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PAPER II

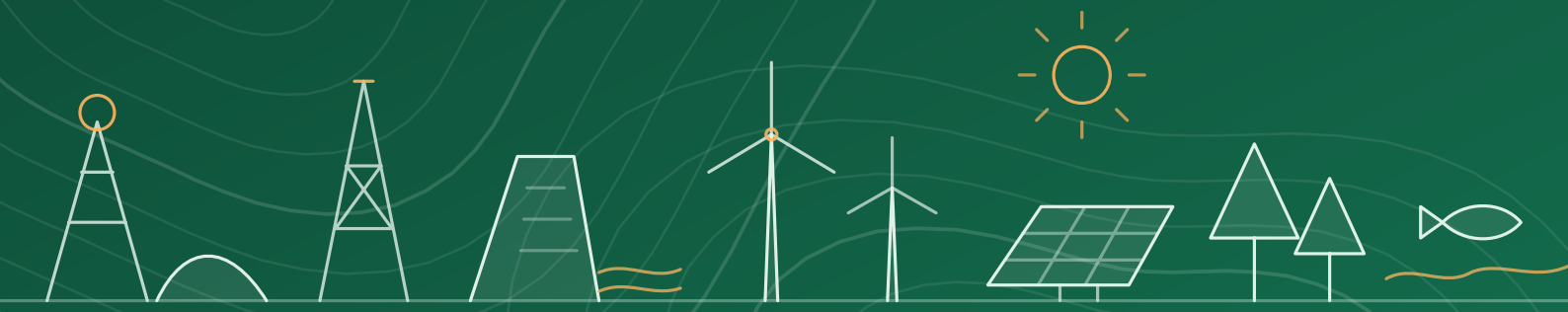
Resources Notes

The complete Resources section of Paper II — land, surface and ground water, minerals, energy, biotic and marine resources, forest and wildlife conservation and the energy crisis, with previous year questions.

Compiled by Arvind KrS

LAND AND WATER | MINERALS | ENERGY | FORESTS AND WILDLIFE | MARINE RESOURCES

25	5	128	114
Chapters	Units	Previous year questions	Diagrams and figures



IN THIS BOOK

01 Land Resources

02 Water Resources

03 Mineral Resources

04 Energy Resources and the Energy Crisis

05 Biotic and Marine Resources

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LOTUSARISE IAS

Geography Optional — Resources

Paper II · Geography of India: Resources

Mains 2027 Edition · Compiled November 2026

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Questions or corrections: support@lotusarise.com

The outline map of India on the cover and on the chapter and unit pages is decorative and not to scale.

How to read these notes

Every chapter is marked against the questions UPSC has actually asked on it, so the points that matter most stand out on the first read and are quick to find at revision.

About 71% of the planet's surface is under water, yet the share fit for human use is tiny.

Yellow marker: key point. A point that carries the ideas UPSC has asked about in this chapter. Read these first, and make sure each one is in your answer.

Surface water is the water held in rivers, lakes, ponds and canals.

Blue marker: definition. The cleanest definition of a term, ready to open an answer with.

Scarcity therefore sits beside floods, and the country is already classed as **water stressed**.

Saffron underline: PYQ term. A key term or phrase that appears in this chapter's previous year questions.

Ground Water PYQ 2024 · 2018 · 2010 +1

PYQ tag on a heading. The years in which UPSC asked about this section. Sections without a tag are background or linking material.

PYQ RADAR **13** questions Last asked **2024**

PYQ radar. At the start of each chapter: how many times the topic has been asked, and how recently. The contents page shows the same count for every chapter.

Suggested method. First read: the whole chapter. Revision: the yellow and blue marks, the tagged headings and the PYQ list at the end of the chapter. Last week before Mains: the PYQ list alone, answering each question in your head from the marked points.

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UNIT 04 | 11 CHAPTERS

Energy Resources and the Energy Crisis

Energy resources; energy crisis.



