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## **GS MAINS CIP** MAINS 2023 CRASH COURSE

**Class Notes** 

# GEOGRAPHY

 Linkages of Concepts & Current Dimensions
 Topic wise segregated Previous Year Questions
 100<sup>+</sup> Practice Questions

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## HUMAN AND ECONOMIC GEOGRAPHY

#### 1. INDIA'S 'HIGHEST POPULATION TAG': PROSPECTS AND ISSUES

Syllabus line: Geographical features and their location



#### Major Highlights:

• **Reason:** China's fertility is lower than anticipated



- **Population Trend:** The global population is expected to grow to around 8.5 billion in 2030, 9.7 billion in 2050 and 10.4 billion in 2100.
- **Distribution of Population:** The rate of population growth significantly vary across countries and regions over the world:
  - More than half of the projected increase in global population up to 2050 will be concentrated in just eight countries: the Democratic Republic of the Congo, Egypt, Ethiopia, India, Nigeria, Pakistan, the Philippines and the United Republic of Tanzania.

#### **Prospects for India:**

• **Demographic Transition**: Theory of demographic transition suggests that population growth is linked to overall levels of economic development.

- **Demographic Dividend:** The **demographic 'dividend'** to be derived from the age structure of the population is due to the fact that India is (and will remain for some time) one of the youngest countries in the world.
  - ➤ The 'demographic dividend' results from an increase in the proportion of workers relative to nonworkers in the population. E.g. Countries like Singapore, Taiwan and South Korea have already shown us how demographic dividend can be reaped to achieve incredible economic growth by adopting forward-looking policies and programmes to empower the youth in terms of their education, skills and health choices.
- **Population in India:** The rising young population provides India with a great opportunity for growth, peppered with the possibility of path-breaking innovation. India's population heterogeneity ensures that this window of demographic dividend becomes available at different times in different States.
- **Higher Productivity**: Population growth will lead to economic growth with more people able to produce more goods. It will lead to higher tax revenues which can be spent on public goods, such as health care and environmental projects.
- **Increased economic activities**: Farming and industry have been able to benefit from economies of scale, which means as the population grows, food output and manufacturing output have been able to grow even faster than population growth.

#### **Issues with India:**

- **Ageing Population:** The increase in the working-age population may lead to rising unemployment, fueling economic and social risks.
- **Resource crunch:** High population growth also affects the depletion of resources
- **Indian Diaspora:** Globally, one in five working-age persons will live in India. The **challenge** is that a sizable working-age population does not mean many workers.
  - > The size of our labour force is constrained by the absence of women from the workforce.
    - **Only about 30 percent of women aged 15 and above are employed** either in wage work on family farms and businesses.
    - The absence of women in factories, the transportation sector and skilled blue-collar work is striking.
  - > Social Security: The 65+ category is going to grow quite fast and it faces several challenges.
    - Provisioning of social security is obviously a big challenge. This will stretch the resources of the future governments.
  - ► Gender inequality: Education is an enabler to bridge gender differentials.
    - The gender inequality of education is a concern.
    - In India, boys are more likely to be enrolled in secondary and tertiary school than girls.

#### **Way Forward**

- **Investments in dependent population:** India needs to invest more in children and adolescents, particularly in nutrition and learning during early childhood.
- **Better welfare schemes:** Countries with ageing populations should take steps to adapt public programmes to the growing numbers of older persons, establishing universal health care and long-term care systems, and by improving the sustainability of social security and pension systems.
- Female workforce participation: India needs to increase female workforce participation in the economy.
- **Channelized Migration:** With industrial growth concentrated in coastal regions and the bulk of our workers coming from central areas, we will also need to figure out how to deal with interstate migration.

#### **Practice Question**

Q. Discuss the implications of India becoming most populated country in the world. Highlight the prospects and challenges faced by India in developing such large population into a human resource.

#### 2. MINERAL BOOM IN AFRICA OPENING NEW AVENUES FOR INDIA

**Syllabus:** Distribution of key natural resources across the world (including South Asia and the Indian subcontinent)

#### India and Africa:

- India seems to have impressed the **Central African Republic** with infrastructure and other developments to have got invited to mine its abundant natural resources ranging from oil, uranium and lithium to gold, diamonds, iron ore and copper.
- India needs natural resources to feed its vast expanding economy. Thus, India can help Africa to build infrastructure like roads, Telecommunication, etc. in sustainable exploitation of its mineral wealth.

#### **Mineral Wealth of Africa:**

- **Transition Metals**: Africa hosts valuable "**transition metals**" a group of elements including cobalt, nickel, manganese and chromium, which will play a key role in the **shift from fossil fuels to low-carbon energy sources**.
- **Decarbonisation:** It is driving demand for a range of minerals including these, graphite, lithium and "**rare earth**" **elements** such as neodymium, samarium and yttrium. They will underpin technologies crucial to the energy transition, including wind turbines, solar panels and electric vehicles.
- **Rich Mineral Wealth:** From north to south, Africa's reserves of such metals are prodigious. Morocco has 70% of the world's phosphate reserves; DRC has 50% of the world's cobalt; Gabon has up to 15% of the world's manganese; South Africa has 91% of the world's platinum, 46% of its yttrium, 22% of its manganese, 35% of its chromium and 16% of its vanadium. The wider southern African region is home to substantial untapped lithium resources, used primarily in the construction of lithium-ion batteries for electric vehicles and grid-scale storage.
- Energy Transition: Overall, the continent has at least a fifth of the world's reserves in a dozen minerals that are critical for the energy transition, according to the Natural Resource Governance Institute (NRGI) which makes Africa essential in the just energy transition.

#### **Prospects for India in Africa:**

- **Critical rare earth minerals:** India needs to form strategic alliances with southern African countries where critical rare earth minerals are produced, as the world looks to the continent to fulfil its everincreasing demand as per EXIM bank report.
- **Green Economy:** The region is richly endowed in lithium, graphite, cobalt, nickel, copper, and other rare earth minerals. All of these are essential for **building the global green economy of the future** and they also comprise new market opportunities **for net-zero transitions.** Thus, India could play a significant role in the African mining value chain to optimise benefits from the demand for battery and electric value chain.
- **Joint Exploration:** India could set up joint exploration activities for securing critical mineral assets. Indian state-run companies can form joint venture to secure minor mineral assets such as lithium and cobalt that could fuel India's plan from mass adoption of electric vehicles by 2030.
- **Increasing India's Market share in REE's:** Currently the World's REE market is controlled by China and here India can play a strategic role by acquiring these mineral reserves for the development of Indo-African relationship.

The major REE consumers like the **US**, the EU, Canada, Australia, Japan, and South Korea are exploring options to develop alternative REE supply chains. Africa is one of the regions targeted as an alternative source of REE commodities, which presents African countries with the opportunity to develop their own REE value chains. Here India can play a significant role by accepting the invitee and become one of the major global player in REE and other minerals in the world.

**Context:** Landlocked in the heart of Africa, Central African Republic has the **largest reserve of iron** ore in the world and the **best quality of rare wood and timber** across the globe. It also has **uranium, iron ore, copper and manganese deposits**. The former French colony has 470 minerals, with oil, gold and diamonds having the greatest potential, according to the World Bank.

#### PYQ

Q. How does India see its place in the economic space of rising natural resource rich Africa? (2014)

**Practice Question** 

Q. How African mineral deposits can help India to become one of the major global player in the development of Rare Earth Elements of the world.

#### 3. SMART CITIES IN INDIA: 22 CITIES TO BE COMPLETED BY MID-2023

Syllabus: Geographical features and their location

**Context:** The Centre's Smart Cities Mission is completed in 22 cities, giving people a better quality of life and a clean and sustainable environment.

#### What is a Smart City?

- Smart Cities Mission a **flagship mission** was launched on June 25, 2015, and 100 cities were selected for redevelopment through four rounds of competition held between 2016 and 2018.
- Smart Cities focus on their most pressing needs and on the greatest opportunities to improve lives. They tap a range of approaches –
  - digital and information technologies
  - urban planning best practices
  - ▶ public-private partnerships
  - policy change
- In the approach to the **Smart Cities Mission**, the objective is to promote cities that provide core infrastructure and give a decent quality of life to its citizens, a clean and sustainable environment and application of '**Smart' Solutions**.

#### Smart City and GIS based planning and management:

• **Unplanned Growth:** Modern urban planning in India is confronted with major challenges such as accelerated growth and land-use change, unplanned expansion and water supply management issues.



- **UAV's and Smart Mapping:** State-of-the-art remote sensing and GIS skills including the use of UAVs will allow rising to the challenge of managing the rapidly changing urban environment of Indian cities.
- **GIS and Smart Planning:** Multidisciplinary field that includes surveying, photogrammetry, remote sensing, mapping, geographic information systems (GIS), geodesy and global navigation satellite system (GNSS)
- **Smart Data Management:** A centralized information system based on GIS provides an IT framework for maintaining and deploying data and applications throughout every aspect of the city development life cycle.
- **Remote Sensing Satellites:** Corona spy-satellite images from the 60s, now declassified, offer us a unique view of the Earth at the very early stages of intense development and thus before the urban explosion in India.
- UAVs and Drones for Urban Planning
  - ▶ Retrieve data from difficult-to-access areas and highly populated cities.
  - Traditional building inspections can be invasive and time-consuming, cameras with thermal imagery technology can help quickly diagnose air leakages to improve a buildings' energy efficiency.
  - Can map major pollution sources in the city and their pathways in the rivers and other water bodies.
  - ► Can provide a big boost to Smart City Mission.

#### Way Forward for Smart City Planning in India

- Understanding of **physical and digital space** for urban planning for a smart city with adequate geospatial datasets and analytical capabilities.
- Help provide a **clean and sustainable environment** and application of **'Smart' Solutions** by encouraging the use of remote sensing and GIS techniques e.g. consideration of 'river space'.
- **Use of drones** in urban planning is very promising but we need to create the enabling environment DGCA rules for scientific and professional uses of drones must be simplified.
- Need to build **trained manpower** for the Smart Cities Mission launched by the Government of India with an objective to promote sustainable and inclusive cities.

Smart cities are being viewed as the new growth centers of economic development and smart urbanization in India, which will have potential to accommodate active migrants from, inter and intra states of India. Thus their scientific planning is important for better urbanization and regional development in India.

#### PYQ

- Q. With a brief background of quality of urban life in India, introduce the objectives and strategy of the 'Smart City Programme'. (2016)
- Q. Smart cities in India cannot sustain without smart villages. Discuss this statement in the backdrop of rural urban integration. -2015
- Q. Account for the huge flooding of million cities in India including the smart ones like Hyderabad and Pune. Suggest lasting remedial measures. -2020

#### **Practice Question**

Q. Discuss how the integration of GIS systems in smart cities development will have pursue better process of urbanization in India.

#### 4. GLOBAL SOUTH WATER-SENSITIVE CITIES: CASE OF INCLUSIVE URBAN PLANNING

**Syllabus:** Changes in critical geographical features (including water bodies and ice-caps) and in flora and fauna and the effects of such changes.

## **Context:** In the contemporary times of climate change, the Neo-liberal capital and builder-led urban development are splitting the cities into unequal parts resulting in non-inclusive and non-equitable development.

#### Why 'non-inclusive' water management is an emerging issue in urban cities?

• The urban cities are facing emerging crisis of **water supply**, **wastewater and storm water management** – from an inclusion, rights and justice perspective.

#### Reasons for prevalence of non-inclusivity:

- **Economic development over Equality:** A techno-managerial discourse dominates mainstream thinking about urban water, wastewater and drainage challenges and their application in developing southern countries. They are often borrowed from research and discourse from Europe and Australia.
- **Divided infrastructure:** The infrastructure developed in the urban cities is built with all the amenities and facilities like water, sanitation, power supply, etc. which is unevenly available in the surrounding squatter region resulting in **division of infrastructure and facilities**.

#### Water-sensitive cities

Water-sensitive cities are geared towards a holistic management of the water cycle to deliver basic urban water services of supply and sanitation while mitigating flood risks and protecting and enhancing the health of the receiving waterways.

- **Issue:** Cities of global south have large informal settlements and they are suffering from large and growing inequity in urban land use, unplanned and informal settlements and their poverty. On the other hand, cities of Global North countries are planned cities.
- **Solution:** A water-sensitive cities framework for the global south should aim to achieve outcomes and impacts relevant to the context.

#### Case Study: Water divide seen in Developed Countries: Europe and Australia

- In many instances, close to 50 per cent and sometimes more of the population lives in congested unplanned settlements (unauthorised or authorised but congested living areas, slums and other informal habitations).
- A builder and real estate development-based urbanisation thrust is creating a crisis in providing basic infrastructure and has negative social impacts.
- These cities have been living beyond the availability and supply of water from rivers and groundwater. Built-up areas in cities have been flouting urban planning norms.
- Heavy infrastructure development in cities, including underground parking and metros, also destroys aquifers and the water recharge potential of groundwater.

#### Significance of "Water Sensitive cities"

- Water to All Residents: The 'water-sensitive cities' discourse and frameworks emerging from global north countries (Europe and Australia) have their foundations in cities with planned urban development with a statutory legal entitlement to housing and basic infrastructure (including water, wastewater and drainage management) for all residents of their cities.
- Access to water and sanitation: The core aim of urban planning is needed to be substantially achieved and access to water and sanitation is realised as a *de facto* human right of all residents.
- Water conservation and management: A water-sensitive city, in the developed country context, aims to achieve second-generation outcomes higher standards and more effective water conservation and wastewater management standards.
- **Overcoming water stress:** The outcomes include nutrient removal, carbon sequestration, energy extraction, methane reduction and adaptation to water stress and/or urban flooding accruing from climate change impact.
- **Environmental conservation infrastructure:** The planned environment with functional grey infrastructure is at the core of a water-sensitive city.

#### Need for "Water Sensitive Cities" in India:

- Lack of sanitation and Drainage: Small and medium-sized cities lack sanitation and drainage infrastructure. Combined sewers that also drain stormwater overflow in monsoons.
- Lack of 24x7 water supply: There is hardly any city with a 24x7 water supply. No Indian city has 100 per cent sewage or septage treatment. The functionality of existing sanitation infrastructure (sewered and/or non-sewered systems) remains challenging for India and the global south.

- Water Politics: For various reasons, essentially centring on the political economy of our water and wastewater management, water is a contested domain.
- **Conflict over water sharing:** We have a range of water conflicts, including inter-city, intra-city, ruralurban and agriculture-industry-domestic water priorities. As a long-term goal, reducing the city's water and wastewater footprint can reduce water conflicts.
- Water conservation in India: Water conservation, groundwater recharge and decentralised nonsewered septage treatment systems need to be prioritised in planned settlements in a city with more open common facilities like parks, institutional buildings, footpaths and wider roads. And the benefits need to be shared with the less privileged.
- Water runoff: Our large and growing cities now constitute a large watershed/catchment, generating its own runoff and increasing the risk of urban flooding during climate events of high-intensity rainfall spells (where existing stormwater drains are not designed to capture the increased runoff).
- **Urban Flooding:** This was witnessed in Bengaluru and Lucknow in 2022 and in Chennai and several other cities in the last decade. We need groundwater recharge, more grey infrastructure and enhanced drainage norms to address urban flooding.

Global south water-sensitive cities framework envisages cities commit to a "Just and Equitable Access, Use, Re use" of water supply to sewerage/septage and stormwater management. The framework recognizes inequity in urban settlements as the basis of planning and designing interventions for water-sensitive cities. There is no 'leapfrogging' possible without addressing infrastructure deficiencies, especially for the less privileged residents of our cities.

#### PYQ

Q. India is well endowed with fresh water resources. Critically examine why it still suffers from water scarcity. -2015

#### **Practice Question**

Q. Analyze how a water divide has been created in the "Global South" causing inequity and non-inclusion. Also discuss how the "Water Sensitive Cities" will help in achieving equitable and sustainable urbanization in India.

#### 5. 15-MINUTE CITIES AND ITS APPLICABILITY IN INDIAN CONTEXT

Syllabus: Geographical features and their location

**Context:** 15-minute city is hailed as a spatial development model to help foster a more local, healthy, equitable and sustainable way of life.

#### **15 Minutes Cities:**

- **Historical Significance:** The model highly discussed in the post-novel coronavirus disease (COVID-19) pandemic context, is the '15-minute city' concept. It was first presented by Franco-Colombian scientist Carlos Moreno and envisions a more decentralised city.
- **Integrated Networks:** The city is not divided into shopping, residential or business districts, but into networks of self-sufficient neighbourhoods wherein individuals can feel connected and catered for.
  - The concept propagates access to goods and services, smaller-scale offices, retail and hospitality, co-working and open green spaces.
- **Spatial Development Model:** The spatial manifestation of this concept could override the need to travel and convert long-distance trips through motorised modes with definite environmental impacts into shorter trips.
- **Humanized City Landscapes**: The concept also humanizes the city scale and gives an opportunity to create public spaces in neighbourhoods sidewalks, parks, squares, traditional markets, and small plazas, etc. It allows for application of other urban design concepts such as 'eyes-on-street', 'build-to-edge' conditions, etc. to enhance their liveability and human happiness.



#### Case Study: First 15 Minutes city of Europe: Copenhagen

**Copenhagen the first European city** to pedestrianize its main shopping street in 1961, an approach many other cities copied. As we moved towards the end of the 20th century, concerns rose over air pollution and more and more cities enhanced their public transport networks, and started building cycling lanes.

#### Limitations of 15 Minutes Cities Model:

- **Urban Divide:** The concept is being criticised for the risk of creating urban divide.
- **Complex Transport System:** Neighbourhoods are required to be connected to each other and to centers of work and family in other parts of the city through a reliable public transport connection.
- **Transit-oriented development:** In fact, the 15-minute city is complementary to the transit-oriented development approach that integrates land use and transport by agglomerating a mix of compatible activities within 400-800 metre accessible distance around public transport services.

#### Applicability of 15 Minutes city in India:

- **Population vs Area based growth:** The ideas and principles underpinning the concept are not new:
  - > The Delhi Master Plan has population-based norms for provisioning amenities (health, education, commerce, etc.).
  - Cities like Mumbai and Bengaluru have area-based norms for layout planning, which, if implemented in utopian conditions, would result in the creation of a well-facilitated complete neighbourhood.
- **Distant work centers**: The spatial structure of Indian cities is characterised by primary and secondary work centers, which host high-order commercial activities along with residential areas located at comfortable commuting distance (maximum one hour) from these economic hubs.
- **Post Covid-19 changes:** Its applicability relies heavily on the argument that the new 'work-fromhome' or 'distant working' would be the new normal for a large workforce. However, considering that a majority of the Indian workforce is employed in the non-tertiary sector (71 per cent according to data aggregator Statista), nearly 90 per cent is employed in the informal sector.



15 Minutes city is one of the smart solutions to the Urban pollution in India and world, which requires development of range of modes of transport like railways and road-based modes, and non-motorised modes like micro-mobility modes, cycles, by walking, etc. But it all zeroes down to the implement-ability of the idea and supporting its application by mandating it in all future re-developments and through the formulation of appropriate guidelines and codes especially at the local level for its application in India.

#### **Practice Question**

Q. What is "15 Minutes City"? How it will help in reducing urban air pollution in Indian cities?

#### 6. THE 'INTERNATIONAL YEAR OF MILLETS'

**Syllabus:** Distribution of key natural resources across the world (including South Asia and the Indian subcontinent)

### **Context** The United Nations has declared 2023 as the International Year of Millets. Despite it having a lot to offer to consumers and farmers, millets aren't the first choice.



#### **Positives of millets:**

- **Nutritionally superior traits:** Millet's score over rice and wheat in terms of minerals, vitamins, and dietary fibre content, as well as amino acid profile.
- For example, Bajra (pearl millet), has iron, zinc, and protein levels comparable to that of wheat, but it's gluten-free and has more fibre.
- It can address the problem of "hidden hunger" arising from the consumption of energy-dense but micronutrients-deficient foods
- Advantages as a crop:
  - ▶ Millets are hardy and drought-resistant crops.
  - > This has to do with their **short duration** (70-100 days, against 115-150 days for rice and wheat)
  - ► lower water requirement (350-500 mm versus 600-1,250 mm)
  - > ability to grow even on poor soils and in hilly terrain

#### What is Millet?

- Millet is a collective term referring to a number of small-seeded annual grasses that are cultivated as grain crops, primarily on marginal lands in dry areas in temperate, subtropical, and tropical regions.
- **Examples**: jowar (sorghum), ragi (finger millet), Kodo (Kodo millet), kutki (little millet), kakun (foxtail millet), Sanwa (barnyard millet), cheena (proso millet), kuttu (buckwheat) and chaulai (amaranth).

#### Where do millets lag despite huge benefits?

- **Eating Habits:** For the poor, both in urban and rural areas, rice and wheat were once aspirational foods
- **The dominance of traditional grains:** Two-thirds of India's population receives up to 5 kg of wheat or rice per person per month at Rs 2 and Rs 3/kg respectively.
  - The recent move to place two fine cereals free of cost from January 2023, further tilts the scales against millets.
- Cooking: Rolling Rotis is easier with wheat than millet flour
- **Low per-Hectare yields:** The national average is roughly 1 tonne for jowar, 1.5 tonnes for bajra and 1.7 tonnes for ragi.
  - ▶ Whereas it is 3.5 tonnes for wheat and 4 tonnes for paddy **are a disincentive.**
- **Presence of Infrastructure for traditional grains:** With access to assured irrigation, they would tend to switch to rice, wheat, sugarcane, or cotton.
- Absence of government procurement at minimum support price (MSP): It makes farmers hesitant to grow even this high-yielding and naturally bio-fortified bajra, suitable for both post-monsoon Kharif and summer cultivation.

#### Indian Agricultural Research Institute (IARI) contribution:

- **Hybrid varieties:** Pusa-1201, a hybrid bajra that gives an average grain yield of over 2.8 tonnes and a potential of 4.5 tonnes per hectare.
- **Characteristics:** It matures in 78-80 days.
- It is **resistant to downy mildew and blasts**, both deadly fungal diseases.

Millets have become a very important crop of India in the contemporary times due to its high resilience to high temperature, low water utilization; sustain heat waves, capability to grow during drought periods, etc. making it one of the most suitable crop to be replace with rice and wheat forming a basis of the food security in the times of climate change.

#### PYQ

Q. Why did the Green Revolution in India virtually by-pass the eastern region despite fertile soil and good availability of water? -2014

#### **Practice Question**

Q. Explain the significance of declaring 2023 as "International year of Millets" by UN in the contemporary times of climate change. Also analyze why despite high benefits, millet production and consumption is low in India.

#### 7. INDIAN BLUE ECONOMY IS THRIVING BUT COUNTRY NEEDS TO BE CAREFUL ABOUT MARINE LITTER

**Syllabus:** Factors responsible for the location of primary, secondary, and tertiary sector industries in various parts of the world (including India)

**Context:** The blue economy in India is thriving, but at the cost of rising marine litter throughout its geographical space with abandoned, lost or discarded fishing gear becoming a serious threat in India and the World.

#### What is Blue Economy?

 The Blue Economy encompasses a wide range of economic activities pertaining to sustainable development of resources and assets in the oceans, related rivers, water bodies and coastal regions – in a manner that ensures equity, inclusion, innovation and modern technology.

#### India and the Blue Economy:

• International Maritime Cooperation: India's engagement in the Blue Economy is rising, as the country issues policy proposals, and actively participates in international and regional dialogues on the Blue Economy, maritime and marine cooperation.

 Food Security and Climate Change: The Federation of Indian Chambers of Commerce and Industry (FICCI) published the Blue Economy Vision 2025, which states that the Blue Economy's impacts are not limited to the ocean but these are crucial for countries' food security, poverty, resilience against dangerous consequences of climate change, maritime cooperation, job opportunities and countries' socio-economic growth.

