datasets and climate model simulations, that the radiative effects of anthropogenic aerosol forcing over the Northern Hemisphere have considerably offset the expected precipitation increase from GHG warming and contributed to the observed decline in summer monsoon precipitation.
- **Droughts**
 - **Increase in droughts:** The overall decrease of seasonal summer monsoon rainfall during the last 6–7 decades has led to an increased propensity for droughts over India. Both the frequency and spatial extent of droughts have increased significantly during 1951–2016.
 - **Location:** In particular, areas over central India, southwest coast, southern peninsula and north-eastern India have experienced more than 2 droughts per decade, on average, during this period. The area affected by drought has also increased by 1.3% per decade over the same period.
- **Sea Level Rise**
 - **Reason :** Sea levels have risen globally because of the continental ice melt and thermal expansion of ocean water in response to global warming.
 - **Rate of acceleration:** Sea-level rise in the North Indian Ocean (NIO) occurred at a rate of 1.06–1.75 mm per year during 1874–2004 and has accelerated to 3.3 mm per year in the last two and a half decades (1993–2017), which is comparable to the current rate of global mean sea-level rise.

- **Tropical Cyclones**
 - **Frequency of Cyclones:** There has been a significant reduction in the annual frequency of tropical cyclones over the NIO basin since the middle of the twentieth century (1951–2018).
 - **Severe cyclonic storm:** In contrast, the frequency of very severe cyclonic storms (VSCSs) during the post-monsoon season has increased significantly during the last two decades (2000–2018).
- **Changes in the Himalayas**
 - **Rise in temperature:** The Hindu Kush Himalayas (HKH) experienced a temperature rise of about 1.3°C during 1951–2014.
 - **Decline of snowfall:** Several areas of HKH have experienced a declining trend in snowfall and also retreat of glaciers in recent decades. In contrast, the high-elevation Karakoram Himalayas have experienced higher winter snowfall that has shielded the region from glacier shrinkage.

Conclusions

- Since the middle of the twentieth century, India has witnessed a rise in average temperature; a decrease in monsoon precipitation; a rise in extreme temperature and rainfall events, droughts, and sea levels; and an increase in the intensity of severe cyclones, alongside other changes in the monsoon system. There is compelling scientific evidence that human activities have influenced these changes in regional climate.
- Human-induced climate change is expected to continue apace during the twenty-first century. To improve the accuracy of future climate projections, particularly in the context of regional forecasts, it is essential to develop strategic approaches for improving the knowledge of Earth system processes, and to continue enhancing observation systems and climate models.