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GEOGRAPHY OPTIONAL | PAPER II · RESOURCES

Energy Crisis



PYQ RADAR 7 questions Last asked **2026** 2026 · 2020 · 2018 · 2017 · 2008 · 1991 · 1988

CONTENTS

01 Nature and Evolution of the Energy Crisis
02 Regional Variation in the Intensity of the Energy Crisis
03 India's Energy Crisis
04 Measures to Overcome the Energy Crisis
05 Previous Year Questions

- An **energy crisis** is a situation in which the **supply of energy fails to keep pace with demand**, or becomes so costly or uncertain that it disrupts economic activity, social life and international relations.
  - It can be **acute**: a sudden shock from war, embargo, accident or extreme weather.
  - It can also be **chronic**: a long-run imbalance from the **depletion of finite fossil fuels**, rising demand and slow growth of alternatives.
- The world economy still draws about **86% of its primary energy from oil, gas and coal** (2025). These **non-renewable stocks** took millions of years to form, are unevenly spread and are traded across a few vulnerable routes. A disruption anywhere therefore travels quickly through prices everywhere.
- For economic geography, the energy crisis is a problem of **spatial mismatch**: energy is produced in a few regions, consumed in others, and moved between them through chokepoints, pipelines and grids.

01 Nature and Evolution of the Energy Crisis

PYQ 2026 · 2020 · 2018 +4

Meaning and Dimensions

- Supply dimension: physical shortage of fuel or power, caused by depletion, under-investment, war or disaster.
- Price dimension: sudden or sustained price spikes that make energy **unaffordable** even when it is physically available.

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- Access dimension: **energy poverty**. In 2023 about **666 million people** still lacked electricity, most of them in Sub-Saharan Africa, and about **2.1 billion** lacked clean cooking fuels.
- Environmental dimension: the crisis of a fossil-based system whose emissions drive climate change. Energy-sector CO_2 reached a record of about **35.8 billion tonnes in 2025**.
- Geopolitical dimension: dependence on a few exporters and transit routes turns energy into a **strategic weapon**.

The Major Oil Shocks and Crises

- **First oil shock (1973–74):** during the Arab–Israeli war of October 1973, Arab members of the **Organization of the Petroleum Exporting Countries (OPEC)** placed an **embargo** on the USA and other supporters of Israel and cut output.
  - Crude prices roughly **quadrupled**, from about **$3 to nearly $12 a barrel**, by early 1974. Saudi Light had been about $1.35 in 1969 and $2.10 in 1972; older accounts give the 1973 rise as $1.5 to $7.
- **Second oil shock (1979–80):** the **Iranian Revolution** (1979) and the **Iran–Iraq War** (1980) cut supplies. Prices more than doubled to over **$35 a barrel** (annual average) by 1980.
  - Saudi Light stood at about **$26 in 1979** (older accounts give $24) and **$34 in 1981**. It fell to about $16 in 1986 and stayed mostly between $12 and $24 through the early 1990s.
  - In the economic crisis that followed, wage demands and the cost of living rose in many countries.
  - Oil-importing developing countries without foreign-exchange reserves were hit hardest, through inflation, balance-of-payments crises and debt.
- Gulf War spike (1990): Iraq's invasion of Kuwait briefly doubled prices.
- **Commodity super-cycle (2003–2008):** demand from China and India outran stagnant supply. Brent peaked near **$147 a barrel in July 2008** before the global financial crisis.
- Regional power crises (2005–2008): **China** faced coal, diesel and power shortages in late 2005 and early 2008, with severe damage to its power networks; **South Africa's** grid failure (2008) cut gold output and pushed up the price of platinum, in a crisis then expected to last to 2012; **Central Asia** suffered when cold weather and low reservoirs crippled hydropower.
  - **Pakistan's** President announced plans in February 2008 to tackle shortages that had reached crisis level, despite the country's own hydrocarbons.
  - A **British** energy crisis was forecast for the years after 2009, as coal stations closed, nuclear replacements lagged and North Sea output fell. Britain's last coal station, Ratcliffe-on-Soar, closed on 30 September 2024.
- **Global energy crisis (2021–2023):** post-pandemic recovery, low gas storage and the **Russia–Ukraine war (2022)** sent European gas prices to record highs. Brent rose to near **$130 a barrel** in March 2022, and Europe turned to imported LNG and rationing plans.
- **Iran war fuel crisis (2026):** the war that began on **28 February 2026** effectively closed the **Strait of Hormuz**, which normally carries about **one-fifth of world oil** and LNG trade.
  - The IEA called it the **largest supply disruption in the history of the oil market**. Brent peaked at about **$118 a barrel on 31 March 2026**, and IEA members agreed a record **400-million-barrel** emergency stock release.