#### India's Vision:

- **Integration of Indian Ocean:** India has greater potential to foster cooperation in the **Indian Ocean** to design blue economic strategies.
- **Blue Economy and Sustainability**: Under its **G20's presidency**, India looks forward to ideate concrete Blue Economy policies.
- **Deep Ocean Mission:** India also has significant ambitions for its offshore mining industry. It has hence announced the Deep Ocean Mission, a plan to mine the metals in the Indian oceans, including **Copper, Nickel, Cobalt, and Manganese**, estimated to be \$110 billion. These industries will no doubt be essential to the blue economy.

#### Marine litter:

- **Plastic Litter:** Plastics are the most common man-made objects sighted at sea, with an estimate of **18,000 pieces of plastic litter floating on every square kilometre of the world's oceans.**
- **Plastic from Land to Oceans:** Estimates show that 4.8-12.7 million tonnes of plastic enters the ocean every year from land-based sources.
- **Plastic Affecting Marine Biodiversity**: It's estimated that 100,000 turtles and marine mammals, such as dolphins, whales and seals, are now killed by plastic marine litter every year around the world.
- **Biodiversity Conservation:** With the ocean economic activities and governance, the preservation of marine biodiversity and resources is stressed.

#### Challenges related to the blue economy in India

- Climate change
- Marine pollution
- Overexploitation of marine resources

The Blue economy is important for India as it provides broader avenues of food production which adheres to the principles of sustainability, but the marine litter is becoming a big challenge which hampers the marine environment and biodiversity. Thus a sustainable fishing practice is the need of the hour for achieving the SDG 14 of life below water and SDG 2 of Zero Hunger.

#### PYQ

- Q. Define blue revolution, explain the problems and strategies for pisciculture development in India. -2018
- Q. Critically evaluate the various resources of the oceans which can be harnessed to meet the resource crisis in the world. -2014
- Q. What are the forces that influence ocean currents? Describe their role in fishing industry of the world. (Answer in 250 words) -2022

#### **Practice Question**

Q. The Blue economy is thriving in India but at the cost of massive marine litter affecting coastal regions of India. Examine.

#### 8. BLACK SOIL IN RED: CLIMATE CHANGE THREATENS WORLD'S FOOD BASKET

**Syllabus:** Distribution of key natural resources across the world (including South Asia and the Indian subcontinent)

## **Context:** The **Food and Agriculture Organization (FAO) report** finds most black soils found in the world have moderate to severely eroded due to land-use change and unsustainable practices.

#### Black Soils (Food Basket of World):

- Black soils, which feed the global population, are under threat, with most losing at least half of their soil organic carbon (SOC) stocks.
- World Distribution: The distribution of black soil areas used as croplands varied in each region.
  - Europe and Eurasia accounted for 70 per cent of the soil in the total cropland, while North America, Latin America and the Caribbean and Asia had 10 per cent each.
- These soils are characterised by a thick, dark-coloured soil horizon rich in organic matter.
- The inherent fertility of the soils make them the food basket for many countries and are considered essential to the global food supply.

#### **Reasons for degradation of Black Soils**

- **Unsustainable practices**: Land-use change, unsustainable management practices and excessive use of agrochemicals are to blame.
  - ► Factor contributing to soil degradation Industrial activities, mining, waste treatment, agriculture, fossil fuel extraction, processing and transport emissions
  - ► Reasons behind soil nutrient loss: soil erosion, runoff, leaching, burning of crop residues
- **Erosion of soil:** Most of the black soils suffered from moderate to severe erosion processes, as well as nutrient imbalances, acidification and biodiversity loss.

#### Significance of Black Soil:

- **Population Support:** Black soils are home to 2.86 per cent of the global population and had 17.36 per cent of cropland.
- **Fertility and high moisture retention:** Black soils are extremely fertile and can produce high agricultural yields thanks to their elevated moisture storage capacity.
- **Carbon Sequestration**: This signifies their importance for climate change mitigation and adaptation.
- **Impact of Global Warming:** However, black soils are quickly losing their soil organic carbon (SOC) stocks. They have lost 20 to 50 per cent of their original SOC stock, with the carbon being released into the atmosphere mostly as carbon dioxide, exacerbating global warming, the report pointed out while quoting previous studies.

#### What is soil degradation?

- Soil degradation describes what happens when the **quality of soil declines** and diminishes its capacity to support animals and plants.
- Soil can lose certain physical, chemical or biological qualities that underpin the web of life within it.

#### State-wise analysis of nutrient deficiency in soil:

- Organic carbon deficiency is widespread across the country.
- Haryana's soils are the most deficient in organic carbon, followed by those of Punjab, Uttar Pradesh, Rajasthan, Tamil Nadu, and Mizoram.
- Nitrogen, phosphorus, and potassium deficiencies were recorded in at least half the samples in 32 states and UTs.

#### What is India's conservation strategy?

- The Government of India is implementing a *five-pronged strategy* for soil conservation.
- This includes making soil chemical-free, saving soil biodiversity, enhancing soil organic matter, maintaining soil moisture, mitigating soil degradation, and preventing soil erosion.

#### Some Important Government initiatives:

- Soil Health Card (SHC) scheme (2015): to provide the status of soil's health to farmers
- **Pradhan Mantri Krishi Sinchayee Yojana**: to prevent soil erosion, regeneration of natural vegetation, rainwater harvesting, and recharging of the groundwater table
- **National Mission for Sustainable Agriculture (NMSA**): to promote traditional indigenous practices such as organic farming and natural farming.
- **Paramparagat Krishi Vikas Yojana:** Organic farming is promoted through the adoption of organic villages by cluster approach and Participatory Guarantee System (PGS) certification

Preserving natural vegetation on black soils such as grasslands, forests and wetlands and adopting sustainable soil management approaches on cropped black soils were the two main goals highlighted by FAO. Thus, for their conservation FAO had made various recommendations for farmers, national governments, research and academia and the global platform International Network of Black Soils.

#### PYQ

Q. Discuss the natural resource potentials of 'Deccan Trap'.

#### **Practice Question**

Q. The black soil is often regarded as the food basket of the world. In light of the statement bring out its significance a cause of degradation while suggesting measures for its conservation.

#### 9. SMART WATER MANAGEMENT: AN INNOVATIVE SOLUTION TO WATER SCARCITY OFFERED BY THE AI.

**Syllabus:** Distribution of key natural resources across the world (including South Asia and the Indian subcontinent)

**Context:** The **Ministry of State for Science and Technology** has announced that the government is providing financial support to a start-up incubated at the Indian Institute of Technology, Kanpur for developing **smart water management technologies.** 

#### What is Smart water management?

• The Smart water management includes different components of management of water by checking different parameters through the use of **Information and communication technologies (ICT)**, **Artificial Intelligence (AI)**, **sensors**, **IOT**, **Big Data**, **unmanned aerial vehicles**, **GIS and robotics** etc., for maintaining quality, stream flow, pollution check, erosion and sedimentation, etc. for sustainable water use and management.



#### Benefits of smart water management:

• **Maintain water flow:** With AI and ICT, stream flow can be determined to check the level of water to help in taking real-time decisions for water use by household, industry, agriculture, etc.

#### **Smart Water-Shed Management**

Watershed management is the process of implementing land use practices and water management practices to protect and improve the quality of the water and other natural resources within a watershed by managing the use of those land and water resources in a comprehensive manner.

In contemporary times, the smart management recognized as a new approach that uses very practical tools that are applicable for different dimensions like water management, ecosystem management, smart home forensics, irrigation, smart city initiatives, medical, etc. For achieving this objective, the integration of all these dimensions with watershed management is done and introduced an innovative framework, i.e., **smart watershed management (SWM).** 

- **Pollution control**: With the integration of AI and ICT, the timely report of water containing various pollutants (turbidity, arsenic, pathogens) can be assessed to smartly control water pollution.
- **Erosion of soil and land**: The smart systems can help in the checking the erosion of the river channels and banks to assure the checking of land erosion and degradation.
- **Sedimentation**: Though the use of smart technologies, the sedimentation could be checked.
- **Use of GIS**: Geographical Information System can integrate various regional aspects (land elevation, water basin, flood plains, agricultural land use, etc.,) for their better planning and management.

#### **Central Groundwater Authority and Smart water management**

• The Central Groundwater Authority has issued guidelines under which every commercial groundwater user must install a **smart water meter** and pay yearly bills.

## The role of Smart Water Management better management of water in water stressed region.

- Water Conservation: The Smart use of water will help in smart use of water in water stressed region which will result in conservation of water. E.g. According to Central Ground Water Authority, India has 256 water stressed districts with highest water scarcity in Maharashtra, Gujarat, Punjab, Rajasthan, and Uttar Pradesh.
- **Illicit discharge detection and elimination:** The smart system will detect the illicit discharge through pipelines, water storage tanks, etc. and will help in reducing them in the water stressed regions of India.
- **Smart water supply**: The smart water-shed management system will calculate the flow discharge of rivers in the river basin; it will provide real-time data which can be followed for the use of water in water stressed regions.
- **Improve water quality**: The smart water-shed management will help in the assessment of polluted water and giving inputs for their treatment for maintaining the quality for water which is important in the water stressed region in India.
- The Smart Water management System will revolutionize the way in which the water is managed in the urban and rural cities in India, which will help in improving conservation practices and participation of communities for collective use of water. Thus helping in socio-economic development, regional development and **achieving SDG 6 i.e.** 'Ensuring access to water and sanitation to all'.

#### **PYQs**

- Q. What is water stress? How and why does it differ regionally in India? -2019
- Q. "The ideal solution of depleting ground water resources in India is water harvesting system." How can it be made effective in urban areas?
- Q. In what way micro-watershed Development projects help in water conservation in drought proneand semi-arid regions of India. -2016
- Q. India is well endowed with fresh water resources. Critically examine why it still suffers from water scarcity. -2015

#### **Practice Question**

Q. What is smart water management? Examine how the water stressed region of India can benefit by the smart water management in India?

#### 10. PALM OIL & ALTERNATIVES

**Syllabus:** Distribution of key natural resources across the world (including South Asia and the Indian subcontinent)

**Context:** Palm oil is water-intensive and requires large patches of land for its cultivation which has paved way for development of greener alternatives of vegetable oil sources in India.

#### India and Edible Oil:

• India is the **second-largest consumer of edible oil** globally and its largest importer. While the government has taken several initiatives over the years to increase the domestic production of edible oils due to its shortage and high price.

#### India and Palm Oil:

- **Growth of Palm Oil production**: Palm oil production grew between 2015-2016 and 2020-2021 at a compound annual growth rate of 6.1 per cent, as reported in the Economic Survey 2021-2022.
- India's Palm Oil Import: India continues to import around 60 per cent of edible oil requirement. More than half of this is palm oil, primarily from Malaysia and Indonesia, followed by soybean and sunflower oils. It is projected that the imports will continue to grow.

#### How Oil Palm gain the highest producing share in India:

- Lower Yield than Global Average: Oil Yield levels in India are usually lower than the global average. The decade of the 1980s saw a series of Technology Missions (TM) to increase productivity, including a TM on oilseeds.
- **Technology Mission on Oilseed and Pulses (TMOP)**: In 1990, with the Technology Mission on Oilseed and Pulses (TMOP), there was an increase in yield and production, improvement in extraction technology and a reduction in import bills after the inception of TMs.
- Integrated Palm Oil Production: Oil palm started receiving special attention in the early 1990s with an oil palm development program under the TMOP. This metamorphosed into an integrated scheme on oilseeds, pulses, oil palm and maize in 2004-2005.
- **Rashtriya Krishi Vikas Yojana**: Also, a special initiative was undertaken in 2011-12 under the **Rashtriya Krishi Vikas Yojana** for the expansion of the area under oil palm cultivation.
- National Mission on Oilseeds and Oil Palm: The 12th Five Year Plan period saw a National Mission on Oilseeds and Oil Palm from 2014-2015 to 2017-18. This was subsumed into the National Food Security Mission-Oilseeds and Oil Palm in 2018-2019.

#### Need for Greener Alternatives to Palm Oil:

- **Deforestation and exploitation of Groundwater:** It seems to be encouraging deforestation and exploitation of groundwater at a time when efforts should be in place for their conservation. It is reported that the yield per hectare of oil palm is higher than other oilseeds.
- **Better Nutrition:** In terms of nutrition, oil from rice bran, groundnut, sunflower and oilseeds such as sesame, mustard and linseed is higher in nutrient content.
- **Tree-Borne oil:** Indian farmers are familiar with the cultivation of various alternative greener oilseeds and tree-borne oils such as Mohua, Karanja and linseed.
- **Lower Gestation Period:** Mustard and its variant rapeseed are less water-intensive and can produce output without any gestation period.
- **Better health benefits:** Rice bran has 18 to 20 per cent oil content that can be extracted and processed as edible oil. The oil contains oryzanol which is very good for metabolism.

#### **Challenges in developing Greener Alternatives:**

- Low Yield and high Gestation: The yield from other oilseeds in India is much below the global average. Further, while four years is stated to be the gestation period for the crop, it takes about seven years to stabilise yield and produce good quality oil.
- **Below MSP Procurement:** Groundnut, soybean, sunflower seed, sesamum, niger seed, rapeseed, mustard, safflower and copra are the oilseeds among the 22 mandated crops for which minimum support price (MSP) is announced by the government. But more often, they are sold at a price below the MSP.

Palm Oil is one of the highly demanded edible oil in India due to its multi-faced use helping in economic development and food security. But at the same time its cultivation is also detrimental to the environment and biodiversity due to loss of forestlands. Thus, development of greener alternatives is indeed necessary for the sustainable development of edible oil production in India for self-sufficiency and environmental conservation.

#### PYQ

Q. 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

#### **Practice Question**

Q. Examine the greener alternatives of palm oil along with their benefits for sustainable selfsufficiency in edible oil production in India.

#### 11. SOUTH-EAST ASIAN FARMERS TAP INTO SUSTAINABLE RUBBER INDUSTRY

**Syllabus:** Factors responsible for the location of primary, secondary, and tertiary sector industries in various parts of the world (including India)

**Context:** Recently Thailand farmers developed practices to develop sustainable rubber industry in **South East Asia.** 

#### **Rubber Plantation in Thailand:**

- Largest Rubber Production: As the world's largest producer of natural rubber (followed by Indonesia, Malaysia, India, China)— supplying more than a third of global stocks in 2021 Thailand's policies have stimulated massive deforestation, plummeting biodiversity and soaring soil erosion.
- Sustainable Practices: The vast majority of the country's plantations are still worked conventionally, but a few farmers are abandoning pesticides to try and lessen their impact on the environment.

Environmental conservation over Economic

gains: Economic benefits are kept at the bottom

#### Features of Rubber:

- Natural rubber comes from various sources, the most common being the Pará rubber tree (Hevea brasiliensis). It grows well under cultivation and yields latex for several years.
- Natural rubber is a **polymer of isoprene**, an organic compound.
- Rubber is a coherent elastic solid obtained from the **latex of a number of tropical trees** of which **Hevea brasiliensis** is the most important.
- Rubber trees have an **economic life period of around 32 years** in plantations.

line while the small-scale benefits of turning to greener methods are given more emphasis.

#### **Cultivation of Rubber Trees:**

- Soil: The trees demand well-drained and well-weathered soils.
  - Lateritic type, alluvial, sedimentary types, and non lateritic red soils are best for the growth of these trees.
- **Precipitation and Temperature:** An evenly distributed rainfall with **at least 100 rainy days a year** and a temperature range of about **20 to 34°C** are optimum conditions for the growth of the Hevea rubber tree.
  - ► A humidity of around 80%, 2000 hours of sunshine, and absence of strong winds are also necessary for the best results.

#### **Status of Rubber Production in India**

- According to FAO 2019, India is the **fourth largest producer and consumer of Rubber in the World.**
- Distribution of Rubber plantation in India:
  - ► **Kerala** is the **largest producer** of natural rubber in India. **Major areas**: Kottayam, Kollam, Ernakulam, Kozhikode districts produce practically all the rubber of this state.

- **Karnataka:** Chikmagalur and Kodagu are the main producing districts.
- **•** Tripura, Assam, Andaman and Nicobar, Goa etc are some other rubber producing States.

The future of natural rubber is very bright, as the alternative i.e. synthetic rubber produced from oil is highly polluting. Also rubber is planned to be banned by the European Union as it causes large scale deforestation in the Tropical region. Thus, sustainable rubber plantation is needed for the achieving of dual goal i.e. economic development and environmental conservation.

#### PYQ

Q. Describing the distribution of rubber producing countries, indicate the major environmental issues faces by them. (250 words) -2022

#### **Practice Question**

Q. Examine the need of sustainable rubber plantation in the India while bringing out the impact of rubber plantation on the rubber growing regions of the world.

#### **12. CLIMATE CHANGE AFFECTING TEA FARMING IN INDIA**

**Syllabus:** Changes in critical geographical features (including water bodies and ice-caps) and in flora and fauna and the effects of such changes.

**Context:** Recently, Assam tea growing region did not see a second flush of tea leaves due to the impact of climate change.

#### Assam Tea:

- Assam tea is generally known for the second flush (period when the tea plants start growing new leaves to be harvested), which comes in May-June and is characterised by its boldness and robustness and is topped with classic flavours of malt and woody astringency.
- It is valued for its rich taste, bright liquors and is considered to be one of the choicest teas in the world. Tea planters in Assam say the pure second flush character is missing.

#### Tea Growing Regions in India

- The main tea-growing regions are in the Northeast (including Assam) and in north Bengal (Darjeeling district and the Dooars region).
- Dibrugarh is currently known as **Tea City of India.** The soil of the district is mostly fertile, alluvial soil.
  - ► It is the gateway to the three tea-producing districts of Tinsukia, Dibrugarh, and Sivasagar.
  - ▶ These three areas account for approximately 50% of India's Assam tea crop.
- The state of Assam is the world's single largest tea-growing region.
- Tea is also grown on a large scale in the Nilgiris in south India.

#### Tea Climate Requirements:

- **Climates:** warm and humid (relative humidity of between 80 and 90 percent)
- **Precipitation:** annual precipitation ranges between 1150 and 6000 mm
- Tea plants cannot grow in temperatures below 13 degrees Celsius or above 30 degrees Celsius. However, during most of the harvesting season, the air temperature in the plains of North-East India, including Assam, stays over 30 degrees Celsius.
- Tea is typically grown under shade trees in the plains of northeast India to maintain the temperature below a point where it won't negatively impact photosynthesis.
- The optimal soil for growing tea is the well-drained fertile soil in highlands with a decent depth, an acidic pH between 4.5 and 5.5, and a medium to a high level of organic matter.

#### **Climate Change and Tea Cultivation:**

- The tea industry in Assam and Bengal is facing the consequences of climate change. Erratic weather patterns, prolonged periods of drought, prolonged periods of rain, and a lot more.
- The crop harvest of the tea estates across Assam has been badly affected due to the moisture stress conditions resulting in stunted growth, wilting, defoliation and die back of branches in varying degrees which has even led to withdrawal of plucking temporarily in some tea estates.

Tea is an important cash crop of Himalayan region (including Himacha Pradesh) and Southern states helping in the growth of farmers and industries in these regions. But the effects of Assam and Climate Vulnerability Index:

- Assam region is the most highly climate vulnerable state in the country, according to a climate vulnerability index done by non-profit Council on Energy, Environment and Water.
- It has a vulnerability index score of 0.616, followed by Andhra Pradesh with 0.483 and Maharashtra with 0.478.

climate change resulting in loss of moisture and humidity is affecting the tea cultivation is becoming a new challenge to the farmers which will result in various socio-economic consequences and hampering regional development.

#### PYQ

Q. 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

#### **Practice Question**

Q. Discuss the impact of climate change on the tea producing regions of India and also highlight the socio-economic issues faces by the tea growing farmers of the region.

#### **13.** THE FUTURE TECH EPICENTRES IN INDIA: TIER II & III CITIES

**Syllabus:** Factors responsible for the location of primary, secondary, and tertiary sector industries in various parts of the world (including India)

## **Context:** As per the **Ministry of Science and Technology**, India ranks globally 3rd in Start-Up ecosystem and also in terms of number of **Unicorns** with 49 per cent of the start-ups from tier-2 and tier-3 cities working in the fields like IT, agriculture, aviation, education, energy, health and space sectors.

#### Key-highlights:

- **Unicorns**: As per the latest data, there are currently 105 unicorns, out of which 44 were born in 2021 and 19 in 2022.
- **R&D:** As per the latest data, India has over 5 lakh R&D personnel, the number that has shown a 40-50% increase in the last 8 years.
  - ➤ Women in R&D: In the last 8 years, women's participation in extramural R&D has also doubled and now India occupies 3rd rank in terms of number of PhDs awarded in Science and Engineering (S&E) after the USA and China.
- Start-ups: India in its 75th year of Independence is now home to as many as 75,000 StartUps.
  - The special focus on Science, Technology and Innovation has fired the imagination of the youth in the country to innovate and solve problems with new ideas.
- **Spread to tier-2 and tier-3 cities:** India's startups today are not limited to only metros or big cities and 49 per cent of the start-ups are from tier-2 and tier-3 cities.

#### Tier II & III Cities - Growth Engines for the Future

- **Plus points:** Inspite of low public investments, these cities are promising a great potential. They have some inherent advantages like-
  - possessing basic amenities
  - ample availability of land and skilled labour

- **Tier II cities:** Tier II cities like Ahmadabad, Kanpur, Chandigarh, Patna, Dehradun, Pondicherry, Pune etc have a population of around one million.
- **Tier III cities:** Minnor cities with population less than one million like Madurai, Baroda, Nashik and Trichy are termed as Tier III cities.

- **Driving factors:** There are many factors driving the growth of real estate in these two tiers walk-towork concept, quality lifestyle, media exposure, the emergence of software companies and an increased affinity to retail.
- **Deviating pressure from metro cities:** The growth of these two tiers gestures towards a positive sign for the nation with their efforts to deviate the pressure on the metros which are dwindling under the burden of space, time and infrastructure.

#### Tier II and Tier III cities with Startups:

- Even in case of design, cities like Ahmedabad and Pune with their multitude design centres and institutes point towards the availability of skilled design talent in these cities.
- In smaller cities like Mysore and Mangalore where less rentals are complimented with good infrastructure, even pre-schools have been growing at an incredible 120% per annum.
- Chandigarh, Coimbatore, Vadodara, Jamshedpur have become the hub of e-commerce and feature as the top four small cities for online shopping.
- Towns of Gujarat like Ahmedabad, Surat and Vadodara have made huge progress industrially.

#### **Govt Support and Initiatives:**

- MSME Sustainable (ZED) Certification
- Startup Leadership Program (SLP)
- ASPIRE (A Scheme for Promotion of Innovation, Rural Industries and Entrepreneurship)
- Startup India Initiative
- Startup India Seed Fund Scheme
- Pradhan Mantri Mudhra Yojna
- Atal Innovation Mission

Tier II and Tier III cities of India due to various geographical advantages and ease of living have become new growth centers of start-ups in India leading to development of industries with forward and backward linkages and helping in socio-economic and regional development.

#### PYQ

- Q. 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. -2017
- Q. Elucidate the relationship between globalization and new technology in a world of scarce resources, with special reference to India.

#### Practice Question

Q. Why Tier II and Tier III cities of India are becoming new growth centers incubating regional start-ups for better economic development of these regions.

#### 14. FIRST INDUSTRIAL CORRIDOR IN SOUTH INDIA

**Syllabus:** Factors responsible for the location of primary, secondary, and tertiary sector industries in various parts of the world (including India)

**Context:** South India's first Industrial Corridor Project is set up at Tumkuru, Karnataka under the National Industrial Corridor Programme.

#### National Industrial Corridor Development Programme

 With the objective to increase the share of manufacturing in the GDP of India, the National Industrial Corridor Development Programme is being implemented whereby 32 greenfield industrial smart cities under 11 industrial corridors are being developed with world class Plug-n-Play infrastructure.

#### Tumkuru Industrial Township:

• **PM-GatiShakti:** Tumakuru Industrial Township has been planned with a holistic and integrated approach in line with the principles of **PM-GatiShakti** to address the issue of last-mile multi-modal connectivity to the economic zone.

- **Multi-modal connectivity:** The multi-modal connectivity ecosystem will ensure a seamless movement of raw materials and finished goods.
- Self-reliance cities: The project will be a mixed-use development comprising land uses like industrial, residential, institutional, green spaces, commercial, etc., making it a completely self-sustainable and resilient smart industrial city.
- **Integrating Industrial Nodes:** The CBIC project includes the development of industrial townships at **three nodes**: Krishnapatnam (Andhra Pradesh), Tumakuru (Karnataka), and Ponneri (Tamil Nadu).
- Innovation and Global Integration: This project will facilitate investments, foster innovation, enhance skills development and build finest manufacturing ecosystem for pitching India as a global investment destination. Target sectors are Food Products, Textile and Apparels, Electronics, Auto & Auto Components, Pharmaceuticals, Chemicals, Engineering, General Manufacturing etc.

#### **Industrial Corridors**

• An industrial corridor is basically a corridor comprising of **multi-modal transport services** that would pass through the states as main artery.

#### **Five Industrial Corridors**

- **Delhi-Mumbai Industrial Corridor (DMIC)** covers Uttar Pradesh, Haryana, Rajasthan, Madhya Pradesh, Gujarat and Maharashtra.
- Chennai-Bengaluru Industrial Corridor (CBIC) covers Tamil Nadu, Andhra Pradesh and Karnataka.
- Bengaluru-Mumbai Economic Corridor (BMEC) covers Maharashtra and Karnataka.
- Amritsar-Kolkata Industrial Corridor (AKIC) covers Punjab, Haryana, Uttarakhand, Uttar Pradesh, Bihar, Jharkhand and West Bengal.
- **East Coast Economic Corridor (ECEC)** covers West Bengal, Odisha, Andhra Pradesh and Tamil Nadu. Vizag to Chennai segment of this Corridor has been taken as phase-1.
- **Freight cargo** from industrial **and National Investment and Manufacturing Zones (NIMZs)** located upto a distance of 100-150 km on both sides of this main artery are brought to the industrial corridor via rail and road feeder links that provides last mile connectivity.
- This will lower costs of logistics and enable firms to focus on their areas of core competence.
- Industrial corridors offer effective integration between industry and infrastructure, leading to overall economic and social development.

Industrial corridors are the new growth centres of India which are integrating the ancillary industries with forward and backward linkages supporting manufacturing and service sector firms in the region. Thus the effective execution of the project will help in the better socio-economic growth and regional development.

#### PYQ

Q. What is the significance of Industrial Corridors in India? Identify industrial corridors, explain their main characteristics. -2018

#### **Practice Question**

Q. How integrated and digital industrial corridors will help India to act as an important part of global supply chain with seamless logistics movement. Analyze.

## 15. SUGAR INDUSTRY TO SOON TRANSFORM INTO THE ENERGY SECTOR

**Syllabus:** Factors responsible for the location of primary, secondary, and tertiary sector industries in various parts of the world (including India)

#### **Context:** According to **Department of Food and public Distribution**, sugar industry is an agrobased industry providing employment to 50 million sugarcane farmers and 5 lakh workers directly and indirectly in India, making India the **second largest producer and largest consumer of sugar in the world.**

#### Indian sugar industry

Indian sugar industry's annual output is valued more than Rs. 80000 crore and sugar production in 2022-23 is estimated at 340 lakh tonnes and 45 lakh tonnes of sweetener towards ethonal manufacturing (Indian Sugar Mills Association).

#### Factors contributing to localization and de-localization of sugar industries in India.

#### I. Localization of Sugar industries:

- **Raw material**: Sugar cane is a weight loosing raw material, thus the location of sugar industries is near to the sugar growing region in India. Before independence, the sugar industry were concentrated in Uttar Pradesh and Bihar region of India, producing 85% of sugar during 1936-37.
- Market: The market for sugar consumption is spread across India and particularly to the food processing sectors like confectionary industries.
- Transport: The sugar industries before independence were developed in Bihar and Uttar Pradesh region of India due to better road and railway transport developed in these region, which had better connectivity to the Punjab, coastal region of Maharashtra, etc.

#### II. De-localization of Sugar industries:

- Raw Material shift: After independence, the sugarcane producing region expanded from the Northern Belt of India towards Deccan i.e. Maharashtra and Southern India i.e. Karnataka and Tamil Nadu due to suitable soil and climatic conditions resulting in the shifting of sugar industries towards these regions.
- Market: The new industries requiring sugar increased in the industrial region of Maharashtra and Southern India becoming one of the factors for the de-localization of sugar industries towards western and southern regions of India.
- Transport: The sugar produced in India was easily transported towards hinterland regions and was also exported to the neighboring countries including Africa for revenue generation, thus with the development of road, railways, sea routes, etc. helped in the de-localization of sugar industries in India.

### Additional factors for the de-localization of sugar industries from Northern India to Southern

India.

- Peninsular India has tropical climate which gives higher yield per unit area as compared to north India.
- The sucrose content is also higher in tropical variety of sugarcane in the south. Θ
- The crushing season is also much longer in the south than in the north. For example, crushing season is of nearly four months only in the north from November to February, whereas it is of nearly 7-8 months in the south where it starts in October and continues till May and June.
- The co-operative sugar mills are better managed in the south than in the north.
- Most of the mills in the south are new which are equipped with modern machinery

#### Potential of sugar industry in becoming new energy industry of India:

The future of the sugar industry, as a whole, lies in development of sugarcane bio-refineries i.e. bioelectricity, bio-ethanol, bio-gas/ bio-CNG, bio-manure, bio-plastic and chemicals etc.

- **Cogeneration from Bagasse:** The electricity is generated by bagasse, which is also contributing towards the clean energy development of India. As per MNRE, the sugar mills in India generate more than 8000 MW of electricity from bagasse.
- **Biofuel:** The production of biofuel in India for petrol has been done for 9547 crore litres, out of which 619 litres have been produced from molasses (Ministry of Consumer Affairs, Food and Public Distribution)
- **Bio-Gas and Bio-CNG**: The Compressed bio-gas and Bio-CNG are other sources of energy from sugar o industry through press-mud and it is estimated that Bio-gas and Bio-CNG produced by the sugar industry can contribute 3% of the total fuel.

The Sugar industry in India is expanding in the North-western India and it is contributing to the socioeconomic development of farmers, industries and workers, while it has also became one of the important sources of energy helping in reducing petroleum import and import bill and achieving energy security for India.





#### PYQ

Q. Do you agree that there is a growing trend of opening new sugar mills in southern States of India? Discuss with justification.

#### **Practice Question**

Q. Why the sugar industries of India will witness a transformation into new energy sector?

#### **16.** JUTE INDUSTRY SEEKS GOVT SUPPORT FOR REVIVAL, GROWTH

**Syllabus:** Factors responsible for the location of primary, secondary, and tertiary sector industries in various parts of the world (including India)

Context:	The spurt in demand for jute bags from key export markets like the US, the UK, the rest
	of Europe and the UAE has certainly rekindled a hope for India for revival of its jute
	industries.

#### **Current Status**

- As per the **Food and Agriculture Organisation (FAO)**, India is the largest producer of jute followed by Bangladesh and China.
- However, in terms of acreage and trade, **Bangladesh takes the lead** accounting for **75% of the global exports in comparison to India's 7%**. **West Bengal, Bihar** and **Assam** account for almost 99% of India's total production.

#### The factors behind present location of jute industries are:

- **Raw material:** Most Jute mills are located in West Bengal mainly on the Hooghly River due to areas lying in basin of the river this ensures the availability of natural resources that can be used as raw material. **The ganga-Brahmaputra delta grows about 90% of jute** and supports raw material.
- Water and power supply: Abundant water is required for processing raw jute along with continual power supply through nearby coal basins.
- **Ease in Transportation and connectivity:** Require to be well **connected by a good network** of railways, waterways, and roadways to facilitate the movement of raw materials to the mills.
- **Factors of Production like labour: High density of population** and skilled/ semi-skilled **labour.** Availability of cheap labour from West Bengal and the adjoining States of Bihar, Orissa, and Uttar Pradesh helps in the carrying on productions.
- Market and capital/Funds: Investments and Financial stimulus is required. Both public and private sources are sine-qua-non.

**Challenges faced by industry and reasons for sub-optimal performances-** Despite major government support schemes and intervention, following mentioned points are pulling down the growth of Jute Industry:

- **Supply of Raw material:** India is not self-sufficient in the supply of raw material. To meet the growing need of the industry, raw material is **imported from Bangladesh**, **Brazil**, **and Philippines**.
- Lower production: Outdated machineries and technological solutions lead to low production.
- **Higher procurement cost:** Mills do not acquire their raw material directly from the farmers, but instead through intermediaries.
- Lack of storage; modernization; and demand
- Lack of incentive mechanism for improving the Jute quality: The focus of Indian Council of Agricultural Research has been on improving the yield of the jute seeds leading to the fiber quality being compromised. Further the Current pricing mechanism doesn't consider quality

#### Some government supportive scheme

- Jute (Jute ICARE) An Initiative to Double the income of Jute Farmers: Improved Cultivation and Advanced Retting Exercise for Jute (Jute ICARE) was launched in 2015 to popularize/introduce some of the better agronomic practices like microbial assisted retting among farmers intensively in a few blocks in West Bengal and Assam on pilot basis.
- Jute Integrated Development Scheme (JIDS):
  - ► To establish local agencies and units in remote areas of the nation by working with legitimate organizations to carry out various tasks.
  - ► Its role is that of facilitator, delivering Basic, Advanced, and Design Development training programs. They also provide backward and forward links to the existing and potential entrepreneurs at the grass-roots level.
- **The Jute Technology Mission (JTM):** With the objective to develop high-yielding varieties to improve productivity and acceptability in markets. Improve retting practices to get better quality fiber and transfer of cost-effective technologies to the farmers further Creating strong market linkages.

The Jute industry occupies an important place in the national economy of India. Given the huge potential of jute and its nature being Bio-degradable, eco-friendly, jute made-ups have a very big international market. But there is an urgent need for the domestic jute market to diversify. The need of the hour is to upgrade and adopt new technology, new manufacturing standards and evolve with time.

#### **Practice Question**

Q. Evaluate the reasons for the localization of the jute industries in the eastern region of India and also highlight the reasons for poor state of Indian jute industry wile suggesting remedial measures for their revival.

#### **17. INTEGRATED RICE-FISH FARMING BY APATANIS**

**Syllabus:** Distribution of key natural resources across the world (including South Asia and the Indian subcontinent)

#### What is Rice-Fish Farming Culture?

- It is the **co-culture of rice and aquatic creatures** with animal production (e.g. fish, shellfish, crab, shrimp and ducks) in paddy rice systems.
- It is a **technique to maximise the use of land and water resources** to provide both grain (carbohydrates) and animal protein.

#### Need for Integrated rice-fish farming

- Asia is the largest producer of rice in the world, with India, China, Taiwan, Indonesia and Bangladesh being among the top producers.
- Rice plays an important role in Indian agriculture, occupying close to 45 million hectares and estimated production at 104.99 million tonnes (2022).
- Rapid human **population growth** poses numerous challenges, especially **food shortages, malnutrition, limited means of irrigation** and shrinking land resources besides deteriorating **environmental quality.**
- **India's traditional primitive farming** involves dual-farming culture and fish as rice both are the staple food of India.

#### Geographical factors favourable for the integrated rice-fish farming in India

- Rice-fish farming constitutes a unique agro-landscape across the world, especially in tropical and sub-subtropical Asia.
- Rice-Fish farming is widely practiced in Asian countries and tropical, sub-tropical countries.
- **Rain fed medium lands, waterlogged lands** like wetlands or **doab areas** are most conducive conditions as it provides round the clock availability of water.
- Low lying areas like eastern part of India where water flows easily and is available in needs. The fertile soil rich in organic manure and with high water holding capacity is used for rice fields. In general soils with medium texture and loam with silty clay are most preferable for rice-fish farming.
- **Natural geographic location** is suited in areas of high humidity and rainfall-eastern and north eastern India, tropical and humid areas.

#### **Benefits from Rice-Fish Farming**

Food and nutritional security	Environmental friendly and sustainable
• <b>Nutritional balance</b> -It provides a good <b>mix of protein and carbohydrates</b> and can be game changer in achievement of food and nutritional security in lagging states of eastern India.	• Lowering down emissions- Rice-fish cultivation system is capable of lowering the emission of methane and other GHGs. Aquatic creatures especially bottom feeders (crabs and carps) disturb the soil layers by their movement or sometimes searching for food. Thus, they influence the CH4 production processes.

**Context:** The Apatanis, one of the major ethnic groups of the eastern Himalayas, practise a distinctive form of agriculture where rice and fish are grown together. These farmers have been practising integrated rice-fish farming in their mountain terraces of Arunachal Pradesh since the 1960s.

0	<b>Regional impact-</b> It will provide <b>good</b> <b>production without compromising</b> <b>environment</b> in areas identified under second green revolution.	• <b>Impact on soil productivity-</b> It <b>Restore <u>soil</u> <u>fertility</u> and avoid soil degradation, which is a major global environmental issue thus ensuring sustainability of food production.</b>
Ø	Multi-dimensional and stakeholders impact- RAF increased the efficiency by way of enhancing cost-benefits from labour and investments. Additionally, increased the income from fish production enhanced the live and livelihood options.	• Low input cost and enhanced income- The rice-fish system requires only a small amount of pesticide and fertiliser as it is a low input system. The adoption of this system has led to an increase in economic efficiency of farmers.
Ø	<b>Optimum utilisation-</b> The <b>rice-fish system</b> <b>yields higher net return</b> with fish, as compared to a single crop of rice. Further tying the aquaculture industry to the agricultural industry in a social way, increases contacts amongvarious stakeholders providing or <b>share</b> <b>useful skills and technical knowledge</b> .	

#### Conclusion

Thus it's Multi-ecological functions covering biodiversity, food security, and soil enrichment and emissions reduction is apt for agricultural and livestock dominated country like India. There shall be considerations from policymakers on the problems of initial investment for poor rural communities and compensate them with farmer-friendly policies, easy loan schemes etc.

#### PYQ

Q. Define blue revolution, explain the problems and strategies for pisciculture development in India.

#### **Practice Question**

Q. Analyze how aquaculture will play a major role in promoting rice-fish farming for sustainable blue revolution in India.

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2

## PHYSICAL GEOGRAPHY

#### 1. EARTH MIGHT HAVE ANOTHER SECRET LAYER INSIDE ITS INNER CORE

**Syllabus:** Important Geophysical phenomena such as earthquakes, Tsunami, Volcanic activity, cyclones etc.

### **Context:** Researchers trying to uncover the secrets of Earth's geology have revealed the **fifth layer of the planet**.

Seismic waves generated by earthquakes have revealed new insights about the deepest parts of Earth's inner core.

#### Interior of the Earth:

- The Earth has **four layers** namely;
  - ▶ The solid crust on the outside,
  - The mantle lying between the crust and the core.
  - ➤ The core split between the outer core and the inner core.
  - The crust is everything we can see and study directly.
  - ➤ The thinnest layer of the Earth, the crust still measures about 40 km on average, ranging from 5–70 km (~3–44 miles) in depth.

There are two types of crust: continental and oceanic crust.

Oceanic crust can be found at the bottom of the oceans

or below the **continental crust;** it is generally harder and deeper, consisting of denser rocks like basalt, while continental crust contains granite-type rocks and sediments. The continental crust is **thicker on land**.

#### Key highlights of the study:

#### The Mantle:

- The research has revealed that the mantle normally is a **2,900 km thick layer** of solid rock sandwiched between the Earth's upper crust and lower core has been hiding two layers inside it.
- One is the "low viscosity" zone in the upper mantle, roughly 100 kilometres in thickness.
- The other layer is the 'low-velocity zone', which is also a part of the upper mantle.
- The low viscosity zone coincides with the **transition zone** between the **upper and the lower mantle**.
- It was also found that mantle covers the **largest area inside** the earth of about 44% of the earth.




#### **About Earthquakes:**

- The study showed that the Earth kept moving months after the earthquake.
- The mantle's viscous properties govern convection and help in transfer of heat between areas of different temperatures. This enables to understand plate tectonics and related phenomenon.

#### Significance of the study:

- The analysis showed that the **partially molten layer** extends from **90 km to 150 kilometres**. Below this depth, the **waves resume speed** found in below the Turkey land.
- This layer sits below the **tectonic plates**, which create **new crusts and destroy** older ones.
- Plate tectonics is thought to have played an instrumental role in making the Earth habitable.

The Earth's interior helps in understanding the origin and formation of Earth while it also helps in understanding the volcanism and earthquakes which are explained by plate tectonics for planning human settlement and industries in these regions.

#### PYQ

Q. Define mantle plume and explain its role in plate tectonics.-2018

#### Practice Question

Q. Analyze the different layers of Earth in understanding the formation of the Earth. Also explain the dynamicity of Earth's crust with the help of plate tectonics.

# 2. EARTH'S INNER CORE MAY HAVE STARTED TO SPIN IN OPPOSITE DIRECTION

Syllabus: Salient features of the world's physical geography

**Context:** According to a new research, published in the journal 'Nature Geoscience', the inner core of Earth seems to have stopped spinning in the same direction as the rest of the planet.

#### **Background:**

- With a radius of almost 2,200 miles, Earth's core is about the size of Mars. It consists mostly of iron and nickel, and contains about one-third of Earth's mass.
- At the center of Earth is the core, a ball with a mean radius of 3480 kilometres that is composed mostly of iron.
- The outer core is liquid while the inner core, with a radius of 1220 km, is solid.
- Because the outer core has a low viscosity, it could be rotating at a different rate from the mantle and crust. This possibility was first proposed in 1975 to explain a phenomenon of Earth's magnetic field called westward drift: some parts of the field rotate about 0.2 degrees per year westward relative to Earth's surface.
- In 1981, David Gubbinsof Leeds University predicted that a differential rotation of the inner and outer core could generate a large toroidal magnetic field near the shared boundary, accelerating the inner core to the rate of westward drift. This would be in opposition to the Earth's rotation, which is eastwards, so the overall rotation would be slower.

Note: The spinning of the Earth's core is by the magnetic field that is generated in the outer core that is regulated by the gravitational effects.

#### New Findings and its significance:

- Earth's inner core is spinning in the opposite direction in comparison to the rest of the planet.
- The rotation of the inner core that actually is the hot iron ball, around the size of Pluto "came to near halt around 2009 and then turned in an opposite direction.
- The inner core started rotating slightly faster than the rest of the planet in the early 1970s. But it had been slowing down before coming in synchronization with Earth's rotation around 2009.
- There has been a **"negative trend"**, meaning the inner core is now rotating slower than the outer Earth's layers. Next change may occur in the mid-2040s.

- The results seem to indicate that **the Earth's inner core changes its speed of rotation every 60-70 years on average.**
- The Study can motivate **some researchers to build and test models which treat the whole Earth as an integrated dynamic system.**
- The slowdown could change how rapidly the entire planet spins, as well as influence how the core evolves with time.

The recent studies will help in understanding the formation of Earth and its different layers, spinning and different spinning of earth's core and its effect on the life present on earth and other geophysical phenomena.

#### Practice Question

Q. Discuss the significance of the Earth's inner core in understanding the evolution of Interior structure of the Earth.

# 3. PSYCHE MISSION OF NASA

Syllabus: Salient features of the world's physical geography

# **Context:** The **Psyche mission of NASA** is a unique journey to understand the metal rich asteroid belt orbiting between the Mars and Jupiter in our solar system and recent discovery of nickel and iron metals in the belt makes it more similar to origin of Earth.

#### **Goals of Psyche Mission**

- Understand a previously unexplored building block of planet formation: iron cores.
- Look inside terrestrial planets, including Earth, by directly examining the interior of a differentiated body, which otherwise could not be seen.
- Explore a new type of world. For the first time, examine a world made not of rock and ice, but metal.

#### **Objectives of Psyche Mission**

- Determine whether Psyche is a core, or if it is unmelted material.
- Determine the relative ages of regions of Psyche's surface.
- Determine whether small metal bodies incorporate the same light elements as are expected in the Earth's high-pressure core.
- Determine whether Psyche was formed under conditions more oxidizing or more reducing than Earth's core.
- Characterize Psyche's topography.

#### Instruments and Investigations

- Multispectral Imager
- Gamma Ray and Neutron Spectrometer
- Magnetometer
- X-band Gravity Science Investigation

#### **Deep Space Optical Communication (DSOC)**

The Psyche mission will test a sophisticated new laser communication technology that encodes data in photons at near-infrared wavelengths (rather than radio waves) to communicate between a probe in deep space and Earth. Using light instead of radio allows the spacecraft to communicate more data in a given amount of time. The DSOC team is based at the Jet Propulsion Laboratory.

#### What is Asteroid Psyche?

- Psyche is a NASA mission to explore a 140-mile-wide (225 kilometers) metallic asteroid called 16 Psyche.
- It is similar to the project "Lucy" launched to study the primordial asteroid near Jupiter.
- The Psyche Asteroid may be the leftover core of an earlier planet which lost its crust and mantle during the multiple collisions during the formation of our Solar System.





Asteroid Psyche between Mars and Jupiter

The significance of Psyche mission of NASA in understanding the Asteroid belt and the origin of Earth:

- **Origin of Asteroid:** The Psyche mission aims to understand that how the planets originated from the planetesimals which are hypothesized in Nebular Hypothesis theory.
- **The Position of Psyche Asteroid:** The inner planets have their solid core while the outer planets are gaseous in composition while the asteroid Psyche is present between these two types of planets and Earth having solid core with presence of **Nickel and Iron** will replicate the conditions of formation of Psyche Asteroid.
- **Interior of Planets:** The mission will also help in the understanding the formation of **different layers of planets such as lithosphere, mantle and core.** It will also help in understanding the **composition** of these layers. Though the asteroid is under the consistent influence of **solar flares** which resulted in the **loss of lighter elements**, but it can help in getting the insight of the interior of asteroid psyche.
- Other Metals: The Asteroid Psyche is known to have other rare metals like gold, platinum, cobalt, iridium and rhenium, which are also found in the Earth in different layers and in different composition.

The study of Psyche Asteroid will help in understanding the interior of Earth through "Indirect Study" and also help in understanding the core of the Earth and its composition which is very significant in the presence of life on Earth.

#### PYQ

Q. How does the Juno Mission of NASA help to understand the origin and evolution of the Earth?

#### **Practice Question**

Q. Evaluate the conditions for the formation of Asteroid belt and the role of Psyche Mission of NASA to understand the origin and evolution of Earth.

# 4. TURKEY EARTHQUAKE

**Syllabus:** Important Geophysical phenomena such as earthquakes, Tsunami, Volcanic activity, cyclones etc.

**Context:** Recently, Turkey witnessed a **7.8 magnitude earthquake** which is one of the most powerful earthquakes in the past two decades with more than **1,300 people** killed and thousands still believed to be trapped under rubble.

#### What makes Turkey a hotbed of seismic activity?

- Turkey is frequently shaken by earthquakes.
- Turkey's proneness to earthquakes comes from its **tectonic location**.
- Turkey, a hotbed of seismic activity, sits on the **Anatolian Plate**, which borders two major faults as it grinds northeast against Eurasia.



#### **Tectonic plates:**

- The Earth's outermost layer comprises some 15 major slabs, called **tectonic plates.**
- The boundaries between these plates are a system of **faults fractures** between two blocks of rocks. Any sudden movement along these faults can cause earthquakes.
- The North Anatolian fault traverses the country from west to east, and the East Anatolian fault, rests in the country's south-eastern region.
- The **North Anatolian fault (NAF) line**, the meeting point of the Eurasian and Anatolian tectonic plates is known to be "**particularly devastating**".
- The NAF, one of the best-understood fault systems in the world, stretches from the south of Istanbul to north-eastern Turkey and has caused catastrophic earthquakes in the past.



#### About Earthquake:

- 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.
- Earthquake is the form of energy of wave motion transmitted through the surface layer of the earth.
- It may be due to faulting, folding, plate movement, volcanic eruptions and anthropogenic factors like dams and reservoirs.



Turkey is bounded on the north by the **Black Sea**, on the northeast by **Georgia and Armenia**, on the east by **Azerbaijan and Iran**, on the southeast by **Iraq and Syria**, on the southwest and west by the **Mediterranean Sea and the Aegean Sea**, and on the northwest by **Greece and Bulgaria**.