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- Attacks on Qatar's **Ras Laffan** LNG complex cut gas supplies to Asia and Europe. A ceasefire on **8 April 2026** did not restore normal shipping, and renewed attacks pushed Brent back above **$110** by October 2026.

Lessons of the Oil Shocks

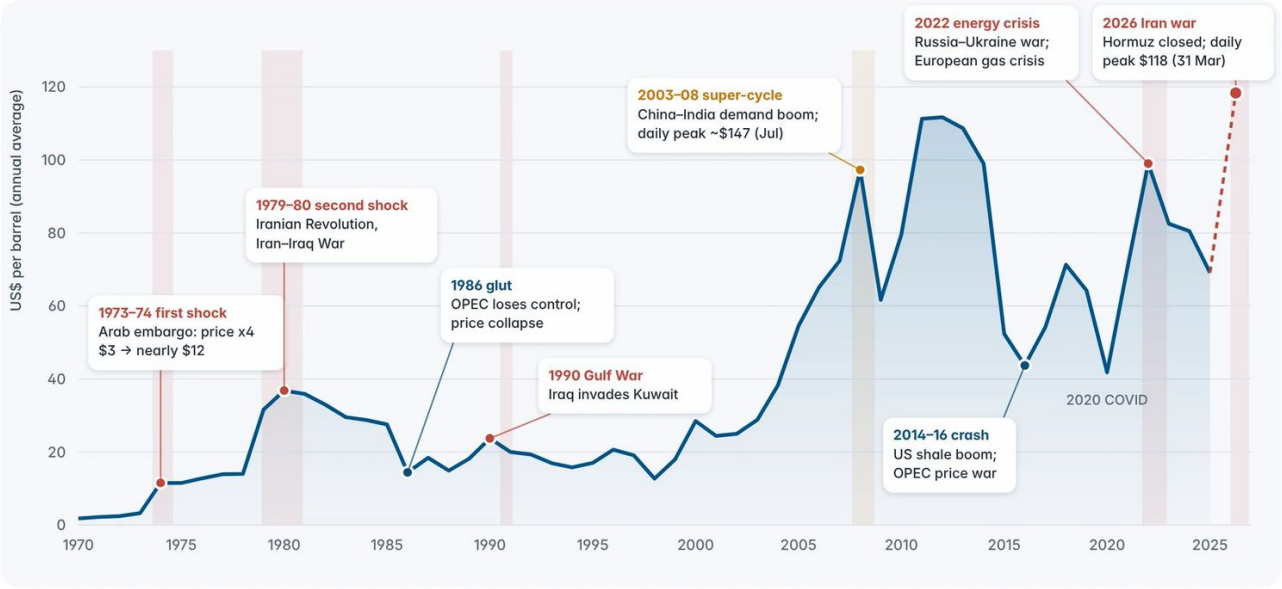
- **New institutions:** the **International Energy Agency (IEA)** was founded in **1974** by oil-importing OECD countries. It coordinates emergency stocks, and members must hold oil stocks equal to **90 days of net imports**.
- **New supply regions:** high prices made costlier fields worth developing. The North Sea, Alaska, Mexico and later deep-water Brazil and US shale reduced dependence on OPEC.
- **Nuclear expansion:** France's **Messmer Plan (1974)** built a large nuclear fleet that now supplies about two-thirds of its electricity. Japan also expanded nuclear power.
- **Efficiency and substitution:** fuel-economy standards, smaller cars and the switch from oil to coal, gas and nuclear in power plants cut the oil intensity of rich economies.
  - Sustained effort went into improving the internal combustion engine for better mileage.
- **Debt crisis in the developing world:** oil importers borrowed recycled **petrodollars** in the 1970s. When interest rates rose around 1980, many Latin American and African countries fell into the **debt crisis of the 1980s**.
- **India's response:** the shocks pushed the development of **Bombay High** (production from 1976), coal expansion and, later, the search for alternative energy.

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ECONOMIC GEOGRAPHY · ENERGY CRISIS

Oil Price Shocks, 1970–2026

Every major energy crisis appears as a spike in crude prices; most began with war or blockade in West Asia.



Supply shocks

- War, embargo or blockade in West Asia: 1973, 1979, 1990, 2026
- Russia–Ukraine war and gas cut-off: 2022

Demand shocks

- Asian industrial boom pushed prices up in 2003–08
- COVID-19 lockdowns crashed demand in 2020

Price crashes

- 1986 and 1998 gluts; 2014–16 shale and OPEC price war
- Low prices hurt exporters and stall investment

Annual averages in nominal US$ (Arabian Light to 1983, Brent from 1984); the 2026 point is a daily peak. Data: Energy Institute Statistical Review; World Bank.

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Causes of the Energy Crisis

PYQ 2026 · 2020 · 2018 +4

Depletion and Rising Demand

- **Finite fossil fuels:** oil, gas and coal are **exhaustible**. Older fields decline, and new reserves lie in deeper, costlier and more fragile settings such as deep sea, Arctic and oil sands. This is the basis of the **"peak oil"** concern.
- Population growth and urbanisation: more people and more cities mean higher demand for transport, housing, cooling and services. World population was long said to grow by about a quarter of a million people a day.
- **Industrialisation of emerging economies: China and India** account for most of the world's demand growth. Their manufacturing, infrastructure and rising consumption push up energy use per head.
- Rising living standards: vehicles, air-conditioners and digital devices raise per capita consumption. data centres and AI are a new and fast-growing source of electricity demand.
- **Uneven consumption:** a small part of humanity uses a large part of the resources. The United States used about 20.6 million barrels of oil liquids a day in 2025 against about 17.4 million for China, with a far smaller population (Energy Institute, 2026). The older comparison set about 300 million Americans against about 1.3 billion Chinese.

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Peak Oil or Peak Demand?

- **Peak oil: M. King Hubbert (1956)** predicted that US oil output would follow a bell-shaped curve and peak around 1970, which it did for conventional oil. The idea was extended to world output.
- **Why the fear faded:** new technology (horizontal drilling, hydraulic fracturing, deep-water drilling) added huge **unconventional** supplies. US shale turned the USA into the world's largest producer.
- **Peak demand:** the debate has shifted to when **demand** will peak. The IEA expects world oil demand to plateau at about **105–106 million barrels a day around 2030** as electric vehicles spread and China's demand slows. OPEC expects demand to keep rising.
- Either way, the crisis is less about the oil "running out" than about **where it is, who controls it and how safely it moves**.