#### Significance of location for Turkey

- Anatolian tectonic plate:
  - > Turkey is located on the Anatolian tectonic plate, which is wedged between the Eurasian and African plates.
  - > On the north side, the **minor Arabian plate** further restricts movement.
- North Anatolian fault (NAF) line:
  - ➤ One fault line the North Anatolian fault (NAF) line, the meeting point of the Eurasian and Anatolian tectonic plates is known to be "particularly devastating".
  - The NAF, one of the best-understood fault systems in the world, stretches from the south of Istanbul to northeastern Turkey, and has caused catastrophic earthquakes in the past.
- East Anatolian fault line:
  - Then there is the East Anatolian fault line, the tectonic boundary between the Anatolian Plate and the northward-moving Arabian Plate.
  - ▶ It runs 650 kilometers from eastern Turkey and into the Mediterranean.
- Aegean Sea Plate:
  - In addition to this, the Aegean Sea Plate, located in the eastern Mediterranean Sea under southern Greece and western Turkey, is also a source of seismic activity in the region.

The Earthquake occurrence over the Turkey-Syria region has made a wake-up call for the countries over the world to develop technologies for early prediction and forecast of earthquakes so that region being affected will be prepared for disaster of such high magnitude and save life at such large scale.

#### PYQ

Q. 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.-

#### **Practice Question**

Q. Discuss the reasons for such high occurrence of earthquakes in the Turkey region alarming the urgent need for early prediction of earthquakes.

## 5. HAWAII VOLCANIC ERUPTION

**Syllabus:** Important Geophysical phenomena such as earthquakes, Tsunami, Volcanic activity, cyclones etc.

**Context:** Scientists and researchers have alarmed the residents of Hawaii Island as the world's largest active volcano 'Mauna Loa' erupted in Dec 2022 after 38 years.

#### **Background:**

- Mauna Loa is among Earth's **most active volcanoes**, having erupted **33 times**.
- It last **erupted in 1984** which led to destruction on the Island.
- It has produced large, voluminous flows of basalt that have reached the ocean eight times since
- It last erupted in 1984, when a lava flow came within 7.2 km (4.5 mi) of Hilo, the largest population center on the island.
- Mauna Loa is certain to erupt again, and with such a propensity to produce large flows, we carefully monitor the volcano for signs of unrest.

#### The Pacific Ring of Fire

- The Ring of Fire, also known as the Circum-Pacific Belt, is a path along the Pacific Ocean characterized by active volcanoes and frequent earthquakes.
- It is largely the result of Plate Tectonics, in which the massive Pacific Plate interacts with less dense plates surrounding it.
- The majority of Earth's volcanic eruptions and earthquakes occur along the Ring of Fire.
- The Alpide belt (which stretches from the Mediterranean region eastward through Turkey, Iran, and northern India) is the next most seismically active region (5-6% of earthquakes).



#### About Mauna Loa:

- It is the **World's largest active Volcano** in the Island of Hawaii in the U.S. state of Hawaii in the Pacific Ocean.
- The volcano makes up 51% of the Hawaii Island landmass.

- It is **an active shield volcano** with relatively gentle slopes.
  - ► Lava eruptions from Mauna Loa are **silica-poor and very fluid**, and they tend to be nonexplosive.



#### How big is Mauna Loa?

- The largest active volcano in the world covers 2,035 sq miles (5,271 sq km).
- It is one of a chain of five volcanoes that form Hawaii's Big Island.
- This one volcano alone comprises half of the whole island.
- Mauna Loa's summit is 13,680ft (4,170m) above sea level, but its base is on the sea floor.
- From there the summit is 30,085ft (9,170m), making it taller than Mount Everest.

#### Significance:

- Its eruption remains important as the volcano covers a large area of the island.
- It gives the opportunity to the current scientist to study the volcanic phenomenon.

#### Mauna Loa Volcano Type:

- **Shield Volcano:** A shield volcano is a broad volcano with sloping sides that is formed mainly out of runny lava that flows out of its central summit vent.
- **Examples of Shield Volcanoes**: are Mauna Loa on the Island of Hawaii, Wolf volcano on the Galapagos Islands, and Nyamuragira in the Democratic Republic of Congo.

The Mauna Loa volcanic eruption is an important geophysical event which is present in the Pacific ring of fire results in the change in landforms and also influences the regional climate by forming aerosols. Thus, their understanding helps in their early prediction and mitigating their harmful consequences.

#### PYQ

- Q. Mention the global occurrence of volcanic eruptions in 2021 and their impact on regional environment. 2021
- Q. Discuss the geophysical characteristics of Circum-Pacific Zone. 2020
- Q. 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

#### **Practice Question**

Q. Discuss the structure and formation of volcanoes present in the islands of Pacific Ocean.

# 6. TONGA VOLCANIC ERUPTION AND TSUNAMI

**Context:** Recently, the experts said that the Tonga volcano wave was 9 times taller than the tsunami in Japan.

#### 90 metres high Tsunami

- The initial tsunami wave created by Tonga's underwater **Hunga Tonga volcano** eruption in 2022 was almost 90 metres high.
- It was nine times higher than the **tsunami recorded near Japan** in 2011.

#### Location

• The volcano is located approximately 70 km from the Tongan capital Nuku'alofa; this distance significantly minimized tsunami's destructive power.

#### Tsar Bomba

• The Tonga volcano eruption unleashed more energy than the Tsar Bomba, the most powerful nuclear device ever detonated.

#### **About Tonga**

- Tonga is a Polynesian country of more than 170 South Pacific islands, of which 36 are inhabited, and home to about 100,000 people.
- It's a remote archipelago that lies about 800 kilometers (500 miles) east of Fiji and 2,380 kilometers (1,500 miles) from New Zealand.

#### Location of Tonga's Hunga-Tonga-Hunga-Ha'apai volcano?

• The Hunga-Tonga-Hunga-Ha'apai volcano, about 30 kilometers (20 miles) southeast of Tonga's Fonuafo'ou island, sits underwater between two small islands at about 2,000 meters (6,500 feet) high from the sea floor, with about 100 meters (328 feet) visible above sea level.

#### How do underwater volcanoes occur?

- There is no specific difference in the formation of submarine (underwater) and subaerial (on land) volcanoes.
- An undersea or submarine volcano is located below the ocean surface and mostly erupts underwater.
- Volcanoes form when molten rock is produced in the second layer of the Earth's interior the mostly solid upper mantle and makes its way through the crust.
- About "three-quarters of all volcanic activity on Earth actually occurs underwater".
- During an eruption, hot magma forces the oceanic crust open. This can lead to tsunamis a series of ocean waves caused by the displacement of water.



#### Issues/ Challenges associated with the recent findings

- **Technological barrier:** Detection and monitoring systems for volcano-based tsunamis are 30 years behind similar tools used to detect earthquake-based events.
- **Catastrophic damage:** The massive volcanic eruption and tsunami in Tonga caused catastrophic damage with homes destroyed and many communities covered in thick ash.

#### Way Forward:

- **Disaster management:** The eruption should serve as a wake-up call for organisations working to safeguard people from such disasters in the future.
- **Monitoring of volcanic activity:** More high-quality research into volcanic eruptions is always a good idea.
- Efficient warning systems: It should include both real time warnings and education on what to do in case of a tsunami or warning such systems save lives.

Tonga volcano is a sub-marine volcano whose eruption caused destructive Tsunami in the Pacific Ocean and emission of gases forming aerosols resulting in the short-term cooling of the regional atmosphere of that region.

#### PYQ

- Q. Mention the global occurrence of volcanic eruptions in 2021 and their impact on regional environment. (2021)
- Q. Discuss the geophysical characteristics of Circum-Pacific Zone. (2020)
- Q. 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)

#### **Practice Question**

Q. What are sub-marine volcanoes? Bring out the difference between the sub-marine and subaerial volcanoes present in the Pacific ocean.

## 7. SUDDEN STRATOSPHERIC WARMING AND POLAR VORTEX

**Syllabus:** Important Geophysical phenomena such as earthquakes, Tsunami, Volcanic activity, cyclones etc.

**Context:** A Sudden Stratospheric warming occurred in the early 2023 due to the weakening of a polar vortex present in the Northern hemisphere causing intense cold wave flow in the Polar and Mid latitude region.

#### What is sudden stratospheric warming?

A sudden stratospheric warming (SSW) refers to a rapid warming in the stratosphere between 10km to 50km above the Earth's surface and it is associated with bringing in cold wave condition in the lower reaches of mid-latitude belt of the world.

#### How Sudden Stratospheric Warming occurs:

To understand the phenomena of SSW, it is important to understand polar vortex and its relation with polar jet stream.

- **Polar Vortex:** The polar vortex is the high pressure phenomena occurring in the stratosphere, which gets strong during winters. But sometimes due to the weakening of the polar vortex, the winds start subsiding towards troposphere.
- **Polar Jet Stream:** The Polar Jet stream remains at polar region when the polar vortex is strong. But when polar vortex gets weaker, the jet streams present here start pushing towards equator wards in a wavy pattern. The formation of wavy pattern also causes warm air from the mid and sub-tropical latitudes into the Polar Regions.



• Warming of Stratosphere: Due to these phenomena, the air in polar vortex present in stratosphere starts descending into troposphere adiabatically, resulting in the compression of winds which also starts heating them.



• **Rise in temperature:** This adiabatic compression results in overall increase in temperature of upto 50°C to 60°C, thus it results in the increase in temperature from -50°C to 0°C for few days in upper atmosphere of the Polar Regions.

#### Impact of Sudden Stratospheric Warming on weather system:

- Cold Wave Conditions: The movement of polar winds into temperate regions causes sudden drop in temperature below 0°C in North and Central USA as in 2018, also it led to cold wave situation in UK and Northern Europe region.
- **Increased Precipitation:** The movement of cold winds from Polar Regions into temperate regions brings moisture to these regions causing precipitation in the form of rainfall or snowfall. E.g. The UK, Northern Europe, Canada and Northern USA, etc.

• Anti-cyclonic condition: Due to increase in colder conditions, there is formation of high pressure conditions over these regions causing increase in anti-cyclones over the affected region of temperate latitude.

The Sudden Stratospheric Warming is an important phenomena causing warming in stratosphere and cooling in lower altitudes of troposphere over the affected region causing changes in regional weather. Thus, understanding the phenomena is important for the prediction and forecasting of weather and related phenomena to tackle the negative effects like loss of lives and crop failure.

#### PYQ

Q. Troposphere is a very significant atmospheric layer that determines weather processes. How?

#### **Practice Question**

Q. Identify the relationship between Polar vortex and sudden stratospheric warming while elaborating their impact on the weather of Northern hemisphere.

# 8. INCREASED SEA SURFACE TEMPERATURE AFFECTING INDIAN MONSOON: STUDY

**Syllabus:** Important Geophysical phenomena such as earthquakes, Tsunami, Volcanic activity, cyclones etc.

**Context:** Global warming hiatus contributed to the weakening of the Mascarene High in the Southern Indian Ocean weakening south-west monsoon in India.

#### What is global warming hiatus?

- A global warming hiatus is referred to a global warming pause, or a global warming slowdown, which is a period of relatively little change in globally averaged surface temperatures.
- The hiatus, however, can result in an increase in the SST.

#### Mascarene high and rise in sea surface temperature:

- **Global warming:** Due to increase greenhouse gases (GHGs) in the atmosphere, there is an increase in temperature of atmosphere and ocean by about 1° C, resulting in increased sea surface temperature of oceans.
- Weak Mascarene high: Due to this increased SST of southern Indian Ocean, the Mascarene high has become weak.
- Weakening of Indian Monsoon: Due to the weakening of Mascarene High, the pressure gradient developed in the India Ocean will get disrupted resulting in the weak movement of cross-equatorial winds towards India.

#### What is Mascarene High?

- The Mascarene High (MH) is a semi-permanent subtropical high-pressure zone present in the Southern Indian Ocean.
- It is also called as the Indian Ocean subtropical high, which is a high-pressure area located between 20° to 35° South latitude and 40° to 90° East longitude.
- It is a region from where the cross-equatorial winds blow to India.
- It has been named after the Mascarene Islands, in the Indian Ocean east of Madagascar consisting of the islands belonging to Mauritius as well as the French Réunion Islands.
- Apart from its large influence on African and Australian weather patterns, it also helps in driving the inter-hemispheric circulation between the Indian Ocean in the south and subcontinental landmass in the north.

#### Role of Mascarene High (MH):

- The warming in SST due to global warming has resulted in a decrease in the pressure gradient between the MH and the Indian landmass.
- This in turn suppressed the intensity of low-level cross-equatorial winds over the western Indian Ocean affecting the onset of the monsoon over the Indian subcontinent and rainfall over East Asia.

#### Impacts:

• The weakening of the Mascarene High in the southern Indian Ocean during global warming hiatus may affect the strength of the upwelling along the coast of Somalia and Oman and thus, influence the Arabian Sea ecosystem.

#### Way Forward

- India needs to invest more resources in better prediction of Monsoon forecast in order to achieve reliability and sustainability.
- With a warming climate, more moisture will be held in the atmosphere, leading to heavier rainfall, consequently, inter-annual variability of the monsoon will increase in future. The country needs to prepare for this change.
- Thus, to secure and bring sustainability to the climate pattern of India we need to **take effective and timely steps not just at the domestic front** (National Action Plan on Climate Change) but **also at the international front** (UN Framework Convention on Climate Change), as we live in a shared world with a shared future.

Mascare High is a high pressure region present in the Southern Indian Ocean, but its significance with regard to be the source region of supply of moisture laden air for monsoon is very important. Thus, the changes weakening this Mascarene High should be brought into light for making it strong for the better socio-economic conditions of farmers dependent on the monsoon winds in India.

#### PYQ

- Q. What characteristics can be assigned to monsoon climate that succeeds in feeding more than 50 percent of the won population residing in Monsoon Asia?-2017
- Q. How far do you agree that the behaviour of the Indian monsoon has been changing due to humanizing landscapes? 2015

#### **Practice Question**

Q. Discuss the implications of global warming on the southern Indian Ocean which in turn is responsible for weak monsoon in India.

# 9. MORE FREQUENT HEAT WAVES LINKED TO CHANGES IN JET STREAM

**Syllabus:** Important Geophysical phenomena such as earthquakes, Tsunami, Volcanic activity, cyclones etc.

**Context:** According to NASA's Earth Observatory, the temperatures across the world have crosses 40°C in places like Europe, North Africa, the Middle East and Asia in past few years. The reason for such increase in heat wave events is linked to the Jet Stream, which is affected by the global rise in temperature.

#### What exactly are Jet Streams?

- In the upper atmosphere, jet streams are relatively **narrow bands of strong wind.**
- Jet streams blow from west to east, but the flow frequently shifts to the north and south.
- This airband can be **160-480 kilometres wide and 900-2150 metres thick**, with a core speed of over **300 kilometres per hour**.
- Aircraft routes that run counter to jet stream's movements are restricted due to their strength.
- Jet streams are associated with major **tropopause breaks**.

#### **Significance of Jet Streams**

- They have a significant impact on **local and regional weather patterns.**
- Temperate cyclones and jet streams have a close relationship in terms of **intensity.**
- Jet streams collide with surface wind systems, resulting in severe storms.
- They also assist in providing a relatively clear picture of the occurrence of **El Nino and La Nina** events.





- Aviators use them as well if they have to fly in the direction of the jet stream's flow.
- When flying in the opposite direction of the jet streams, however, aviators avoid them because jet streams are unpredictable and can cause sudden movement even when the weather appears calm and clear.

#### How Jet Stream is affected by Global Warming:

- Due to global warming, the polar regions of the earth are getting warmer faster than the mid-latitude region and this is resulting into the decrease in difference of temperature between the high and mid-latitudes.
- As the temperature difference is declining, there is a slight drop in zonal winds in the Jet Stream which is resulting in higher meandering of Jet Stream.
- According to Nature Journal Study, the Arctic is heating seven times faster than the global average at around 2.7°C and 4°C a decade.

#### Jet Stream and Heat Wave:

- **Omega Block:** Due to higher meandering of Jet Stream, there is **more convergence** of Jet Stream resulting into the **High Pressure formation in Upper atmosphere** which traps the warm winds in the same region with their accumulation over time. This convergence is also called as "Omega Blocks" resembling Greek letter omega, which is circling around the world.
- **Heat Waves:** Due to this phenomena happening for several days, the region experiences increase in temperature resulting in increased heat wave events. This change in Jet Stream pattern is resulting in increased heat wave events across the globe like North America, Europe, South and South-East Asia, etc. by increasing temperature around 4°C to 7°C in the affected region.

The increased heat wave events which is linked with the change in Jet Stream pattern whose primary cause is global warming is affecting agricultural crops, increased energy use, health issues, loss of biodiversity, etc. affecting the human and environment in a negative way. Thus, limiting the Green House Gas emissions and making a global effort to stable increasing global temperature is indeed needed to control global warming and conserve Earth.

www.iasscore.in



The Convergence in Jet Stream also called as Omega Block

#### PYQ

Q. Bring out the causes for the formation of heat islands in the urban habitat of the world. -2013

#### **Practice Question**

Q. Analyze the effect of jet streams on prevalence of prolonged heat wave conditions over different regions of the world.

# 10. ARCTIC CYCLONES TO INTENSIFY AS CLIMATE WARMS, NASA STUDY PREDICTS

**Syllabus:** Important Geophysical phenomena such as earthquakes, Tsunami, Volcanic activity, cyclones etc.

**Context:** Recently it was seen that the development of **fronts** and **cyclones** in the mid and high latitude region has intensified due to increased extremity in temperatures in Arctic region.

#### What study says?

- **Intense cyclones:** The cyclones are becoming stronger in terms of pressure, wind speeds and precipitation due to climate change.
- Initially storms drop more snowfall, but as air temperatures continue to rise and cross above freezing temperatures, storms drop rainfall, which is a really big change for the **sea ice pack**.
- More intense storms will be a hazard to shipping activities, oil and gas drilling and extraction, fishing, and Arctic ecosystems and biodiversity that's where maritime **weather forecasting** is important but still challenging and difficult

#### **Future Predictions:**

- By the end of the century, **cyclone wind speeds could increase up to 38 mph**, depending on storm characteristics and the environmental conditions of the region.
  - ▶ The peak intensity of such storms could be up to 30% longer, and precipitation will likely increase.
  - If cyclones start to bring rainfall in the spring, sea ice may begin melting sooner and less of it will survive the summer melt season.
- Such changes will enable the ocean to provide more energy to the atmosphere for deep convection, which increases the potential of storms to intensify and persist.
- Much like hurricanes in low and mid latitudes, Arctic cyclones use this energy like fuel in an engine. Storms in coming decades could travel farther north and reach areas of the Arctic typically left untouched.
- The changing weather could increase risks for Arctic ecosystems, communities, and commercial and industrial activities.

What are Air Masses?	
	Types of air masses
An air mass is a large body of air with	• Arctic: These air masses form in the Arctic region
generally uniform temperature and	and are very cold.
humidity. Air masses form over source	• <b>Tropical:</b> These air masses form in low lying
regions that give them their uniform	latitudes and are warm up to a moderate level.
temperature and humidity. Moreover, low	• <b>Polar:</b> These air masses form in the high-latitude
wind speeds prevent these large volumes	region and are cold.
from moving. So, while they stay stationary	• <b>Equatorial:</b> They start forming over the Equator
over a region, they acquire the conditions of	and are warm.
that region, either temperature or humidity.	

Then as wind speeds increase, they move to other areas, still keeping their source region's states. They can also clash with different air masses in other regions and cause storms.

#### The battle between air masses

While air masses contain uniform temperature and moisture, where they meet is where weather systems take shape. The boundary separating two air masses is what Meteorologists call a **"front"**. These boundaries can have large gradients, or contrasts, in temperatures and dew points.

- A cold front is when a colder air mass is replacing a warmer air mass.
- A warm front is when the opposite occurs and warm air is replacing colder air.
- Stationary fronts form when the boundary between the air masses does not move.

When these air masses collide, you can bet the weather will likely turn unsettled. An example of colliding air masses is the developing storm system in the central United States this week. A maritime tropical air mass, with warm and humid conditions, is meeting up with a continental polar air mass, with cold and dry conditions to the north.

#### PYQ

Q. Discuss the concept of air mass and explain its role in macro-climatic changes.-2016

#### **Practice Question**

Q. Analyze the reasons for the increased cyclonic activities in the Arctic region influencing the primary and tertiary activities in the region.

# 11. FEWER CYCLONES IN THE BAY OF BENGAL BUT FREQUENCY INCREASED IN THE ARABIAN SEA

**Syllabus:** Important Geophysical phenomena such as earthquakes, Tsunami, Volcanic activity, cyclones etc.

**Context:** Recently a report highlighted the events of occurrence of Cyclones in the **Arabian Sea** has increased as compared to the **Bay of Bengal** over several years due to Climate Change.

#### The Name Game

Cyclones are the local name of the **Indian Ocean and the South Pacific Ocean**, but in the Northwest Pacific Ocean they are known **as typhoons**, and in the Northeast Pacific Ocean and North Atlantic, they are known as **hurricanes**.



#### What are Cyclones?

• A cyclone is a huge **strong wind system** that blows around the centre of an intense low-pressure area.

#### How are they formed?

- Tropical storms are those that form between the latitudes **Tropic of Cancer** and the **Tropic of Capricorn** and rotate in the **anti-clockwise direction**.
- The surface of oceanic waters heats up due to the sun and as warm air and moisture rise up from the surface of the warm waters, more air rushes to fill the space in.
- This air in turn rises with humidity, creating a cycle of warm, moist air rising up. This system grows in height and size, spreading out and causing a **tropical cyclone**.



• In the northern hemisphere, cyclone winds blow anticlockwise and they reverse in the southern hemisphere.

#### What is the general trend of cyclones?

- Generally, India gets **5 cyclones** on an average in a year.
- 4 in the Bay of BengaL
- 1 in the Arabian Sea

#### The Geographic Location:

The Arabian Sea and the Bay of Bengal are both a part of the **Indian Ocean**, which extends on the west along the African coast and Madagascar up to the Arabian Peninsula and the Gulf of Oman, down to the North Indian Ocean below India, along the Andaman Sea, and goes all the way to the Australian coast

#### The changing trend of cyclone frequency:

- In recent years, the **frequency of cyclones has increased** and more than that, there has been a decrease in the length of the monsoon season as well in the post-monsoon season.
- However, in the particular case of the Arabian Sea, in the last 30 years, from 1990 onwards, there is a significantly increasing trend of **extremely severe cyclones**. And as a result, the most intense cyclones in the region are causing a lot of devastation over the **western coast of India**.
- Not only is the Arabian Sea, but the Bay of Bengal also witnessing many severe cyclones in recent times.

#### How climate change is contributing to the increased frequency of cyclones?

- Climate change is increasing the damage that cyclones, cause in several ways like;
  - > Increasing sea surface temperatures that can make cyclones more powerful
  - > Increasing the rainfall intensity during the storm
  - **Rising sea levels**, which increase the distance in the interior of inland that storm surges can reach affecting coastal ecosystem.
- The strongest cyclones have become more common across the world and scientists project that **climate change will continue to make the strongest cyclones more powerful**.
- The strength of cyclones affecting the countries bordering the North Indian Ocean has been increasing as the planet has warmed.
- Climate change is increasing the danger from cyclones in several ways like cyclones are fuelled by available heat.

The change in cyclone trend in the Arabian Sea is attributed to the climate change with rise in ocean and atmospheric temperature resulting in increase in their frequency. Thus, understanding this pattern will help in early preparedness and planning for hazards and disasters in these regions.

#### PYQ

- Q. Tropical cyclones are largely confined to South China Sea, Bay of Bengal and Gulf of Mexico. Why?-2014
- Q. The recent cyclone on east coast of India was called 'Phailin'. How are the tropical cyclones named across the world? Elaborate. -2013
- Q. Discuss the meaning of colour-coded weather warnings for cyclone prone areas given by India Meteorological Department. (Answer in 150 words) -2022

#### **Practice Question**

Q. Analyze the reason for changing cyclone trend in the Arabian Sea region and assess its impact on India.

### 12. CLIMATE CHANGE'S INFLUENCE ON HURRICANES

Context: Hurricane Fiona was the 2022 Atlantic season's first major hurricane.