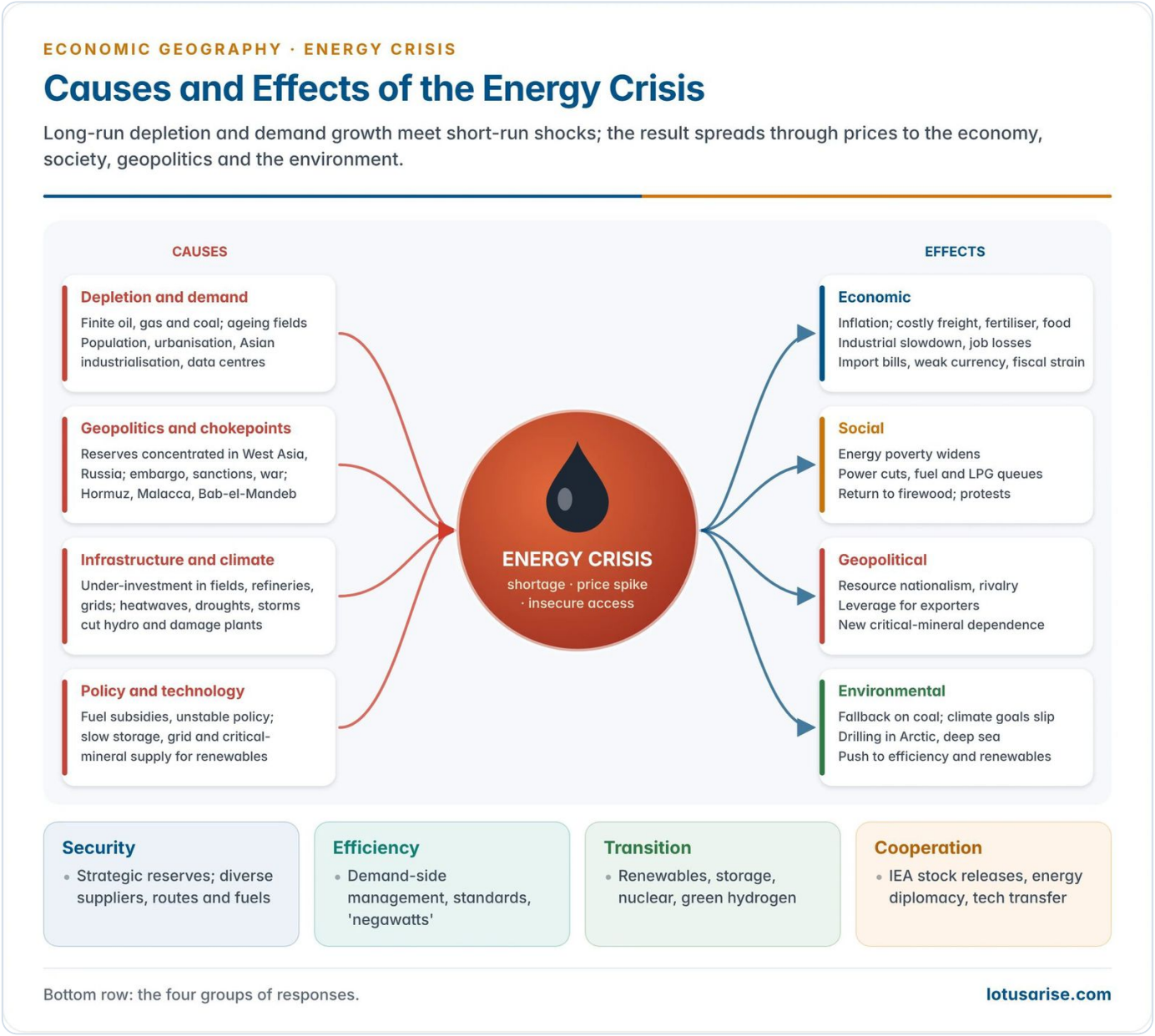
Geopolitical and Supply Disruptions

- **Concentration of reserves:** most proven oil and gas reserves lie in **West Asia, Russia and a few OPEC+ states**. Conflict, sanctions or regime change there disrupts world supply.
- **Embargoes and sanctions:** the 1973 embargo, sanctions on Iran and Venezuela, and the sanctions on Russia after 2022 restrict supply to particular markets.
- **Chokepoints:** a large share of seaborne energy passes a few narrow straits: **Hormuz, Malacca, Bab-el-Mandeb, Suez and the Turkish Straits**. Houthi attacks in the Red Sea (2023–24) and the 2026 Hormuz closure showed how fragile these routes are.
- Cartel behaviour: production quotas of **OPEC+** keep prices above competitive levels.

Infrastructure, Technology and Policy

- **Under-investment** in exploration, refining, transmission and storage creates bottlenecks. Ageing power plants and grids fail under stress.
- **Extreme weather and climate change:** heatwaves raise demand, droughts reduce hydropower and cooling water for thermal plants, and storms damage refineries and grids.
- **Slow transition:** renewables are growing fast, but **storage, grid integration and critical-mineral supply** lag behind. Fossil fuels therefore remain the backbone.
- Poor policies: heavy fuel subsidies discourage conservation, while frequent policy changes deter long-term investment.
- Accidents, strikes and attacks: pipeline failures, labour strikes, port and production bottlenecks, and attacks on infrastructure cause short but sharp disruptions. The drone strike on Saudi Arabia's Abqaiq plant on 14 September 2019 suspended 5.7 million barrels a day.
- **Limits of each alternative:** hydroelectricity is capital-intensive and environmentally sensitive, nuclear energy is costly and potentially hazardous, and overuse of wood and animal waste degrades the land.

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Impacts of the Energy Crisis

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Economic Impacts

- **Inflation:** energy enters every production chain, so higher fuel prices raise the cost of **manufacturing, freight, fertiliser and food**.
- Slower growth and job losses: energy-intensive industries such as steel, aluminium, cement, chemicals and ceramics cut output or shut down.
- **Trade imbalances:** importers face larger bills, weaker currencies and wider current-account deficits. Wealth shifts from consumers to exporters (**petrodollar** flows).
- **Agriculture and food security:** dearer diesel, irrigation power and fertiliser raise food prices. Diversion of crops to biofuels adds pressure.
- Fiscal strain: governments spend more on subsidies and relief, as in the excise cuts on fuel in many countries during 2022 and 2026.
- Investment shifts: each crisis also spurs investment in **efficiency, domestic production and renewables**.

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Social Impacts

- **Energy poverty widens:** low-income households spend a larger share of income on fuel and power.
- Disruption of daily life: load-shedding, fuel queues and cooking-gas shortages affect health, schooling and livelihoods.
- Unrest: fuel-price protests and riots have followed price hikes in many countries, from the 1970s to recent years.

Geopolitical Impacts

- **Resource nationalism** and competition for supplies, long-term contracts and overseas assets.
- **Shifts in power:** exporters gain leverage, while the **US shale revolution** turned the USA into a net petroleum exporter and changed trade flows.
- **New dependencies:** clean-energy supply chains depend on **critical minerals** (lithium, cobalt, nickel, rare earths) whose mining and refining are concentrated, especially in **China**.

Environmental Impacts

- During shortages, countries **fall back on coal**, as Europe did in 2022 and Asian importers did in 2026, slowing climate action.
- Pressure to secure supply pushes extraction into **ecologically sensitive areas** such as the Arctic, the deep sea and tropical forests.

Energy, Development and the Energy Ladder PYQ 2018

- Energy use rises with income. A US resident uses roughly **ten times** as much commercial energy as an Indian, and the gap with the poorest African countries is larger still.
  - **Traditional or non-commercial energy** means firewood, charcoal, dung, farm waste and animal power. **Commercial energy** means coal, oil, gas, hydroelectricity, nuclear, wind and solar power.
  - **Conventional** sources are coal, petroleum, natural gas and electricity. **Non-conventional** sources are solar, wind, tidal, geothermal and biogas.
- Poor households move up an **energy ladder** as income rises: from **firewood, dung and crop residue** to **kerosene and LPG**, and then to **electricity and piped gas**.
  - A crisis pushes households back down the ladder. In 2022 and 2026, high LPG prices led many poor families in South Asia to return to firewood, with harm to health from indoor smoke.
- The crisis is therefore also a **development problem**. Without reliable and affordable energy, industrialisation, irrigation, health services and education all stall.
- The **water–energy–food nexus** links the three: power is needed to pump irrigation water and make fertiliser, while thermal plants and hydropower need water. A shock in one spreads to the others.

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02 Regional Variation in the Intensity of the Energy Crisis

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- The crisis is **global in origin but regional in impact**. Its intensity in a region depends on four things:
  - **resource endowment**;
  - **import dependence**;
  - **level of development and income**;
  - **diversity of the energy mix**.

REGION TYPE	EXAMPLES	NATURE OF CRISIS	INTENSITY
Major exporters	Saudi Arabia, UAE, Qatar, Russia, Norway	Revenue windfall in price spikes; exposed to price crashes and transit attacks	Low for supply, high for revenue volatility
Self-sufficient diversified producers	USA, Canada, Brazil	Price pass-through, but domestic supply cushions shocks	Low to moderate
Rich importers	EU, Japan, South Korea	High import bills, gas dependence, industrial slowdown; can pay and store	Moderate to high
Emerging importers	China, India	Huge demand growth, oil and gas import dependence, coal reliance	High
Poor importers	Pakistan, Bangladesh, Sri Lanka, East African states	Cannot afford spot cargoes; load-shedding, fuel queues, debt crises	Very high
Energy-poor regions	Sub-Saharan Africa	Lack of access itself is the crisis	Chronic