GSSCORE

#### About Hurricanes

- A hurricane is a large rotating storm with high speeds of wind that gust at least **74 mph** that forms over warm waters in tropical areas.
- In the southern hemisphere, hurricanes rotate in a **clockwise direction**, and in the northern hemisphere they rotate in an **anti-clockwise direction**.
- This is due to what's called the **Coriolis force**, produced by the Earth's rotation.
- Hurricanes have three main parts:
  - ► the calm eye in the center
  - > the eyewall where the winds and rains are the strongest
  - > the rain bands which spin out from the center and give the storm its size

#### How are hurricanes formed?

- Hurricanes begin as tropical disturbances in warm ocean waters with surface temperatures of at least 80 degrees Fahrenheit (26.5 degrees Celsius). Those low-pressure systems are fed by energy from warm seas.
- **Tropical Depression:** A storm with wind speeds of 38 miles (61 km) an hour or less is classified as a tropical depression.
- **Tropical storm**: It becomes a tropical storm, when its sustained wind speeds top 39 miles (63 km) an hour.

#### The system divides storms into five categories:

- **Category 1**: Winds 74 to 95 mph (Minor damage)
- Category 2: Winds 96 to 110 mph (Extensive damage Can uproot trees and break windows)
- **Category 3**: Winds 111 to 129 mph (Devastating Can break windows and doors)
- **Category 4**: Winds 130 to 156 mph (Catastrophic damage Can tear off roofs)
- **Category 5:**Winds 157 mph or higher (The absolute worst and can level houses and destroy buildings)

#### How climate change is impacting hurricanes?

- **Rising temperature:** Hurricanes feed off of heat energy, so as Earth's global temperatures continue to rise.
- Intensification: Climate change is making hurricanes wetter, windier and altogether more intense. There is also evidence that it is causing storms to travel more slowly, meaning they can dump more water in one place.
- **Heavy rainfall:** Climate change can also boost the amount of rainfall delivered by a storm. Because a warmer atmosphere can also hold more moisture, water vapour builds up until clouds break, sending down heavy rain.
  - Recent Study: According to a recent study, during the 2020 Atlantic hurricane season (one of the most active on record), climate change boosted hourly rainfall rates in hurricane-force storms by 8%-11%.

Hurricanes are basically the tropical cyclones formed in the tropical latitudes, but their intensity and frequency is changing due to the rise in temperature attributed to the anthropogenic induced climate change resulting in their early intensification causing havoc in Atlantic region.

#### PYQ

Q. Tropical cyclones are largely confined to South China Sea, Bay of Bengal and Gulf of Mexico. Why?-2014

#### Practice Question

Q. Examine the conditions for the formation of hurricanes and also analyze the impact of climate change of their formation and intensity?

# 13. CLIMATE CHANGE: THE COLLAPSE OF A MAJOR ATLANTIC CURRENT WOULD CAUSE WORLDWIDE DISASTERS

**Syllabus:** Important Geophysical phenomena such as earthquakes, Tsunami, Volcanic activity, cyclones etc.

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Context: New research published in Nature Climate Change found that planetary warming has placed a critical Atlantic current, called the Atlantic Meridional Overturning Circulation (AMOC), at risk of collapse.
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#### What is AMOC?

- The AMOC is a water pattern within the larger **Gulf Stream** that circulates warmer water from the southern Atlantic into cooler northern regions.
- On a local level, it regulates temperatures for much of Europe and transports nutrients that support northern fisheries. If the AMOC collapses, scientists say, effects will be felt around the world.

#### Why researchers are worried about AMOC?

- The AMOC is at its weakest point in 14,500 years -- since the end of the last ice age when glaciers began melting and freshwater diluted the salinity of the ocean, slowing the current.
- Once the AMOC fully collapsed, temperatures dropped across the entire Northern hemisphere for the next 3,000 years.
- Scientists predict a present-day collapse would equate to a permanent La Niña state, where significant changes to wind, temperatures, and precipitation patterns would cause substantial and unpredictable increases in extreme weather conditions, such as drought, monsoons, and hurricanes.

#### Why AMOC is important for global weather?

- The collapse of a major ocean current is yet another example of how the climate crisis is chipping away at the world's natural systems.
- Due to due to planetary warming, the AMOC is at a "major climate tipping point," with its flow declining by 15% since 1950.
- At the same time, the world's glaciers are again melting, and many face the imminent risk of collapse.
- Longer-lasting La Niña seasons are also exacerbating extreme weather conditions, including the recordbreaking drought in the Western US and flood season in China.
- Meanwhile, primarily human-caused carbon emissions are at a three million-year high, adding to the warming effect and its related impacts.

#### Implications of decline of AMOC:

- Without a proper AMOC and Gulf Stream, Europe will be very cold.
- Gulf Stream, a part of the AMOC, is a warm current responsible for mild climate at the Eastern coast of North America as well as Europe.
- An AMOC shutdown would cool the northern hemisphere and decrease rainfall over Europe.
- It can also have an effect on the El Nino.
- El Nino is a climate pattern that describes the unusual warming of surface waters in the eastern tropical Pacific Ocean.
- It can also shift monsoons in South America and Africa.

#### Causes of decline in AMOC:

- Climate models have long predicted that global warming can cause a weakening of the major ocean systems of the world.
- Freshwater inflow from the melting of the Greenland ice sheet.
- In July 2021, researchers noted that a part of the Arctic's ice called "Last Ice Area" has also melted.
- The freshwater from the melting ice reduces the salinity and density of the water.
- Now, the water is unable to sink as it used to and weakens the AMOC flow.

- Indian Ocean may also be helping the slowing down of AMOC.
- Increasing precipitation and river run-off.

Because of the complexity of the AMOC, uncertainty remains around the potential outcomes of its slowdown. AMOC is slowing down, it is projected to slow further, and this might mean like a catastrophe for global climate if the current collapses altogether. Thus, a global effort is needed to tackle this scenario of global warming and its impact on the global conveyor belt.

#### PYQ

- Q. What are the forces that influence ocean currents? Describe their role in fishing industry of the world. 2022
- **Q.** How do ocean currents and water masses differ in their impacts on marine life and coastal environment? Give suitable examples. 2019
- Q. Explain the factors responsible for the origin of ocean currents. How do they influence regional climates, fishing and navigation?- 2015.

#### **Practice Question**

Q. Explain the significance and impact of slowing down of ocean currents on the different regions of the world.

# 14. EFFECT OF OCEAN SALINITY ON CLIMATE AND ITS IMPLICATIONS FOR EARTH'S HABITABILITY

**Syllabus:** Important Geophysical phenomena such as earthquakes, Tsunami, Volcanic activity, cyclones etc.

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Context: According to study of NASA, the climate change is causing increased salinity in the sub-tropical regions and decline in salinity in tropical and high latitude regions due to variation in temperature and precipitation causing changes in hydrological cycle impacting regional climate of the world.
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#### How saline is Sea and Ocean?

- Sea water salinity is expressed as a ratio of salt (in grams) to liter of water. In sea water there is typically close to 35 grams of dissolved salts in each liter. It is written as 35‰ The normal range of ocean salinity ranges between 33-37 grams per liter (33‰ 37‰).
- But as in weather, where there are areas of high and low pressure, there are areas of high and low salinity. Of the five ocean basins, the Atlantic Ocean is the saltiest. On average, there is a distinct decrease of salinity near the equator and at both poles, although for different reasons.
- Near the equator, the tropics receive the most rain on a consistent basis. As a result, the fresh water falling into the ocean helps decrease the salinity of the surface water in that region. As one move toward the poles, the region of rain decreases and with less rain and more sunshine, evaporation increases.
- Fresh water, in the form of water vapor, moves from the ocean to the atmosphere through evaporation causing the higher salinity. Toward the poles, fresh water from melting ice decreases the surface salinity once again.
- The saltiest locations in the ocean are the regions where evaporation is highest or in large bodies of water where there is no outlet into the ocean. The saltiest ocean water is in the Red Sea and in the Persian Gulf region (around 40%) due to very high evaporation and little fresh water inflow.

#### **Role of Salinity in Oceans:**

About 3.5% of seawater is dissolved salt, measured as salinity. At the sea surface — where the ocean exchanges water with Earth's atmosphere — salinity is an indicator of water cycle processes. Salinity also plays an active role in driving ocean circulation, helping to distribute heat around the globe and regulate climate.



#### Climate change causing variations in ocean salinity:

Salinity variations are caused by precipitation, evaporation, runoff, and ice freezing and melting.

- **Precipitation:** Due to climate change the certain regions of the world are experiencing increased precipitation resulting in adding of freshwater into the oceans causing decline in salinity. For e.g. Near the equator in the North Pacific Ocean, one of the wettest regions on the planet, heavy rainfall adds an abundance of water to the sea surface. This results in a band of low salinity water off the coast of Central America.
- **Evaporation:** Due to global warming, certain regions of the world are experiencing increased rate of evaporation resulting in increased salinity in these regions. For e.g. North Atlantic Ocean due to high evaporation has formed a salty patch of water.
- **River Runoff:** Rivers are one of the important agents that add freshwater to the sea or oceans resulting in the decline in the salinity of those regions.
  - Low river water: Due to climate change, many rivers are experiencing decline in river water flow which is altering the salinity of the sea into which river is confluencing. For e.g. Mississippi river in North America saw decline of water flow.
  - ➤ High river flow: Due to climate change the rivers originating from glaciers or increased precipitation are experiencing increased water flow resulting in increased water flow into the oceans or sea. For E.g. Rivers and their Tributaries originating from Himalayas, Alaska, Siberia, Alps, etc.
- **Ice Freezing and melting:** The ice in the form of glaciers, ice sheet, sea ice, etc. are melting and freezing at different seasons, but due to climate change, there is alteration in this freeze-thaw cycle resulting in high melting of ice and causing rise in fresh water while decline in salinity in the polar regions.

#### Impact of salinity variations in regional climate:

- **Ocean circulation:** This phenomena affects the circulation of oceans from poles to equator causing slowing of these currents and affecting the regional weather by increased temperature in equatorial belt and decline in temperature in polar and high latitudes.
- **Hydrological cycle:** The hydrological cycle is impacted resulting in variation in precipitation and rainfall. For e.g. High saline water has requires more heat for evaporation, thus resulting in decreased evaporation and low cloud formation with low precipitation.
- Warming of high latitudes: The water with high salinity has tendency to absorb more heat, hence resulting in rise in temperature in the countries of **Canada, North Europe, Japan**, etc. and resulting in extreme temperature in the region.
- **Cyclones:** The decline in salinity in tropical regions will result in lowering of the temperature of evaporation which in turn will create more moisture in the same levels of heat resulting in the forming of more number of cyclones and also help in their rapid intensification. For e.g. the increased frequency of high intensity cyclones in North Indian Ocean.

The salinity and temperature are two important factors controlling the balance of ocean and hydrological cycle, which is being disturbed due to climate change resulting in extreme weather phenomena like floods, droughts, cyclones, etc. creating socio-economic problems for the population residing in respective regions. Thus, understanding the inter-linkage between ocean and salinity is necessary to have planned strategy to mitigate the impacts arising due to them.

#### PYQ

Q. Account for variations in oceanic salinity and discuss its multi-dimensional effects.-2017

#### **Practice Question**

Q. Recently the salinity present in different latitudes of the earth are witnessing change due to climate change. Evaluate.

## 15. BOMB CYCLONE

**Syllabus:** Important Geophysical phenomena such as earthquakes, Tsunami, Volcanic activity, cyclones etc.

**Context:** A bomb cyclone, a severe winter storm, had hit the United States and Canada in December 2022.

#### What is Bomb Cyclone?

- A bomb cyclone is a winter cyclone. It occurs through the process known as bombogenesis.
- The word "bombogenesis" is a combination of cyclogenesis which describes the formation of a cyclone or storm and bomb, which is self-explanatory.
- A bomb cyclone occurs when a mid-latitude cyclone rapidly intensifies or quickly drops in atmospheric pressure, marking the strengthening of the storm.
- It occurs when a storm's central barometric pressure drops at least 24 millibars in 24 hours.
- A millibar is a way of measuring pressure. The lower the pressure, the more powerful the storm.
- Some storms have intensified as rapidly as 60 millibars in 24

A bomb cyclone, which is also called bombogenesis, is a rapidly intensifying area of low pressure, or basically a winter hurricane.



hours. A few bomb cyclones even develop "eyes," similar to the centre of a hurricane.

#### How is Bomb Cyclone different from Hurricanes?

• It essentially amounts to a rapidly developing storm system, distinct from a tropical hurricane because it occurs over mid latitudes where fronts of warm and cold air meet and collide, rather than relying on the balmy ocean waters of late summer as a catalyst.

There are four active regions which are hot spots for Bomb Cyclone

- The Northwest Pacific
- The Northern region of the Atlantic Ocean
- The Southwest Pacific
- The Southern region of the Atlantic Ocean.
- **Bomb cyclones have cold air and fronts:** Cold air rapidly weakens hurricanes, while it is an essential ingredient for bomb cyclones.
- **Bomb cyclones form during winter:** Hurricanes form from late spring to early fall, while bomb cyclones form from late fall to early spring.
- **Bomb cyclones form at higher latitudes:** Hurricanes form in tropical waters, while bomb cyclones form over the northwestern Atlantic, northwestern Pacific and sometimes the Mediterranean Sea.

#### **Outcomes and Impact of the Cyclone:**

- While this kind of storm is **not exceedingly rare**, this one is very strong, with high winds that are bringing **heavy snow or rain to many areas**.
- **Air pressure** dropped to at least 962 millibars, while elsewhere it was as high as 1,047 millibars which is a really sharp gradient.
- This has led to the development of **extreme storm conditions** near the core of the low-pressure system, with **particularly harsh conditions**.

The Bomb cyclone occurring in the eastern coast of USA is due to the increased sea surface temperature resulting in sudden drop in the pressure which is resulting in the rapid intensification and high destruction over the affected region. Thus, human induced global warming which is a primary reason for these phenomena is needed to be addressed on the global platforms for taking decisions for its mitigations and early preparedness.

#### PYQ

- Q. Tropical cyclones are largely confined to South China Sea, Bay of Bengal and Gulf of Mexico. Why?-2014
- Q. The recent cyclone on east coast of India was called 'Phailin'. How are the tropical cyclones named across the world? Elaborate. 2013

#### **Practice Question**

Q. Analyze the factors for the formation of bomb cyclone and also discuss its implications on the affected regions.

# 16. IMPACT OF INDIAN OCEAN DIPOLE ON INDIAN SOUTHWEST MONSOON

**Context:** According to IMD, a positive **Indian Ocean Dipole** condition is set to be formed over the Northern Indian Ocean which will impact Indian monsoon, which is already under the influence of El Nino.

#### What is Indian Ocean Dipole?

Indian Ocean Dipole (IOD) is a hydro-meteorological phenomenon in the Northern Indian Ocean, characterised by a difference in sea-surface temperatures. Basically, IOD is the difference between the temperature of eastern (Bay of Bengal) and the western Indian Ocean (Arabian Sea). Indian monsoon depends upon not only El Nino La Nina but also IOD and other such ocean phenomena.

#### Characteristics of IOD:

- **Temperature difference:** IOD occurs because of temperature difference. This temperature difference results into pressure difference which results in flowing of winds between eastern and western parts of Indian Ocean.
- **Development:** IOD develops in the equatorial region of Indian Ocean from April to May, peaking in October.



- Three Phases: The IOD has three phases such as Neutral, Positive and Negative IOD.
  - Neutral Phase of IOD: During this phase water flows from the Pacific between Indonesia's islands, keeping seas warm to the northwest of Australia. Air rises above this area and falls across the western half of the Indian Ocean basin, blowing westerly winds along the equator.

Positive Phase of IOD: During this phase the Westerly winds weaken along the equator, allowing warm water to move to Africa. Changes in the winds also allow a rise of cool water from the deep ocean in the east. This creates a temperature difference across the tropical Indian Ocean with cooler than normal water in the east and warmer than normal water in the west. This event has been found to be beneficial for the monsoon.



➤ Negative Phase of IOD: During this phase westerly winds intensify along the equator, allowing the concentration of warmer waters near Australia. This creates a temperature difference across the tropical Indian Ocean, with warmer than normal water in the east and cooler than normal water in the west. This event obstructs the progression of monsoon over India.



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#### How does it impact the southwest monsoon?

- **Increased rainfall due to positive IOD:** There is no established correlation between Indian summer monsoon rainfall and IOD. But, studies have shown that a positive IOD year sees more than normal rainfall over central India. It was demonstrated that a positive IOD index often negated the effect of El Nino Southern Oscillation (ENSO), resulting in increased Monsoon rains in several ENSO years.
- **Droughts Due to negative IOD:** A negative IOD, on the other hand, complements El NiNo leading to severe drought.
- **Cyclones:** At the same time, positive IOD results in more cyclones than usual in Arabian Sea. Negative IOD results in stronger than usual cyclogenesis (Formation of Tropical Cyclones) in the Bay of Bengal. Cyclogenesis in Arabian Sea is suppressed during this time.

Thus, an IOD can either aggravate or weaken the impact of El Nino on Indian monsoon. If there is a positive IOD, it can bring good rains to India despite an El Nino year. For example, positive IOD had facilitated normal or excess rainfall over India in 1983, 1994 and 1997 despite an El Nino in those years. Similarly, during years such as 1992, a negative IOD and El Nino had cooperatively produced deficient rainfall.

#### PYQ

- Q. What characteristics can be assigned to monsoon climate that succeeds in feeding more than 50 percent of the won population residing in Monsoon Asia?-2017
- Q. How far do you agree that the behaviour of the Indian monsoon has been changing due to humanizing landscapes? Discuss. -2015

#### **Practice Question**

Q. What is Indian Ocean Dipole? Discuss the impact of Indian Ocean Dipole on the monsoon of India.

# 17. ARCTIC AND ANTARCTIC SAW RECORD WARMTH AND ICE MELT IN 2022

**Syllabus:** Changes in critical geographical features (including water bodies and ice-caps) and in flora and fauna and the effects of such changes.

**Context:** The Arctic and Antarctic saw record warmth and ice melt in 2022, the sea ice around Antarctica shrank to the smallest area ever recorded in early 2022, and there were exceptionally high temperatures at both poles.

#### **Causes of Melting of Sea Ice and Glaciers:**

- **Burning of fossil fuels ha**s resulted in the buildup of greenhouse gases in the environment thus influencing the warming trend because they trap heat in the atmosphere.
- **Oil and gas drilling** process also emit Methane, which is the main constituent in natural gas.
- **Deforestation** is actually proving detrimental to the environmental balance.
- **Ice breaking ships** breaking through the ice at sea, end up leaving trails of open waters. The Arctic sea ice is able to reflect most of the heat thus aiding in keeping the Arctic and the rest of the Northern Hemisphere cool.

#### Highlights of UNEP 2019 Emission Gap report -

- The world will fail to meet the **1.5°C temperature goal of the Paris Agreement** unless global greenhouse gas **emissions fall by 7.6 per cent each year**.
- **Global temperatures are set to rise about 3.2 degrees C by 2100**, the report says, bringing catastrophic weather including hotter, deadlier heatwaves and more frequent floods and drought.
- The top four emitters (China, USA, EU and India) contributed to **over 55% of the total emissions** over the last decade, excluding emissions from land-use change such as deforestation.
- The rankings would change if land-use change emissions were included, with Brazil likely to be the largest emitter.
- India is the fourth-largest emitter of Green House Gases (GHGs).
- It is among a small group of countries that are on their way to achieve their self-declared climate targets under the Paris Agreement.

#### Consequences of melting of Sea ice and glaciers:

- **Electricity Production:** A lot of places all over the world depend exclusively on the constantly flowing water from glaciers that are melting in producing electricity. Reducing or stopping the flowing of water will mean stopping the production of electricity.
- Heat Sink: It has ramifications for the global climate. This region is a heat source in summer and a heat sink in winter.
- **Biodiversity Loss:** It could trigger a multitude of biophysical and socio-economic impacts, such as biodiversity loss, increased glacial melting, and less predictable water availability—all of which will impact livelihoods and well-being in the HKH.
- **Glacial Lake Outburst Floods:** Faster snow and glacier melting due to warming is already manifesting in formation of glacial lakes. Glacial lake outburst floods (GLOF) are becoming frequent and causing huge casualties and loss to local infrastructures.
- New Trade Route Consequences: With the growing impacts of climate change, along with new infrastructure development, trade routes and hydropower dams planned for the fragile region, the effects on the biodiversity is set to worsen further.
- **Impact on Environmental Services**: Along with species loss this will mean the loss of the key environmental services the region provides such as water and carbon storage to the rest of Asia.

The Arctic and Antarctic region of the world which in-houses the largest ice and glaciers of the world is witnessing its melting due to global warming, thus through bringing major GHG emitters on global platform and implementing binding protocols for maintaining the ice and glaciers over the two poles of earth.

#### PYQ

- Q. How do the melting of the Arctic ice and glaciers of the Antarctic differently affect the- 2021 weather patterns and human activities on the Earth? Explain. 2021
- Q. How does the cryosphere affect global climate?-2017
- Q. What are the economic significances of discovery of oil in Arctic Sea and its possible environmental consequences?-2015
- Q. Why is India taking keen interest in resources of Arctic Region?

#### **Practice Question**

Q. What are the consequences of increased melting of ice and glaciers of the two poles of the earth on the global weather patterns? Analyze.

#### $\sim \sim \sim \sim \sim$

# 3

# INDIAN GEOGRAPHY

## 1. RARE TRIPLE DIP LA NINA AND ITS IMPACT ON INDIA

**Syllabus:** Important Geophysical phenomena such as earthquakes, Tsunami, Volcanic activity, cyclones etc.

**Context:** Australia's Bureau of Meteorology (BOM) predicted that a third consecutive event of La Niña could be underway.

#### What is La Niña and El Nino-Southern Oscillation (ENSO)

- ENSO refers to the **El Niño/Southern Oscillation**, the interaction between the atmosphere and ocean in the tropical Pacific.
- ENSO is a series of linked weather and ocean-related phenomena.
- El Niño is the warm phase of ENSO.
- La Niña involves the large-scale cooling of the ocean surface temperatures in the central and eastern equatorial Pacific Ocean coupled with changes in the tropical atmospheric circulation (winds), pressure, and rainfall.
- It usually has the opposite impact on weather and climate as El Niño.
- La Niña is characterized by **lower-than-normal air pressure** over the **western Pacific**. These low-pressure zones contribute to increased rainfall.
- La Niña years are associated with **above-average trade winds**, pushing the warmer waters towards Asia and drawing in cooler than normal water temps to the equatorial pacific.
- **Causes:** La Niña is caused by a build-up of **cooler-than-normal waters**in the tropical Pacific, the area of the Pacific Ocean between the Tropic of Cancer and the Tropic of Capricorn.
  - ► Unusually strong, eastward-moving trade winds and ocean currents bring this cold water to the surface, a process known as upwelling.
  - ► Effects: La Niña affect patterns of rainfall, atmospheric pressure and global atmospheric circulation.

#### What does a triple La Niña mean?

- A triple La Niña or a 'triple dip' La Niña is a rare occurrence, lasting for three years in a row. It has happened only twice since 1950.
- On the contrary, the occurrence of two consecutive La Niña winters in the Northern Hemisphere is common.

#### Impact on India

- Monsoon: India may experience an extended monsoon lasting up to October due to La Niña.
- The India Meteorological India (IMD) has predicted that monsoon withdrawal may begin in the first week of September, but it is likely that some parts of India may continue to witness heavy rains.

#### Impact of El Nino and La Nina

- El Nino is associated with drought or weak monsoons.
- La Nina is associated with strong monsoons and above average rains and colder winters.
- Agriculture: La Nina could have negative impacts on Indian agriculture.
- Farmers will be at risk of losing their standing Kharif crops if it rains during this period.
- The harvesting of the Kharif crops begins in September-end or early October. And any rain just before that would prove detrimental to the standing crops.