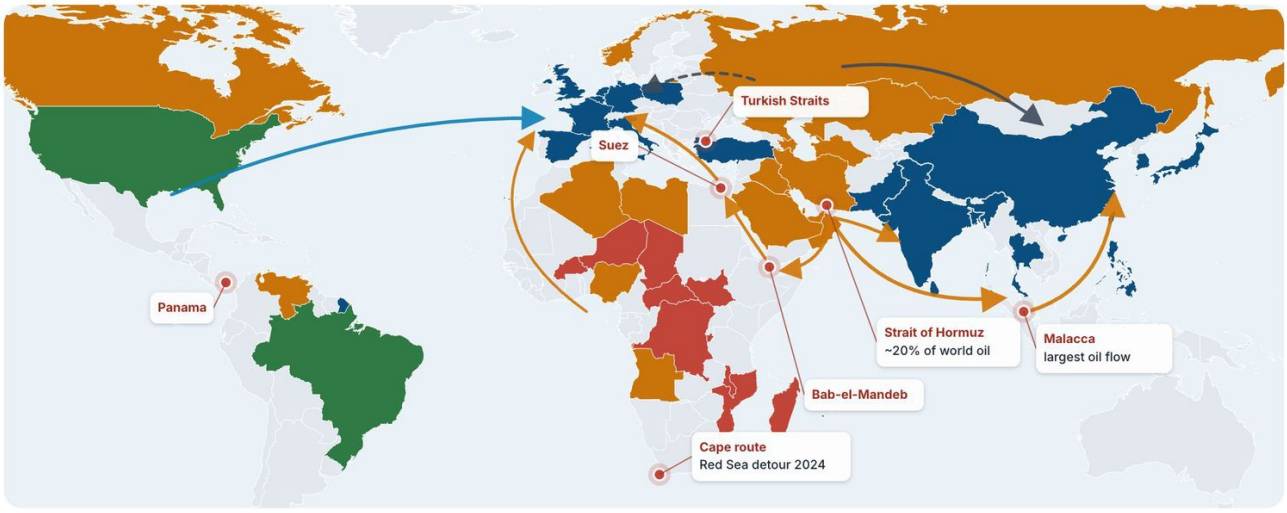
- **West Asia:** holds about half of proven oil reserves. Its conflicts set the world price, yet it gains from high prices unless its own export routes are blocked, as in 2026.
- **Europe:** its dependence on Russian pipeline gas before 2022 made it the epicentre of the 2022 crisis. It then diversified to LNG, renewables and efficiency.
- **East and South Asia:** Japan, Korea, China and India import most of their oil and much of their gas through **Hormuz and Malacca**, so they were the most exposed in 2026. **Pakistan, Bangladesh and Sri Lanka** suffered acute shortages and blackouts.
- **Sub-Saharan Africa: Nigeria and Angola** export oil, yet the region has the world's lowest electricity access. Its crisis is one of **access and investment**, not only of supply.
- **North America:** shale oil and gas made the USA the largest producer of both. Its crisis is one of **prices**, not shortages.

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ECONOMIC GEOGRAPHY · REGIONAL VARIATION

Why the Energy Crisis Hits Regions Differently

Energy is produced in a few regions, consumed in others and moved through a handful of narrow straits; import dependence and income decide how hard a shock lands.



Exporters

- West Asia, Russia, Norway, Canada, Nigeria, Angola, Venezuela
- Gain from high prices; hit when their own routes close (2026)

Importers

- Europe in 2022; Japan, Korea, China, India in 2026
- Poorer importers (Pakistan, Bangladesh, Sri Lanka) face blackouts

Access-poor

- Sub-Saharan Africa: crisis of access and investment
- Most of the 666 million people without electricity

Classes are indicative. Flows: orange = oil/LNG by sea, blue = US LNG, grey = Russian pipelines (dashed = cut after 2022). Boundaries: Survey of India outline (datameet).

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03 India's Energy Crisis

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- India is the world's **third-largest energy consumer** and **third-largest oil consumer**, but its per capita energy use is well below the world average.
- **Import dependence:**
  - **88.7% of crude oil** was imported in 2025-26 (245.3 million tonnes), up from older figures of 86–88%;
  - **49.9% of natural gas** was imported in 2025-26, as LNG;
  - about **60% of LPG** is imported, and about 90% of that came through Hormuz before the war.
  - The oil bill's share of total imports rose from under 9% in the 1960s to about 30% after the first oil shock.
- **Coal dependence:** coal supports **over 70% of electricity** and meets about 55% of primary energy (2026), and thermal stations as a whole gave 77.01% of generation in 2024-25. Domestic coal is **high-ash and low in calorific value**, so coking coal for steel is imported.
  - Coal stock shortages at power plants in **October 2021 and April–May 2022** caused power cuts in several states.