La Nina is attributed to increased rainfall in the Indian region causing increased precipitation and floods in the major parts of India. Thus understanding this phenomena helps in the better management and diversion of river water to avoid floods and better utilization of water resource.

#### PYQ

Q. Most of the unusual climatic happenings are explained as an outcome of the El-Nino effect. Do you agree?-2014

#### **Practice Question**

Q. What is Triple dip La Nina? Explain its significance and impact on the Indian monsoon?

# 2. MICRO-EARTHQUAKES IN INDIA PREVENTING TURKEY LIKE EVENTS

**Syllabus:** Important Geophysical phenomena such as earthquakes, Tsunami, Volcanic activity, cyclones etc.

# **Context:** Micro tremors have been helping release tectonic stress and protecting India from a devastating event, experts said and asserted that the country has seen a paradigm shift towards effective response and mitigation.

#### Should India be concerned?

- India is witnessing micro tremors regularly which, in turn, is helping release tectonic stress and offering protection from the possibility of a devastating event.
- The triple junction on India's western side near the border with Pakistan is continuously releasing stress due to the occurrence of micro-level earthquakes.
- There are a few earthquakes of magnitude 4 and 5 as well.

#### **Triple Junction**

- A triple junction is a point where three tectonic plates meet and interact.
- These are important areas of geological activity and can be sites of significant seismic and volcanic activity.
- The movement of the plates can cause a significant build-up of stress and strain in the Earth's crust that is eventually released in the form of earthquakes.

#### How prone is India to earthquakes?

- India is located in a seismically active region. India is divided into four seismic zones based on the potential for earthquake activity in each region.
- According to the **Ministry of Earth Sciences**, 59 per cent of India's land mass is prone to earthquakes.
  - Zone V is seismically the most active region, while Zone II is the least.
  - Around 11 per cent of the country's area falls in Zone V, 18 per cent in Zone IV and 30 per cent in Zone III and the remaining in Zone II.
  - ► The zones are used to guide building codes and construction practices.



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**Zone 5** is the zone where the most intense earthquakes occur, while the least intense quakes take place in zone 2. Approximately 11% of the country's area falls in Zone 5, 18% in zone 4, 30% in zone 3 and the remaining in zone 2.

#### Is India ready?

• India is well-prepared to deal with the fallout of large-scale earthquakes as it has a dedicated, wellequipped and trained force in the form of the **National Disaster Response Force (NDRF).** 

#### National Disaster Response Force (NDRF)

- Founded in: 2006
- NDRF is a distinguished, unique Force across the country functioning under the **Ministry of Home Affairs**, Government of India.
- The National Disaster Response Force is an Indian specialized force constituted "for the purpose of special response to a threatening disaster situation or disaster" under the Disaster Management Act, 2005. The "Apex Body for Disaster Management" in India is the **National Disaster Management Authority.**
- At present, National Disaster Response Force consist of 15 battalions from the **BSF, CISF, CRPF, ITBP, SSB and Assam Rifles.**

The micro earthquakes play a very significant role in the adjustment of plates in the Himalayan region (between Eurasian and Indian Plate) for release of pressure and avoiding building up greater force. Thus, helping in overcoming high intensity earthquakes as happened in Turkey –Syria region in 2023.

#### PYQ

Q. 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

Q. Discuss the geophysical characteristics of Circum-Pacific Zone. -2020

#### **Practice Question**

Q. What are micro-tremors? How it helps in overcoming the high intensity earthquakes?

# 3. ISRO TO BOOST NAVIC, WIDEN USER BASE OF LOCATION SYSTEM

Syllabus: Geographical features and their location

**Context:** On the side-lines of the India Space Congress, the Indian Space Research Organisation (ISRO) recently revealed its plans to expand the reach of NavIC (Navigation with Indian Constellation) beyond India and not to a limited territory around India.

#### NavIC (Navigation with Indian Constellation):

- NavIC, also known as the Indian Regional Navigation Satellite System (IRNSS), is an independent standalone indigenous navigation satellite system developed by the Indian Space Research Organisation (ISRO).
- NavIC, which consists of 7 satellites, covering the whole of India's landmass and up to 1,500 km from its boundaries, is conceived with the aim of removing dependence on foreign satellite systems for navigation, particularly for "strategic sectors".
- Currently, NavIC's application in India is limited in -
  - ► Public vehicle tracking,
  - For providing emergency warning alerts to fishermen venturing into the deep sea where there is no terrestrial network connectivity and
  - ► For tracking and providing information related to natural disasters.
- The next step India is pushing for is to include it in smartphones.

 According to India's draft satellite navigation policy 2021, the government will work toward "expanding the coverage from regional to global" to ensure the availability of NavIC signals in any part of the world.

#### **Global Competitors of India:**

- **GPS:** The main difference between GPS (caters to users across the globe and its satellites circle the earth twice a day) and NavIC (currently for use in India and adjacent areas) is the serviceable area covered by these systems.
- Like GPS, there are three more navigation systems that have global coverage **Galileo** from the European Union, Russia-owned **GLONASS** and China's **Beidou**.
- **QZSS**, operated by Japan, is another regional navigation system covering the Asia-Oceania region, with a focus on Japan.

#### **Remote Sensing Satellite in India**

- Remote sensing is the acquisition of information about an object from a distance without physically coming into contact with the object.
- It is based on the principle that different objects have different radiation characteristics. It is useful for monitoring and evaluation of natural resources etc. through analysis of data obtained by observation from remote platform.

#### Various Remote Sensing Satellites of India

- **RESOURCESAT-2A:** A follow-up to the missions of RESOURCESAT-1 and RESOURCESAT-2 which were launched in October, 2003 and April, 2011 respectively. The new satellite provides services similar to other RESOURCESAT missions. It will provide regular micro and macro information on farm land and crop volume, forest, mineral deposits, coastal information, rural, and urban sprawl, underground and water bodies, along with helping in disaster management.
- **Cartosat:** The Cartosat is a series of Indian optical earth observation satellites built and operated by the Indian Space Research Organisation (ISRO). The Cartosat series is a part of the Indian Remote Sensing Program. They are used for Earth's resource management, defence services and monitoring.
- **Oceansat-2:** Oceansat-2 is the second Indian satellite built primarily for ocean applications. It was a part of the Indian Remote Sensing Programme satellite series. Oceansat-2 is an Indian satellite designed to provide service continuity for operational users of the Ocean Colour Monitor (OCM) instrument on Oceansat-1.
- **RISAT-2B:** RISAT-2BR1 is a radar imaging earth observation satellite. This satellite will provide services in the fields of agriculture, forestry and disaster management.
- **SARAL Satellite:** An Indo-French joint mission for oceanographic studies. Designed for altitude measurements for simple ocean movement and ocean surface elevation studies.

#### The NavIC will undergo following significant changes in the near future:

- Adding the L1 band into NavIC: Currently NavIC is only compatible with the L5 and S bands and hasn't easily penetrated into the civilian sector.
  - ► L1 bandwidth is part of the GPS and is the most used for civilian navigational use.
- **Increasing the safety of the signals:** There are two types of codes Long Code and Short Code. NavIC currently only offers short codes. This must become Long Code for the strategic sector's use, to prevent the signal from being compromised.
- **5 new satellites to replace decommissioned NavIC satellites:** To be launched in the coming months, the new launches (medium earth orbit (MEO) satellites) will make NavIC truly "global" like GPS.
  - Currently, NavIC satellites orbit earth in a geostationary or geosynchronous (GEO) orbit, about 36,000 km from earth.
  - ▶ MEO orbits occupy a space between GEO and Low Earth Orbit (LEO).

#### Significance of NavIC:

• **Real Time Information:** It give real time information for 2 services i.e standard positioning service open for civilian use and Restricted service which may be encrypted for authorised user like for military. Currently we uses GPS system of USA for navigation.

- **Dependency on other countries:** India became one of the 5 countries having their own navigation system like GPS of USA, GLONASS of Russia, Galileo of Europe and BeiDu of China. So India dependence on other countries for navigation purposes reduces.
- Technological Development: It will help in scientific & technological advancement of India.
- **Strong Defense**: It will make Indian Armed Forces self-reliant. While advanced nations like US and Russia are having GPS and GLONASS, countries like China, European Union and Japan are trying to have their own full-fledged or partial constellations.
- Helping Neighboring Countries: Further with an extensive coverage, one of the stated future use of the project includes sharing of the project with the SAARC nations. This will help in integrating the regional navigation system further and a diplomatic goodwill gesture from India towards countries of the region.

The development of NavIC system is an important achievement of India for traffic management, disaster prediction, response and management, thus making India one of an important country with its own constellation of satellite for regional navigation.

#### PYQ

Q. Why is Indian Regional Navigational Satellite System (IRNSS) needed? How does it help in navigation? -2018

#### **Practice Question**

Q. What is NavIC satellite system? How it will help in regional navigation and hazard preparation?

# 4. DISCOVERY OF 'CRITICAL' LITHIUM & ITS IMPACT ON ENVIRONMENT

**Syllabus:** Distribution of key natural resources across the world (including South Asia and the Indian subcontinent)

**Context:** Months after India's first lithium reserves were discovered in Jammu and Kashmir (5.9 million tonnes), the **Geological Survey of India (GSI)** has found another reserve of the crucial mineral in Degana in Rajasthan's Nagaur district. It is believed that these reserves are much bigger in quantity than the one found in the Union Territory and can meet 80% of the total country's demand.

#### Why is the finding a big deal?

- Usage: The soft, shiny gray metal is an extremely important one in today's world. It is used, among other things, to build the batteries that electric vehicles cannot do without. Hence the name 'white gold'.
- Self-reliance in the LIB [lithium-ion battery]: If India has its own sources of lithium, it would not have to rely too much on imports for its lithium needs, as it currently does.

#### **About lithium (Properties)**

- Lithium is a non-ferrous metal and is one of the key components in EV batteries.
- It has the symbol Li and is a chemical element.
- It's a silvery-white metal with a delicate texture.
- It is the lightest metal and the lightest solid element under normal circumstances.
- It must be kept in mineral oil since it is very reactive and combustible.
- It is both an alkali and a rare metal.
- In 2020-21, India imported Rs 173 crore worth of lithium and Rs 8,811 crore worth of lithium ions. India's lithium needs are also likely to rise, given the push for electric vehicles.
- Rare: Lithium reserves are also rare.
- There are 98 million tonnes of lithium globally. Now India has found 5.5% of these resources

#### How critical is lithium for India?

• The lithium deposits are critical for India as the country puts its focus on electric mobility for both public and private transport, especially in the country's prime cities such as **New Delhi**, **Mumbai**, **Bangalore**, **Kolkata**, **and Chennai**.



- These metals are strategic in nature and have a wide range of applications in nuclear and other high-tech industries, including electronics, telecommunications, information technology, space, and military.
- India's Ministry of Mines further stated that 51 mineral blocks including Lithium and Gold were handed over to respective state governments.
  - ▶ Out of the 51 mineral blocks, 5 blocks are of gold.
  - > Other blocks pertain to commodities like potash, molybdenum, and base metals.

#### India's lithium reserves

- According to the Indian Mines Ministry, the government agencies made small discovery of lithium resource at a site in Mandya, Karnataka.
- It is the country's first lithium reserve.

#### Lithium Production in the world

- According to the US Geological Survey (USGS), global lithium production in 2019 stood at 77,000 tonnes.
- Australia, Chile, China and Argentina are the world's top four lithium-producing countries.
- Australia is by far the world's top producer of lithium, with an output of 42,000 tonnes in 2019.

#### What is the Lithium Triangle?

- The Lithium Triangle is a region of the Andes rich in lithium reserves around the borders of Argentina, Bolivia and Chile.
- The lithium in the triangle is concentrated in various salt pans that exist along the Atacama Desert and neighboring arid areas.
- The area is thought to hold around 54% of the world's lithium reserves.

The Indian Navy has shown interest in the Lithium Triangle as lithium will be required on Li-ION batteries that are planned to be fitted in future submarines.

Lithium as a rare earth mineral has gained a very important place in the contemporary times of transition of the economies from fossil based to renewable energy based and its discovery in India will increase India's geostrategic importance in the World.

#### PYQ

- Q. Elucidate the relationship between globalization and new technology in a world of scarce resources, with special reference to India.
- Q. Despite India being one of the countries of the Gondwanaland, its mining industry contributes much less to its Gross Domestic Product (GDP) in percentage. Discuss. 2021

#### **Practice Question**

Q. Discuss the implication of the discovery of lithium rare earth reserves in the Western Himalayan region in India. Also explain the criticality of the Lithium reserves in the Indian Economy?

# 5. SAVE HIMALAYAN ECOLOGY: LEARNINGS FROM TURKEY-SYRIA QUAKE & JOSHIMATH CRISIS

**Syllabus:** Changes in critical geographical features (including water bodies and ice-caps) and in flora and fauna and the effects of such changes.

**Context:** Joshimath, the ancient Uttarakhand town has become a cause of concern. Though the town of Joshimath has been witnessing cracks emerging for the past two decades, things have escalated over a few days when the area was declared a disaster prone region.

#### Journey of Joshimath Town's development:

- Joshimath is a busy town in Chamoli district.
- The region is the part of the Himalayan ecosystem.
- Despite a population of only about 23,000, it has been heavily built-on, with hotels, resorts, and a bustling market that caters mainly to tourists, pilgrims, trekkers and personnel of the army and the Indo-Tibetan Border Police (ITBP).
- After the **1962 India-China war**, Joshimath emerged as a place of strategic importance.
- It leads to villages along the India-China border and is also en route to Barahoti, a disputed territory along the border.
- The town is also a gateway to noted sites such as;
- The pilgrimage Badrinath for Hindus and Hemkund Sahib for Sikhs;
- The international skiing site of Auli; and
- The Valley of Flowers, a UNESCO World Heritage site.
- Today, Joshimath is overly burdened with structures built without any regard for the land's load-bearing capacity.
- The signs of sinking first appeared in October 2021, when cracks continued to appear around town and residents resorted to repairs.
- The situation became particularly alarming towards the end of 2022 and the beginning of 2023, when large parts of the town experienced sudden land-sinking and several houses developed major cracks as well.



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#### Reasons for Vulnerability of region:

- Joshimath is built on the deposits of an **old landslide**, which means the slopes can be destabilised even by slight triggers.
- The town is also in **Zone V**, denoting highest risk, in India's seismic zonation scheme.
- It lies between two thrusts, the Main Central Thrust (MCT) and the Vaikrita Thrust (VT), and thus occupies a seismically active terrain.

The M.C. Mishra **committee's report of 1976** warned against heavy and unscientific construction in the town mentioning that, "Joshimath is a deposit of sand and stone, hence was not a suitable place for the coming up of a township. Vibrations produced by blasting and heavy traffic will also lead disequilibrium in natural factors."

#### Contributing factors for disasters in the region:

- **Role of NTPC:** Locals have blamed the **NTPC's 520-MW Tapovan Vishnugad hydropower project**, under construction in the area, for exacerbating the Joshimath land subsidence.
- Recently, NTPC has punctured a tunnel to connect Auli, near Joshimath for supply of water.
- **Char Dham project:** The 6-km **Helang-Marwari bypass**, being built by the Border Roads Organisation (BRO), is also under scrutiny for weakening slopes and further destabilising the local topography.
- The bypass is part of the 825-km Char Dham highway expansion project in Uttarakhand, which experts have already questioned for unscientific slope-cutting, which resulted in several landslides.
- **Inadequate drainage and wastewater disposal:** The 2022 USDMA report pointed to a lack of drainage and wastewater disposal systems as being part of the subsidence problem.
- About **85% of buildings** in the town, including those owned by the army aren't connected to a sewerage system and have soak pits instead.

#### The Himalayan ecosystem:

- **Fragile Himalayan Ecosystem:** The Himalayas are ecologically **fragile and economically** underdeveloped, with geo-environmental constraints imposing severe limitations on the level of resource productivity.
- **Agriculture**: Consequently, subsistence agriculture constitutes the main source of livelihood in the region.
- **Tourism:** The rapid growth of tourists in the region has brought about extensive land-use changes in the region, mainly through the extension of cultivation and large-scale deforestation.
- **Ecological balance:** This irrational land transformation process has not only disrupted the ecological balance of the Himalayan watersheds through reduced groundwater recharge, increased run-off and soil erosion, but has also adversely affected the ecology and economy of the adjoining Indo-Gangetic plains by recurrent floods and decreased irrigation potential.



#### Why Himalayan region is susceptible to disasters?

The Hindu Kush Himalayan region is prone to numerous types of disasters because of its

- Steep terrain
- fragile geology
- intense and variable precipitation
- Common incidents of floods and landslides
- neo-tectonic mountain-building process, like earthquakes, landslides, floods, etc

#### Other factors:

- **Overexploitation of the ecosystem**(tourism, increased consumerism)
- **Exploitative development projects:**The indiscriminate exploitation of the fragile Himalayan region in the name of development projects has extracted a heavy price in terms of environmental damage.
- **Fragmentation of natural resources:**String of hydroelectric and road projects in the Himalayan States have already resulted in the fragmentation of natural systems.

#### Recent disasters in the region:

- In last ten years, two major earthquakes have occurred in Uttaranchal namely the Uttarkashi earthquake (1991) and the Chamoli earthquake (1999).
- 380 people were killed when massive landslides washed away the whole village Malpa, Uttaranchal (then Uttar Pradesh) in 1998.
- In 1999, forest-fires in the hills of Uttaranchal destroyed more than 3, 75,000 hectares of forest. The same year, more than 450 cases of forest fire were reported in Himachal Pradesh and by May 1999, more than 80,000 hectares of forests were turned to ashes.
- The kedarnath floods in 2013, had took lives of several innocent people and disaster in the region

The Himalayan region is susceptible to various mass movement phenomena like avalanche, debris movement, soil creep, etc. which is needed to be well understood for better management and conservation of Himalayan ecosystem.

#### PYQ

- Q. "The Himalayas are highly prone to landslides." Discuss the causes and suggest suitable measures of mitigation. -2016
- Q. Bring out the causes for more frequent occurrence of landslides in the Himalayas than in the Western Ghats. -2013
- Q. How will the melting of Himalayan glaciers have a far-reaching impact on the water resources of India? -2020

#### **Practice Question**

Q. Examine the causes of land subsidence in the Himalayan region resulting in the crisis for human settlement and environment.

# 6. ZERO COAL IMPORT REMAINS ELUSIVE AS CENTRE LEANS ON FOREIGN SUPPLIES AGAIN

**Syllabus:** Distribution of key natural resources across the world (including South Asia and the Indian subcontinent)

**Context:** According to World Economic forum, India has become the third largest emitter of greenhouse gases with one of the highest coal imports in the world with 209 million tonnes in 2022 (Ministry of Coal).

#### Recent trend of coal imports in India:

- The coal imports in India have a declining trend with 234.35 million tonnes in 2018-19 to 209 tonnes in 2021-22.
- But the coal imports have increased in the year 2022-23 due to the increased energy demand and supply chain disruption due to Russia-Ukraine war in early 2022.

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Secondly, the import of coal is substituted by the increase in domestic production which can be seen as 716 million tonnes in 2019-20 and increased to 778 million tonnes in 2021-22.

#### About Coal Reserves in India

- It is the most important and abundant fossil fuel in India. It accounts for 55% of the country's energy needs. The country's industrial heritage was built upon indigenous coal. The Coal resources of India are mainly available in older Gondwana Formations of peninsular India and younger Tertiary formations of north-eastern region.
- Coal is India's most abundant fossil fuel. As of 1 April 2020, the total geological reserves of coal in India stood at a little over 344 billion tonnes.
- Hard coal deposits spread over 27 major coalfields, are mainly confined to eastern and south central parts of the country. The lignite reserves stand at a level around 36 billion tonnes, of which 90 % occur in the southern State of Tamil Nadu.

#### What is the current status of coal stocks?

- India is the 2nd largest producer and consumer of coal in the world after China. Coal stocks at power plants across the country are down in comparison to their normal levels.
- The insufficient stocks of coal are reflected in data released regularly by the **National Power Portal** (NPP), which tracks the coal stocks at thermal power plants across the country.
- As of April 21, the thermal power plants across the country had **a total stock of 21.9 million tonnes (MT) of coal**. The daily usage of coal at these plants stood at 2.7MT.

#### Trend of renewable energy production in India:

India ranks fourth in renewable energy production and have highest growth of renewable energy production in the world which can be seen with 76.37 GW productions in 2014 and reaching to 167.75 GW in 2022.

#### Challenges India facing to achieve zero coal import:

- **Rising Energy Demand:** With India becoming largest populated country by mid-2023, it will witness an increase in energy demand due to increasing population, urbanization and industrialization.
- **Lower renewable capacity development**: Due to various reasons India achieved only 119 GW energy target out of 175 GW by 2022, thus it can be seen that the lower pace of renewable energy development is one of an important reason for rise in coal demand for energy production.
- **HEP projects**: The hydroelectric projects proposed in the Himalayan and peninsular regions are facing issues in completion due to environmental factors and resistance from local population. For e.g. small HEP are stalled in the states of Arunachal Pradesh, Uttarakhand, Himachal Pradesh, Jammu and Kashmir, etc.
- Lack of Infrastructure and technology: India lacks appropriate infrastructure for the development of renewable and other sources of energy which is needed to be developed for making energy infrastructure and use more sustainable in India.

#### Measures taken for achieving zero coal import:

- **Development of Renewable energy capacity**: Increasing the share of renewable energy capacity of India which can also be seen in the 500 GW target by 2030, will help in achieving the zero coal import of India.
- **Enhancement of indigenous coal production**: The coal production in India has seen rise since last 5 years and helped in reducing coal import but, the minimizing coal use should be the paramount aim for sustainable development.
- **Investment in R&D**: The current share of GDP in the innovation and R&D is just 0.7%, much lower than world average of 1.8% resulting in low R&D and innovation related to renewable energy share in India.
- **Technological development**: Enhancing the technological development with respect to renewable and other sources of energy such as bio-fuel and biotechnology should be enhanced for lowering coal import in India.

Zero coal import is an important target for India not only for reducing coal usage for energy production but also to achieve the sustainability in the path of sustainable development. Thus, through technological innovation and developing other sources of sustainable energy twin goal of SDG 7 of clean energy security and SDG 12 of responsible consumption and production can be achieved.
#### PYQ

Q. In spite of adverse environmental impact, coal mining is still inevitable for development." Discuss.-2017

**Practice Question** 

Q. Analyze the significance of zero coal import target of India and the challenges faced in achieving it for sustainable development.

# 7. INDUS WATERS TREATY: DEMANDS FOR ITS RENEWAL ARE NOT NEW, BUT WHAT HAS CHANGED NOW?

Syllabus: Geographical features and their location

**Context:** India has issued a notice to Pakistan for modification to the treaty as per Article XII (3) of the Indus Water Treaty (IWT) due to Pakistan's refusal to implement the treaty.

#### Indus water treaty and ongoing issues:

- Under the notice, India has called on Pakistan to enter into intergovernmental negotiations within 90 days.
- According to India, the treaty requires that disputes be resolved through bilateral negotiations and consultations between the two countries, rather than through international arbitration.

#### What is the Indus Water Treaty?

- In 1960, India and Pakistan signed the Indus Waters Treaty with the World Bank as a signatory of the pact.
- Under the treaty, India got control over the three eastern rivers Beas, Ravi, and Sutlej while Pakistan got control of the western rivers Indus, Jhelum, and the Chenab.
- According to the treaty, India has the right to generate hydroelectricity through the run-of-the-river (RoR) projects on the western rivers which, are subject to specific criteria for design and operation.



#### **Dispute Resolution between India and Pakistan**

- According to Article IX of the treaty that deals with the "Settlement of Differences and Disputes", there are three possible steps to decide on objections raised by either side.
  - Working within the "Permanent Indus Commission" (PIC) of the Indian and Pakistani delegation of water experts that meet regularly.
  - ► Consulting a World Bank-appointed neutral expert.
  - Setting up a court process to adjudicate the case through the World Bank and the Permanent Court of Arbitrage (PCA).

#### Timeline of the dispute between the two nations

- In the following year in 2016, Pakistan unilaterally retracted this request and proposed that a **Court of Arbitration** should adjudicate its objections.
- Instead of responding to Pakistan's request for a Court of Arbitration, India moved a **separate application** asking for the appointment of a **Neutral Expert**, which is a lower level of dispute resolution provided in the Treaty.
- On March 31, 2022, the **World Bank** decided to resume the process of appointing a Neutral Expert and a Chairman for the Court of Arbitration.

# Importance of Indus river basin in development of Hydro-electric power projects in India:

• **Perennial River system:** The Indus rivers have their origin in the Himalayas where melting of glaciers and springs provide water to maintain the perennial flow of rivers in the Indus river basin, the waters of such rivers can be utilized for the development of hydro-electric power project in the region.

- **High potential of rivers**: The potential of Indus river system to produce hydro-electricity is quite high which is still untapped. For e.g. Jammu and Kashmir has a potential to produce 16,475 MW of hydro power, however a total capacity of 3236 MW have been harnessed yet on the rivers of Jhelum, Chenab and Indus.
- **Geographical terrain:** The major part of the Indus river basin is situated over the Himalayan region and at high attitude which helps in the formation of natural potential for the electricity development in the mountainous regions. For e.g. the Indus River originates at 4255 m above mean sea level.
- **Run-off the rivers**: The Run off the river projects are developed on the rivers having high altitude, substantial flow rate and enough tilt to speed the river flow. various run off the river projects developed on Indus river basin are Kiru hydroelectric project on Chenab river.

#### The consequences of hydro-electric power projects on environment.

- **Deforestation:** The development of large and small hydro-electric power projects requires large scale land which causes deforestation on extensive scale for **e.g. the Ujh multi-purpose project envisages** 680 hectares of forest land and clearance of 214502 trees in Kathua region of J&K.
- **Biodiversity Loss**: The Biodiversity such as various wildlife species living in forest and aquatic ecosystem **like Indian fox, Jungle cat, leopard, tiger, snow leopard, hangul and various fishes, dolphins and other organisms** face habitat loss resulting in biodiversity loss.
- Soil erosion and degradation: Due to the construction of dam and reservoirs, the soil present surrounding the region gets removed also sometimes it gets washed away due to flooding, causing degradation of soil.
- Earthquake and land subsidence: When a dam or a reservoir is constructed, it leads to the formation of immense pressure over the under lying mountains. It results in the isostatic adjustment of mountains and plates resulting in their displacement causing earthquake and land subsidence. E.g. construction of Tehri dam resulting in land subsidence in Joshimath in Uttarakhand and such earthquakes can also occur on the Indus river system.
- **Rehabilitation and displacement**: The dam construction not only results in the loss of habitat of wildlife animals but it also results in the loss of habitat of local people and tribals making them vulnerable. E.g. Ujh project resulted in the displacement of 28000 people living in 52 villages of which Dharalta and Dungara are going to get fully submerged.

The Indus river basin is very strategic to India for the energy security which is being consistently opposed by Pakistan under Indus water treaty of 1960, thus India needs to develop its untapped potential for the development of hydro-electric energy and achievement of SDG 7 of clean energy and SDG 14 and SDG 15 of environment and biodiversity conservation.

#### PYQ

Q. Present an account of the Indus Water Treaty and examine its ecological, economic and political implications in the context of changing bilateral relations. -2016

#### **Practice Question**

Q. Bring out the significance of Indus water treaty in the development of infrastructures and its impact on socio-economic conditions of India.

# 8. LACK OF STRONG WESTERN DISTURBANCES BEHIND EARLY HEAT IN NORTH INDIA: IMD

**Syllabus:** Important Geophysical phenomena such as earthquakes, Tsunami, Volcanic activity, cyclones etc.

#### Context:

The India Meteorological Department (IMD) issued a forecast for a fresh spell of rainfall along with thunderstorms and hailstorms over northwest, east and northeast India from **March 30 to April 1, 2023.** 

#### India Meteorological Department (IMD):

- It is an agency established in 1875 under the Ministry of Earth Sciences.
- It is the principal institution responsible for meteorological observations, weather forecasting and seismology.

#### The changing weather scenario in Northern India:

- Rainfall this month has also brought with it a drop in temperatures.
- In Delhi, for instance, the maximum temperature dropped to a low of **3 degrees Celsius** on March 19.
- Last year, when Delhi recorded no rainfall at all in March, the national capital saw higher maximum temperatures of **38 and 39 degrees Celsius after March 20.**



#### Phenomenon behind Western Disturbance (WD):

- Western disturbances are storms that originate in the **Caspian or Mediterranean Sea**, and bring nonmonsoonal rainfall to northwest India.
- They are labelled as an **extra-tropical storm** originating in the Mediterranean, is an area of low pressure that brings sudden showers, snow and fog in northwest India.
- These travel eastwards on high-altitude westerly jet streams massive ribbons of fast winds traversing the earth from west to east.
- Equilibrium exists in nature due to which the air in a region tries to normalise its pressure.
- A WD is associated with rainfall, snowfall and fog in northern India. It arrives with rain and snow in Pakistan and northern India.
- WD brings winter and pre-monsoon rain and is important for the development of the Rabi crop in the Northern subcontinent.
- The WDs are not always the harbingers of good weather.
- Sometimes WDs can cause extreme weather events like floods, flash floods, landslides, dust storms, hail storms and cold waves killing people, destroying infrastructure and impacting livelihoods.

#### **Reasons for Weak Western Disturbances:**

- This winter season, the country has received only three intense Western Disturbances: two in January and one in March. December and February passed without a single intense Western Disturbance.
- Clouds formed by the Western Disturbances have a moderating effect on the maximum temperatures during the winter season. As they were missing this winter season, the north Indian plains experienced severe cold waves and cold days in December and most of January due to the cold northern winds flowing down from the Himalayas.
- One of the reasons for the abnormally hot February was the formation of a high pressure area near the land surface, which caused the air to descend, compress and heat up.
- Increased temperature in recent times due to global warming and climate change has led to an increase in temperature causing weakening of western disturbances.

#### Implications of weak Western Disturbances on India:

• The higher day temperature has led to adverse effect on wheat approaching reproductive growth period, which is sensitive to temperature. High temperature during flowering and maturing period leads to loss in yield.



- With high temperatures in March due to weakening of Western Disturbances damaged 30-40 per cent wheat crop in Punjab, Haryana, Himachal Pradesh, Uttar Pradesh and Madhya Pradesh.
- This had a rippling effect i.e. the domestic wheat prices skyrocketed and forced the Centre to take several difficult decisions, from banning wheat exports to selling its wheat reserves at low prices.
- The glaciers and snowfall are crucial for the water security of the region. As permafrost melts because of the warming, replenishment of glaciers will not happen.

The weakening of western disturbances induced by climate change is a warning to restrict the global temperature rise to be limited to 1.5 C and adhering back to the Paris agreement for reduction in emission of GHGs for sustainable earth.

#### PYQ

Q. How far do you agree that the behaviour of the Indian monsoon has been changing due to humanizing landscapes? Discuss. -2015

#### **Practice Question**

Q. Analyze the impact of weak western disturbances on Indian weather and its resultant impact on the Northern Indian region.

## 9. IMPACT OF HIGHER TEMPERATURE ON WHEAT CROPS

**Syllabus:** Changes in critical geographical features (including water bodies and ice-caps) and in flora and fauna and the effects of such changes.

**Context:** India has set up a panel of officials to assess the impact of rising temperatures on the wheat crop, as the weather office warned that **above normal temperatures** would prevail in key producing states.

#### About the Committee:

- India's agriculture commissioner will head the committee, and officials from the country's key wheat growing states and government scientists will also be on the panel.
- India, the world's second biggest wheat producer. Earlier this month its production was likely to rise 4.1% to a record 112.2 million tonnes.
- India is also the world's second-biggest consumer of wheat.

#### Important facts about the Crop:

- Wheat is the main cereal crop in India. In recent years, the major increase in the productivity of wheat has been observed in the states of Haryana, Punjab and Uttar Pradesh.
- **Climatic requirement:** Tropical and sub-tropical zones, temperate zone and the cold tracts (far north)
- **Soil:** Soils with a clay loam or loam texture, good structure and moderate water holding capacity are ideal for wheat cultivation.

#### **Indian Wheat Growing Zones:**

The entire wheat growing areas of the country has been categorized into 6 major zones as follows

Zones	States/Regions Covered		
Northern Hill Zone(NHZ)	Hilly areas of J&K( except Jammu, Kathua and Samba districts), Himachal Pradesh ( except Una & Paonta valley),Uttarakhand (excluding Tarai region) & Sikkim		
North Western Plains Zone (NWPZ)	Punjab, Haryana, Western UP(except Jhansi Div),Rajasthan (excluding Kota & Udaipur div), Delhi, Tarai region of Uttarakhand, Una & Paonta valley of HP, Jammu, Samba & Kathua districts of J&K and Chandigarh.		
North Eastern Plains Zone(NEPZ)	Eastern UP(28 dist), Bihar, Jharkhand, WestBengal, Assam, Odisha and other NE states (except Sikkim)		

Central Zone	MP, Gujarat, Chattisgarh, Kota& Udaipur Div. of Rajasthan & Jhansi Div. of UP.
Peninsular Zone	Maharashtra, Tamil Nadu(except Nilgiris & Palani Hills),Karnataka & Andhra Pradesh
Southern Hill Zone(SHZ)	Nilgiris & Palani Hills of Tamil Nadu

#### Why higher temperature is a concern for the crop?

- The optimum temperature range for ideal germination of wheat seed is 20-25 C though the seeds can germinate in the temperature range 3.5 to 35 c.
- Areas with a warm and damp climate are not suited for wheat growing.
- This higher day temperature might lead to **adverse effects** on wheat approaching the reproductive growth period, which is sensitive to temperature.
  - ▶ High temperature during flowering and maturing periods leads to loss in yield.
  - ► The country grows only one wheat crop in a year, with planting in October and November, and harvesting from March.

The Rising temperature in the form of heat wave, which is attributed to the climate change is impacting the yield of wheat in the Northern Region of India. Thus, effective policies and management of wheat crop production is needed on urgent basis as wheat forms a major share of the food security in India and also supporting other countries like of Africa to meet their food requirements.

#### PYQ

- Q. The effective management of land and water resources will drastically reduce the human miseries. Explain.-2016
- Q. Bring out the causes for the formation of heat islands in the urban habitat of the world. -2013

#### **Practice Question**

Q. Analyze the impact of heat waves on the production of wheat crops in the Northern Belt of India. Suggest measures to achieve food security in the changing climate regime.

# 10. INDIA LIKELY TO GET 'BELOW NORMAL' MONSOON RAINS IN 2023 DUE TO ONSET OF EL NINO CONDITIONS.

**Syllabus:** Important Geophysical phenomena such as earthquakes, Tsunami, Volcanic activity, cyclones etc.

**Context:** As per the information by private weather forecasting agency *Skymet*, India is likely to get **"below normal"** monsoon rains in 2023 with an increasing likelihood of El-Nino, which typically brings dry weather to Asia.

#### Highlights of the forecast:

- As per the agency, the likelihood of **El Nino** is increasing.
- El Nino return may affect the weather patterns and bring a **weaker monsoon in India** and parts of Asia, especially over the Indian Ocean region.

#### Measurement of Normal to average rainfall:

- India defines **average**, or normal, rainfall as between 96% and 104% of a 50-year average of 88 centimetres (35 inches) for the **four-month season** beginning June.
- Monsoon rains in India are expected to be **94% of the long-term average**, retaining its previous view of **sub-par monsoon**.
- Skymet expects northern and central parts of the country to be at risk of being rain deficit.
- Punjab, Haryana, Rajasthan and Uttar Pradesh, are likely to observe less than normal rains during the second half of the season.

• The Indian Meteorological Department (IMD) also agreed to the news and is expected to announce its annual monsoon forecast soon.

#### The upcoming El Nino:

• The change in sea surface temperature associated with El Nino Southern Oscillation (ENSO) might seem marginal but is enough to disrupt weather patterns globally.

#### El Nino Southern Oscillation (ENSO):

- The combined phases of La Nina and El Nino are termed El Nino-Southern Oscillation (ENSO).
- The phenomenon affects rainfall patterns, global atmospheric circulation, and atmospheric pressure across the planet.
- In the neutral state, (neither El Niño nor La Niña) trade winds blow east to west across the surface of the tropical Pacific Ocean, bringing warm moist air and warmer surface waters towards the western Pacific and keeping the central Pacific Ocean relatively cool.
- It can affect even the large-scale circulation of air in the polar stratosphere i.e. 8km above the Earth.
- The US National Oceanic and Atmospheric Administration (NOAA) has reported that the equatorial Pacific Ocean will return to its neutral state between March and May of 2023, and it is likely that El Niño conditions will develop during the northern hemisphere's autumn and winter.

#### Concerns for India:

- Monsoon dependency: Nearly half of India's farmland, which has no irrigation cover, depends on annual June-September rains to grow crops such as rice, corn, cane, cotton and soybeans.
- **Risk of Food Inflation:** Unseasonal rains and hailstorms have damaged ripening, winter-planted crops such as wheat in India's fertile **northern, central and western plains**, exposing thousands of farmers to losses and raising the risk of further food price inflation.



#### About El Nino:

- El Niño is Spanish for "**the boy child**," which is often used to refer to Jesus Christ, and the phenomenon earned this name because it typically occurs in December around Christmas.
- El Niño occurs every 2-7 years and can last anywhere between nine months and two years.
- El Niño is the warm phase of the El Niño Southern Oscillation (commonly called ENSO) and is associated with a band of warm ocean water that develops in the central and east-central equatorial Pacific (between approximately the International Date Line and 120°W), including off the Pacific coast of South America.

#### Conditions in the equatorial Pacific Ocean prior to the occurrence of El Niño:

• The tropical pacific has consistent westerly moving trade winds. The trade winds push warm water on the surface of the ocean from **east to west (westerly)**.



- This causes warm water to build upon the western side of the ocean near Asia.
- Meanwhile, on the eastern side of the ocean, near **Central and South America**, cold waters are pushed up towards the surface.
- Because of this, there is a difference in temperature across the equatorial pacific, with warm water to the west and cold water to the east.
- The warm water in the west heats the air, making the warm air rise and leading to drastic weather, including rain and thunderstorms.
- The rising warm air causes a circulation between east and west in the Pacific, with the warm, moist air rising in the west, and cool, dry air descending in the east.
- All of these natural occurrences lead to a reinforcement of the easterly winds and cause a self-perpetuating motion in the air in the Pacific.

The El Nino plays a major influencing factor in influencing monsoon winds by weakening the intensity of the winds which affects the agricultural crop production throughout India. Thus, understanding the phenomena and preparing well in advance in essential for the food security of India and socio-economic wellbeing of the farmers.

#### PYQ

- Q. Most of the unusual climatic happenings are explained as an outcome of the El-Nino effect. Do you agree?-2014
- Q. What characteristics can be assigned to monsoon climate that succeeds in feeding more than 50 percent of the won population residing in Monsoon Asia? -2017

#### **Practice Question**

**Q.** The El Nino effect can play a major role in spiking the temperature levels above 1.5°C and causing changes in climatic phenomena and affecting food security. Examine

# **11. INDIA AND WATER SHARING TREATIES WITH ITS NEIGHBOURS**

Syllabus: Geographical features and their location

**Context:** As India falls under a strategic location between the Mountains to the North and Ocean in the South, it tends to hold the flow of several Rivers from its territory to other neighboring countries.

Let us trace important rivers shared by India with its Neighbour countries.

#### The river web in South Asia

- **Perennial Rivers:** Perennial rivers have shaped the history, politics, culture, and economy of South Asia for several centuries.
- **Transboundary rivers :** Several of these perennial South Asian rivers have transboundary basins and watercourses.
- **Countries sharing water treaties with India:** India, Pakistan, Bangladesh, Bhutan, Nepal, and Afghanistan share major rivers among them.
- Indus basin: It is consisting of the Indus, Ravi, Beas, Sutlej, Jhelum, and Chenab rivers which inter-links India, Pakistan, and China.
- The Brahmaputra and the Ganges basins: It inter-link China with India, Nepal, Bangladesh, and Bhutan.
- India and Nepal: The Kosi, Gandaki, and Mahakali rivers join Nepal with India.
- India and Bangladesh: Major rivers shared between India and Bangladesh are the Brahmaputra, Ganges, and Teesta.

#### India-Bangladesh:

- India and Bangladesh share **54 rivers.**
- India holds the **highest number of rivers** flowing from India to the Bay of Bengal region via Bangladesh.
- **The Ganga:** The Ganges in (**Bangladesh: Padma**) is a trans-boundary river of Asia that flows through India and Bangladesh.

- ➤ It flows south and east through the Gangetic plainof North India, receiving the right-bank tributary, the Yamuna, which also rises in the western Indian Himalayas, and several left-bank tributaries from Nepal that account for the bulk of its flow.
- Teesta begins its journey in Sikkim and flows through north Bengal before entering Bangladesh.
- Feni flows 135 km south of Tripura capital Agartala. In a total catchment area of 1,147 square km of the river, 535 square km falls in India and the rest in Bangladesh.
- The other major rivers include Bramhaputra, Meghna, Surma, Jamuna, Kushiyara, Barak, etc.

#### **Kushiyara River**

- The Kushiyara River is a distributary river in Bangladesh and Assam, India.
- It forms on the India-Bangladesh border as a branch of the Barak River when the Barak separates into the Kushiyara and Surma.
- **Origin:** The waters that eventually form the Kushiyara originate in the uplands of the state of **Assam** and pick up tributaries from **Nagaland and Manipur.**
- From its origin at the mouth of the Barak, also known as the 'Amlshid bifurcation point'.

#### India-Pakistan:



- The water of River Indus and other west-flowing rivers from India were the issues between India and Pakistan since Independence.
- Indusis a Trans-boundary river of Asia and a trans-Himalayan river of South and Central Asia.
- The river rises in **Western Tibet**, flows northwest through the disputed region of Kashmir, and flows south-by-southwest through Pakistan, before emptying into the Arabian Sea near the port city of Karachi.
- Other major rivers are Sutlej, Chenab, Jhelum, Beas, Ravi, etc.

#### India-Nepal:

- The Kosi and Gandak are one of the major rivers from Nepal entering India.
- Other Rivers include Rapti, Narayani, kali, etc.
- The Rivers entering India via Nepal are mostly originated from the Tibetan plateau and Himalayan ranges.



#### India-China:

- The most disputed river in India-China region is the Brahmaputra, which is also known as the **Yarlung Tsangpo** in Tibet.
- It gets originated in the **Manasarovar Lake region**, near Mount Kailash, on the northern side of the Himalayas in Burang County of Tibet.
- The river drains the Himalayas east of the Indo-Nepal border, a south-central portion of the Tibetan plateau above the Ganga basin, the south-eastern portion of Tibet, the Patkai hills, the northern slopes of the Meghalaya hills, the Assam plains, and the northern portion of Bangladesh.

#### **Important Treaties**

- **The Indus Water Treaty (1960)** specifies the terms of sharing the water of six transboundary rivers between India and Pakistan.
- **The Ganges Treaty (1996)** between India and Bangladesh brought an end to their longstanding bilateral dispute.
- India and Nepal signed treaties in 1954, 1959, and 1996 for water-sharing and project-development concerning the Kosi, Gandaki, and Mahakali rivers respectively.

The river water treaties form a peaceful accord between the water sharing countries for their use and development of infrastructures like dams, Hydro-electric power plants, Multi-purpose projects, etc. Thus, it helps in resolving bilateral and multi-lateral issues between the India and river sharing countries in Trans-boundary Himalayan region of Asia.

#### PYQ

Q. Present an account of the Indus Water Treaty and examine its ecological, economic and political implications in the context of changing bilateral relations. -2016

#### **Practice Question**

Q. What is the significance of water treaties between India and its neighbouring countries for peaceful sharing of water resource in changing bilateral relations between them?



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# CLIMATE CHANGE

## 1. MARINE HEAT WAVES

**Syllabus:** Important Geophysical phenomena such as earthquakes, Tsunami, Volcanic activity, cyclones etc.

**Context:** A new study has suggested that warm subsurface waters in the Bay of Bengal likely helped fuel the 2020 Amphan super cyclone.

#### **Recent Data on Marine Heat Waves**

- According to a study, **marine heatwaves**, or those that form on oceans, are on the rise in the waters around India.
- Emerging studies have reported their occurrence and impacts throughout the global oceans, but their impact in the tropical Indian Ocean is little understood.
- Furthermore, according to the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report, sea surface temperature across the Indian Ocean is likely to rise by 1 to 2 °C if global warming is 1.5°C to 2°C.

#### What are Marine heatwaves:

- First described in 2011: The term "marine heatwave" was initially used to describe an extreme surface warming event off the west coast of Australia during 2010-11 austral summer.
- Marine heatwaves like **The Blob** has resulted in mass mortalities in marine mammals and birds, and collapse of fisheries and aquaculture in the US, Korea, etc.
- Marine heatwaves are periods of extremely high temperatures in the ocean (above the 90th percentile).
- These events cause marine habitat destruction due to coral bleaching, seagrass destruction, and loss of kelp forests, affecting the fisheries sector adversely.
- Impact on the Monsoon
- The marine heatwaves in the western Indian Ocean and the Bay of Bengal are found to result in dry conditions over the central Indian subcontinent.
- There is an increase in rainfall over south peninsular India in response to the heatwaves in the Bay.

#### What causes marine heatwaves?

- Marine heatwaves can be caused by a whole range of factors, and not all factors are important for each event.
- The most common drivers of marine heatwaves include ocean currents which can build up areas of warm water and air-sea heat flux, or warming through the ocean surface from the atmosphere.
- Winds can enhance or suppress the warming in a marine heatwave, and climate models like El Niño can change the likelihood of events occurring in certain regions.

# THE IMPACT OF MARINE HEATWAVES ON SOCIETY



2015-Closure fo recreational clam fishery. \$40 million USD loss in tourist spending

2012-\$38 million USD loss to commercial

to reduce early lobster

This resulted in a \$108 million USD gain to commercial fisheries.

landings during a

subsequent marine

heatwavte in 2016.

fisheries.

managers implemented quotas

**BUT** fishereis



# WHAT ARE MARINE HEATWAVES?

Marine heatwaves occur when ocean temperatures are extremely warm-much warmer than expected for the location and time of year-for an extended period of time (5 days or more). They can occur at any time of year and often have significant impacts on marine ecosystems and industries.

Marine heatwaves have become longer and more frequent over recent decades as teh oceans have absorbed excess heat from teh atmosphere and become significantly warmer.

SOME IMPACTS OF MARINE HEATWAVES

#### GLOBALLY AVERAGED NUMBER OF ANNUAL MARINE HEATWAVE DAYS





2003-Mass mortalities of at least 25 difference marine species.



2010-Bleaching and mass mortalities of coral in South Asia. Between \$49 and 74 million loss in tourism.



2011-Mass mortality of seagrass in Shark Bay a UNESCO world herigate site. Between 2 and 9 Tg  $CO_2$  released back into the atmosphere equivalent to the amount of  $CO_2$  released by a small developing country in year





2016-17-mass moratality of farmed salmon. \$800 million USD export loss to aquaculture industry.

# WHAT DOES THE FUTURE HOLD?

Ultimately, without improved global action to tackle climate change, the oceans will continue to warm leading to more intense and frequent MHWs, further impacting marine ecosystems.

In the short term, societies will need to adapt to a warmer world to better manage human-ocean interactions.



K. E. Smith et al., Science 374, eabj3593 (2021).

Link to paper



#### Trends of Marine heat wave in Indian Ocean:

- Bay of Bengal recorded surface temperatures of 32-34°C, before Cyclone Amphan.
- 93% of the heat from global warming goes into the oceans.
- Warm waters are an energy source for cyclones.
- As the Arabian Sea warms, the number and intensity of cyclones and heavy rains increase.
- Over the Arabian Sea,
- 150% rise in the number of very severe cyclones
- 80% rise in the total duration of cyclones
- 20%-40% rise in the intensity of cyclones Over the Bay of Bengal, rapid intensification may be occurring more.

#### Key findings about Marine heatwave and Cyclone:

- The heat content in the subsurface ranged between 135 and 150 kilojoules per square centimetre before the cyclone.
- Warm subsurface waters could intensify cyclones by allowing heat to flow between the sea and atmosphere. Warmer waters fuel cyclones.
- The subsurface water may have warmed because of the high sea level anomaly, which is the difference between the total and average sea level.
- An increase in sea level is brought about by anticyclonic eddies, which is a circular movement of water.

Marine heat waves have increased in recent times due to increased global warming and sea surface temperature impacting marine and coastal biodiversity in the ocean and seas all over the earth. Thus, their management is needed to keep hydrosphere healthy and the biodiversity thriving to achieve SDG 14 i.e. life below water.

#### PYQ

- Q. How do ocean currents and water masses differ in their impacts on marine life and coastal environment? Give suitable examples. 2019
- Q. What are the consequences of spreading of 'Dead Zones' on marine ecosystem?-2018

#### **Practice Question**

Q. What are marine heat waves? How they are impacting the marine and coastal ecosystems?

### 2. URBAN GREENING

Syllabus: Geographical features and their location

**Context:** During the novel coronavirus pandemic, momentarily we do have witnessed an outflow of people from the bigger cities to suburban and rural areas. *But now this trend is reversing and urban occupancy is rebounding.* 

The need for housing with adequate amenities in the cities is growing fast. The government and the industry are struggling in keeping up the pace to fulfil the *increasing demand for sustainable urban housing*.

#### Background

New job opportunities and natural population increase is making people move to the cities, thereby *putting enormous stress on the shared resources* which are getting translated into an additional burden on the cities. To name a few, it has resulted in the concretisation of cities, increases in greenhouse gas emissions, declining water table, etc.

#### Analysis

Climate change, urban emissions and declining green spaces in the cities is throwing challenges on cities infrastructure and is asking for immediate remedial action and timely course correction to avoid the situation from getting out of hand.

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#### Why do we need green spaces in the cities?

To mitigate the effect of Pollution: It can help to reduce a phenomenon known as the urban heat island effect, which refers to heat trapped in built-up areas. Increased temperatures in summer lead to an increased demand for cooling.

#### The urban heat island effect:

It appears in towns and cities as a result of human activity. The heat generated by people, transport, shops and industry is trapped in the narrow roads and concrete structures, unable to escape to the atmosphere. This can bring the temperature in urban areas up 3-4°C higher than the surrounding countryside.



- **Crucial for Community Health**: Green spaces are good for human health and they are crucial for community health. Research shows that cities with healthy community forests are more resilient. Cities gain from the environmental, social and economic benefits of urban trees and green spaces when it is part of overall planning and infrastructure.
- Avoid Flooding & Degradation of Water Quality:
- The impermeable materials used for roads and pavements mean that rain is not absorbed and remains on the surface, which results in flooding.
- High levels of surface water run-off are that rainwater washes pollutants away from the surfaces it falls onto, transporting them into watercourses.
- Wildlife and Habitats: Cities are considered to host a less diverse range of plants, animals and birds than nearby rural areas. However, green spaces within an urban area can be home to many of the same species that are more commonly associated with rural settings.

#### **Need for Urban Greening Guidelines**

It is imperative to prepare Urban Greening Guidelines which will act as a model for States and cities particularly the state town planning departments, Urban Development Authorities and Urban local bodies who are responsible for managing them.

#### The Objectives of urban green guidelines:

- To highlight the impact of urbanization on urban greenery
- To suggest practices and methods for protecting and enhancing urban greenery in a sustainable manner
- To identify the key stages in planning and development where urban greenery may be integrated with the build environment.
- To recommend suitable guidelines for enhancing urban greens.

The urbanization is being witnessed in every corner of India which is needed to be planned according to the principles of environment for sustainable planning and management of urban cities. Thus, following urban Greening guidelines is important by various authorities at different levels for effective urban expansion.

# 3. DESERTIFICATION: 'DROUGHTS REDUCED INDIA'S GDP BY UP TO 5% IN 20 YEARS

**Syllabus:** Changes in critical geographical features (including water bodies and ice-caps) and in flora and fauna and the effects of such changes.

#### **Context:** According to the **Drought in Numbers, 2022** report released at the **15th Conference of Parties** (CoP15) to the **United Nations Convention to Combat Desertification (UNCCD)**, the frequency and duration of drought is increasing at an alarming rate across the world since the onset of the 21st century.

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#### Background

- According to **Desertification and Land Degradation Atlas of India**, released by **the Space Applications Centre of the Indian Space Research Organisation**, some 97.85 million hectares (mha) — nearly 30 per cent of India's total geographical area (TGA) — underwent land degradation during 2018-19.
- In 2003-05, 94.53 mha (28.76% of the TGA) underwent land degradation. This number increased to 96.40 mha (29.32% of the TGA) in 2011-13.
- Some 83.69 mha underwent desertification in 2018-19.
- The level of desertification increased in 28 of 31 states and Union territories between 2011-13 and 2018-19.
- In eight states—Rajasthan, Delhi, Goa, Maharashtra, Jharkhand, Nagaland, Tripura, and Himachal Pradesh—around 40 to 70 per cent of land has undergone desertification.
- Around 23.79% of the area undergoing desertification/land degradation in the country was contributed by **Rajasthan, Maharashtra, Gujarat, Karnataka, Ladakh, Jharkhand, Odisha, Madhya Pradesh and Telangana**.

#### What are the concerns for India?

- The assessment has featured India as one of the severely drought-impacted countries. Nearly twothirds of the country suffered drought during 2020-2022.
- Geographically, India's drought vulnerability compares with that of sub-Saharan Africa.
- The effect of severe droughts was estimated to have reduced India's gross domestic product by 2-5 per cent over the 20 years from 1998 to 2017.
- India's drought-prone area has increased by 57 per cent since 1997.
- One-third of India's districts have faced more than four droughts over the past decade and 50 million people are affected by drought every year.
- Some 97.85 million hectares nearly 30 per cent of the country's land underwent land degradation during 2018-19.
- Drought impacts India's dominantly rainfed agriculture which accounts for 60 per cent of the sown area on average.



#### What is Land degradation/Desertification?

• UNCCD defines desertification as "land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities".

- Drylands affected by desertification not only lose their ability to support plant life but also their ability to offer ecosystem services, such as management of water systems and storage of carbon use in global warming.
- With changing climate, prolonged droughts, and increasing incidences of floods, landslides, and frost heaving are in any case reducing the amount of productive land.
- At the same time, the growing demand for food, fodder, fuel and raw materials is increasing the pressure on land and the competition for natural resources.

#### United Nations Convention to Combat Desertification (UNCCD)

- Established in 1994, UNCCD is the sole legally binding international agreement linking environment and development to sustainable land management.
- The Convention addresses specifically the arid, semi-arid, and dry sub-humid areas, known as the drylands, where some of the most vulnerable ecosystems and peoples can be found.
- The UNCCD is particularly committed to a bottom-up approach, encouraging the participation of local people in combating desertification and land degradation.

| What are the impacts of land degradation? |                                                  | How to combat desertification? |                           |
|-------------------------------------------|--------------------------------------------------|--------------------------------|---------------------------|
| ø                                         | Loss of soil fertility                           | o                              | Terracing on hill slopes  |
| ø                                         | Erosion                                          | o                              | Drip Irrigation           |
| o                                         | Impacting vegetation, soil quality & water table | o                              | Contour binding           |
| o                                         | Destructing the ecosystems                       | o                              | Dune stabilization        |
| o                                         | Economic loss                                    | o                              | Cover crops               |
| o                                         | Leading to climate crisis                        | o                              | Climate-smart agriculture |
| ø                                         | Impact on human health                           | ø                              | Windbreaks                |

#### Steps Taken by Government of India to combat desertification

- Integrated Watershed Management Programme: It aims to restore ecological balance by harnessing, conserving, and developing degraded natural resources with the creation of Rural Employment. It is subsumed under Pradhan Mantri Krishi Sinchai Yojana.
- **UNCCD**: India became a signatory to the United Nations Convention to Combat Desertification (UNCCD) in 1994 and ratified in 1996.
- **National Afforestation Programme:** Implemented since 2000for the afforestation of degraded forest lands.
- National Action Programme to Combat Desertification: It was prepared in 2001to address issues of increasing desertification and to take appropriate actions.
- **Fodder and Feed Development Scheme:** Launched in 2010 to improve degraded grassland and also the vegetation cover of problematic soils like saline, acidic and heavy soil.
- National Mission on Green India: It is a part of the National Action Plan on Climate Change (NAPCC). It was approved in 2014 to protect, restore and enhance India's diminishing forest cover with a deadline of 10 years.

Land degradation and desertification is one of the major effects of climate change and in India it is being witnessed in its overall spatial extent. Thus, to combat desertification and land degradation, suitable policies and measures for protection and conservation is needed.

#### PYQ

Q. The process of desertification does not have climatic boundaries. Justify with examples. 2020

#### **Practice Question**

Q. What are the reasons for desertification in India and bring out the suitable measures to be followed to combat desertification in India.

# 4. BUDGET 2023-24: CENTRE'S MANGROVE RESTORATION SCHEME STRESSES ON ITS SCIENTIFIC IMPLEMENTATION

**Syllabus:** Changes in critical geographical features (including water bodies and ice-caps) and in flora and fauna and the effects of such changes.

**Context:** Recently, the Budget 2023 announced a new program for mangrove plantations along the coastline and on saltpan lands called Mangrove Initiative for Shoreline Habitats & Tangible Incomes (MISHTI) which experts have called an essential step in the fight against the climate crisis.

#### What is MISHTI?

- **Mangrove Initiative for Shoreline Habitats and Tangible Incomes**: It has been launched to protect India's mangroves along the coast and saltpan lands.
- **Mangrove Alliance for Climate:** The initiative follows India's steps of joining the Mangrove Alliance for Climate that was launched during COP 27 in Sharm-el-Sheikh in 2022.
- **Convergence of funds:** The scheme involves a convergence of funds available under the MNREGS, CAMPA funds and other sources.
- **Plantation of mangroves:** The scheme is expected to boost large scale plantation of mangroves and carbon and biodiversity offsets while attracting private resources towards mangrove conservation.
- **Livelihoods:** According to WWF-India, MISHTI has potential to generate and improve livelihood conditions through engagement of plantations, tourism and improved marine catch.
- **Climate change**: Experts have hailed the scheme as step towards combating the climate crisis but have cautioned of the need for scientific implementation.
- **Budgetary allocation:** The Budget did not mention any specific allocations for the scheme although the Ministry of Forests, Environment and Climate Change was assigned ₽3079.40 crores.

#### Status of Mangroves in India

- According to the **Forest Survey Report 2021**, India has a total mangrove cover of 4,992 square kilometres and recorded an increase of 17 square km in mangrove cover relative to the previous assessment in 2019 with **Odisha**, **Maharashtra and Karnataka** having the most.
- The last century saw the loss of 40% of the country's mangrove cover while Kerala lost around 95% of its cover in the last three decades as a result of agriculture, aquaculture, tourism and development.
- Community restoration projects to achieve planting and preservation of 5000 ha of mangroves has been undertaken in Gujarat.
- Mangroves are under severe threat from climate change as trees have been reported to be moving upstream in the **river Hooghly.**
- A 2020 study found that this might be caused by variations in the pollution load, mean sea level rise, and human activity.
- It is yet unclear how sea level rise will affect the vulnerable mangrove environment along the Indian coastline.
- Mangroves in India are home to **Royal Bengal tigers, Gangetic dolphins, estuarine crocodiles**, and numerous other aquatic bird and reptile species.

#### Why are mangroves important?

- **Carbon Sinks:** Only 0.1% of the planet's surface is covered by mangroves, but they are efficient carbon sinks that have the capacity to store up to ten times as much carbon per hectare (ha) as terrestrial forests.
- **Natural storm barriers:** These plantations can serve as a natural storm surge barrier, defending coastal settlements. More than \$65 billion in property damage is prevented each year by mangrove ecosystems, and over 15 million fewer people experience floods as a result.
- Halophytic trees: These salt-tolerant trees can remain frozen for a millennium if not disturbed because they retain the majority of their carbon in their soil and sediments.
- **Biodiversity:** Mangroves are also key spawning and rearing habitats of fish and also sustain a diverse food web, with molluscs and algae-filled substrate serving as a nursery for tiny fish, mud crabs, and shrimp, providing a living for neighbourhood artisanal fishermen.

- **Carbon sequestration:** Huge volumes of carbon dioxide are removed from the atmosphere by mangrove forests, and their preservation can help with this process as well as prevent the release of that carbon when mangroves are destroyed.
- **Carbon Credit**: Mangrove Restoration projects can serve as sites of carbon credit generation, facilitating an increase in carbon trading.

#### What is the status of mangrove restoration projects?

- Low success rate: Mangrove restoration initiatives, however, have had mixed results. Efforts in Sri Lanka to restore 1,000–1,200 acres of mangroves were only successful in 200–220 ha.
- **Low survival rate:** According to a 2017 study, the survival rate of the restoration project sites ranged from 0-78%.
- **Faulty selection of variety:** The failure of mangrove restoration operations was mostly due to the selection of the incorrect species for the incorrect site.
- **Unscientific farming**: Another reason for failure was the prevalence of unscientific farming practices.
- **Soil conditions:** According to a study on the Sri Lankan restoration project, mangrove seedlings should be planted at specific soil conditions or the results would be unfavourable.

Mangroves form an important part of coastal ecosystem which also helps in acting as a barrier during storm surge and cyclonic activities, thus their restoration through convergence of various funds will help in employment generation and conservation of coastal environment in India.

#### PYQ

Q. Discuss the causes of depletion of mangroves and explain their importance in maintaining coastal ecology.

#### **Practice Question**

Q. Enumerating the conditions favourable for the presence of mangroves in India, discuss the significance of Mangrove restoration program.

# 5. ENHANCED PHYTOPLANKTON BLOOM TRIGGERED BY ATMOSPHERIC HIGH-PRESSURE SYSTEMS OVER THE NORTHERN ARABIAN SEA

**Syllabus:** Changes in critical geographical features (including water bodies and ice-caps) and in flora and fauna and the effects of such changes.

**Context:** A new study, entitled Ecosystem state change in the Arabian Sea shows that Algal Blooms in the Arabian sea will threaten the food chain system present over the region.

#### More on the news:

- According to the data from NASA's ocean color satellite, productivity of Noctiluca during the winter monsoon was also rising, contrary to what we expected.
- In 2009, with the help of NASA and the US government, the Indian Space Research Organization and India's Ministry of Earth Sciences, began examining the physiology of this organism more closely, and discovered that it was **thriving because the Arabian Sea was losing oxygen**.
- And since they are not a preferred food for higher trophic organisms, they mostly attract only salps, jellyfish and turtles, thereby **short-circuiting the food chain** in the Arabian Sea.
- At least 120 million people along these coasts are now at risk.

#### **Climatic Conditions over Arabian Sea:**

- **Conditions during winter:** During winter, the dry, cool air brought by prevailing northeasterly trade winds leads to surface ocean heat loss and convective mixing in the northern Arabian Sea.
- **Convective mixing:** The convective mixing process leads to the injection of nutrients up into the surface waters and exert a dominant control on winter productivity.
- **Role of Atmospheric High Pressure system**: Our findings suggest that the atmospheric high-pressure systems that traverse the northern Arabian Sea every winter and spring disrupt winter convective mixing and create an array of environmental conditions conducive to trigger phytoplankton blooms.



- **Stratification of Sea layers:** The arrival of an atmospheric high with the anti-cyclonic flow in the northern Arabia Sea sets the stage for a sequence of events culminating in intermittent mixed-layer restratification due to buoyancy gain aided by increased specific humidity, supplemented with abundant sunlight due to clear skies, and suppressed turbulent mixing owing to weak winds.
- **Significance of Euphotic zone:** These combined with the mixed layer that is shallower than the euphotic zone and the influx of nutrients into the euphotic zone brought by convective mixing between the calm periods, caused unprecedented high concentrations of chlorophyll in the northern Arabian Sea.

#### Phytoplankton:

- Phytoplanktons are the autotrophic (self-feeding) components of the plankton community and a key part of ocean and freshwater ecosystems.
- Phytoplanktons obtain their energy through photosynthesis, as do trees and other plants on land. This means phytoplankton must have light from the sun, so they live in the well-lit surface layers (euphotic zone) of oceans and lakes.
- In comparison with terrestrial plants, phytoplanktons are distributed over a larger surface area, are exposed to less seasonal variation and have markedly faster turnover rates than trees.
- Phytoplanktons form the base of marine and freshwater food webs and are key players in the global carbon cycle.
- They account for about half of global photosynthetic activity and at least half of the oxygen production, despite amounting to only about 1% of the global plant biomass.
- Phytoplanktons are very diverse, varying from photosynthesizing bacteria to plant-like algae to armor-plated coccolithophores. Important groups of phytoplankton include the diatoms, cyanobacteria and dinoflagellates, although many other groups are represented.

## Linkage between global warming and algal blooms:

- **Increase in temperature:** According to the study, global warming has exerted a disproportionately strong influence on the Eurasian land surface, causing a steady decline in snow cover [in the Himalayas].
- Winter convective mixing: This has disrupted "winter convective mixing" which occurs when cold winter winds blow over the Arabian Sea, driving the surface waters down, which are in turn replaced by nutrient rich waters from below.
- **Covering of large area of sea:** That process allows photosynthetic phytoplankton the basic building block of our ocean food chain to thrive, along with all the fish species that eventually result in the seafood bounty so many of us rely on.

## Significance of Phytoplanktons:

- They contribute more than half of the oxygen in the environment.
- They reduce global warming by absorbing human-induced carbon dioxide.
- They also serve as the base of the ocean food chain.
- They are important bioindicators regulating life in oceans. Their abundance determines the overall health of the ocean ecosystem.
- The productive fisheries in the world's ocean are driven by Phytoplankton blooms.

## General reason behind the phytoplankton boom

- **Increase in nutrient availability:** The primary cause of phytoplankton blooms is an increase in nutrient availability, particularly nitrogen and phosphorus.
- These nutrients can come from a variety of sources, including agricultural runoff, wastewater discharge, and atmospheric deposition. When there is an abundance of nutrients in the water, phytoplankton can grow and reproduce rapidly, resulting in a bloom.
- Warmer sea surface temperatures: Warm water temperatures, high light levels, and calm water conditions can all contribute to phytoplankton blooms by allowing phytoplankton to stay near the surface and access the light they need for photosynthesis.
- **Climate change:** It can also disrupt ocean circulation, affecting mixing between ocean layers and how nutrients move around the ocean.
- **Human development** also plays a role. Fertilizer runoff from agriculture can increase nutrient loads in the ocean, leading to blooms.

#### Impacts of Phytoplankton bloom:

- Phytoplankton blooms can have both positive and negative impacts on the environment.
- In some cases, they can **support the growth of other organisms in the food chain and improve water quality** by absorbing excess nutrients.
- However, in other cases, blooms **can deplete oxygen levels in the water**, leading to **fish kills** and other negative impacts on aquatic life.
- Some phytoplankton species can also **produce toxins that can harm human health and the health of other animals** that consume them.

Phytoplankton forms a basic part of the food chain present at lowest trophic levels but very important in sustaining the other fauna present in higher trophic levels, thus algal bloom occurring in the Arabian sea region will not only impact the regional biodiversity but the marine economic system present in the region.

#### Practice Question

Q. Analyze the favorable conditions formed due to the change in climate resulting in algal bloom impacting food chain and marine ecosystem.

#### 6. HEAT WAVES IN INDIA: CAUSES AND IMPACT

**Syllabus:** Important Geophysical phenomena such as earthquakes, Tsunami, Volcanic activity, cyclones etc.

**Context:** There is an ongoing heatwave in India that has forced millions of people indoors to look out for possible solution to overcome the effect of rising temperature. The driving up temperatures beyond normal in **north, west, central and east India** in the month of **March and April** is a cause of concern for India.

#### • IMD has said that **April was the hottest**in northwest India in 122 years.

#### What are heatwaves?

• The **India Meteorological Department** qualitatively describes heatwave as a condition of air temperature which becomes fatal to the human body when exposed.

#### **The General Occurrence**

- **Months:** Heat waves usually occur in the months of March to June and in some rare cases even in July.
  - > The peak month of the heat wave over India is May.
- **Regions:** Heat waves generally occur over plains of **northwest India**, **Central**, **East and north Peninsular** India.
  - ▶ It covers Punjab, Haryana, Delhi, Uttar Pradesh, Bihar, Jharkhand, West Bengal, Odisha, Madhya Pradesh, Rajasthan, Gujarat, parts of Maharashtra and Karnataka,

#### **Declaration of Heatwave**

- Heatwave: A heatwave is declared when an area logs a maximum temperature of 45 degree Celsius.
- Severe heatwave: A severe heatwave is declared if the maximum temperature crosses 47 degrees.
- For coastal regions, heat wave may be described provided actual maximum temperature is 37 degrees or more.

#### Understanding the geographical aspect of heatwave

- One of the causes of these extreme heat waves has been the unusual north-westerly winds.
- These anomalous north-westerlies overpowered the moist southerly winds that typically come off the water and kept pre-monsoon showers offshore.
- This deviation from normal wind trends allows hot air from desert areas to the northwest to spread over much of the country.
- Heat waves form when high pressure aloft in around 3,000–7,600 metres above the region and remains over a region **for several days** up or



- This is common in summer, both in **Northern and Southern** Hemisphere as the jet stream **'follows the sun'**. On the equator side of the jet stream, in the upper layers of the atmosphere, is the high pressure area.
- During summer, weather patterns are generally slower to change than in winter. As a result, this upper level high pressure also moves slowly.
- Under high pressure, the air subsides (sinks) toward the surface, warming and drying adiabatically, inhibiting convection and preventing the formation of clouds.
- Reduction of clouds increases shortwave radiation reaching the surface.
- A low pressure at the surface leads to surface wind from lower latitudes that bring warm air, enhancing the warming.
- Alternatively, the surface winds could blow from the hot continental interior towards the coastal zone, leading to heat waves there causing adiabatic warming.

#### What are the favourable conditions of heat wave formation?

- **Transportation / Prevalence of hot dry air over a region**: There should be a region of warm dry air and appropriate flow pattern for transporting hot air over the region.
- Absence of moisture in the upper atmosphere: As the presence of moisture restricts the temperature rise.
- The sky should be practically cloudless: To allow maximum insulation over the region.
- Large amplitude anti-cyclonic flow over the area.

#### Wet Bulb Temperature

- This heatwave has also brought the wet bulb temperature concept into mainstream conversation.
- In simpler terms, wet bulb temperature tells us at what level our bodies will be unable to cool themselves down by sweating.
- In this case, the threat of a heat stroke rises dramatically.
- Wet bulb temperature combines heat and humidity to indicate how much evaporation can be absorbed into the air.
- It measures the lowest temperatures that our bodies can reach when we are in hotter environments, by sweating.

#### What is heat Index?

- The heat index is a measure of how hot it feels when relative humidity is factored with the actual air temperature.
- It is used to measure the intensity of heat waves in a region.
- In certain countries it is defined in term of the heat index based on temperature and humidity or based on extreme percentile of the temperatures.

India is experiencing the increased intensity of heat waves in the spatial extent and having various impacts detrimental to human health, agricultural crop, biodiversity, increase in power consumption, etc. Thus, management of heatwave conditions in the times of climate change through incorporation of Bio-house methods, climate smart housings, etc. to overcome its effects in a sustainable manner.

#### PYQ

Q. Bring out the causes for the formation of heat islands in the urban habitat of the world. -2013

#### **Practice Question**

Q. Examine the conditions contributing to the increased heat waves conditions across Indian subcontinent while enumerating its possible impacts on India.

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