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- **Rising peak demand:** the record of about 250 GW in May 2024, driven by heatwaves and cooling, was passed on 25 April 2026 at 256 GW and again on **21 May 2026 at 270.82 GW**.
  - Coal carried 171.7 GW at that peak, and renewable sources with hydro about 34%.
  - Shortage came after sunset: 0.18 GW in solar hours against **2.57 GW in non-solar hours**, with seven states short.
- 2026 shock:
  - **LPG** was the first fuel to run short, with long queues, restaurant closures and the shutdown of Gujarat's **Morbi ceramic cluster**.
  - The government cut excise duty on petrol and diesel by **₹10 a litre**.
  - Piped natural gas from domestic sources held up better.
  - About **70% of crude imports came from outside Hormuz** by March 2026, on the Petroleum Ministry's count. Refiners turned to Russia, Africa and Latin America, and Indian warships escorted tankers east of the strait under **Operation Urja Suraksha**.
- **Strategic reserves:** underground **Strategic Petroleum Reserves** at **Visakhapatnam, Mangaluru and Padur (Udupi district, Karnataka)** hold **5.33 million tonnes**, about **9–10 days of net imports**. With company stocks, total cover is about 74 days, against the IEA norm of 90. Phase II at **Chandikhol and Padur** will add **6.5 million tonnes**.
  - Phase II has a concession signed for Padur on 1 October 2025, and a parliamentary committee report of August 2026 records Bina and Bikaner as sites under consideration. India has been an IEA associate member since 2017, and the 90-day rule binds only full members.
- Distribution problems: losses of state power distribution companies, theft and poor finances weaken supply even where generation exists.
- Responses:
  - non-fossil capacity crossed **50% of installed capacity in June 2025**, five years ahead of the 2030 target, and reached **300.50 GW, over 54% of about 552 GW, on 31 July 2026**. Total capacity was about 558.9 GW in September 2026;
  - the **pledge for 2031–35**, submitted on 24 April 2026, is a 47% cut in emissions intensity and 60% non-fossil capacity by 2035;
  - ethanol blending reached **E20 in 2025**;
  - more piped gas, LNG terminals and diversified crude sources (Russia, the USA, Guyana, Brazil);
  - the **solar energy** push and the National Green Hydrogen Mission.

The Long-Run Shortage

- **The classic picture:** demand has outrun supply because of population, industry, cities and transport.
  - It showed in **repeated outages, announced and unannounced cuts, and unstable voltage**, and in plants running below capacity for want of coal and gas.
  - **Peak shortage** ran at about 11–12.5% between 2001 and 2006.
  - The **Twelfth Plan** projected domestic energy output of 669.6 million tonnes of oil equivalent by 2016-17 and 844 million by 2021-22, only about 71% and 69% of need.

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- **Consumption per head stays low:** about 998 kWh in an older count, against 1,378 kWh in China, 1,934 in Brazil, 6,231 in Britain, 7,816 in Japan and 13,066 in the United States.
  - It reached about **1,400 kWh in 2023-24** (Central Electricity Authority), so demand will keep climbing with living standards.
- **The gap has changed shape:** the Ministry of Power reports zero annual energy shortage for 2025-26, against 4.2% in 2013-14. The International Energy Agency reports that short-term shortages more than doubled in January–May 2026 over the same months of 2025.
  - The two claims measure different things. Annual energy is now met, while **evening peaks** remain short, because solar output falls just as demand holds up.

Where the Crisis Falls Within India

- **Resources and demand lie apart.** **Coal** is concentrated in Jharkhand, Odisha, Chhattisgarh and West Bengal; **hydroelectric power** on Himalayan rivers and Western Ghats streams; and **wind** and solar in the west and south.
  - Demand peaks elsewhere: on 21 May 2026 **Maharashtra (31.5 GW), Uttar Pradesh (29 GW) and Gujarat (25.9 GW)** drew the most.
- **Oil and gas enter by the coast.** Imported **petroleum** moves inland through lines such as Salaya-Mathura and Mundra-Panipat from Gujarat and Paradip-Haldia-Barauni in the east, and **natural gas** through coastal LNG terminals. A Hormuz closure therefore struck quickly at Gujarat's Morbi ceramics.
- **Households feel it unequally.** Rural and poor households depend most on firewood, dung and subsidised LPG, and they fall back fastest when prices rise.

Can Efficiency Alone Resolve It?

- **What efficiency can do:** the conservation drive, led by the **Petroleum Conservation Research Association** and the Bureau of Energy Efficiency, cuts bills, frees supply, reduces import needs and lowers emissions.
- **What it cannot do alone:**
  - It does not replace imported crude for transport or imported LPG for kitchens, the two fuels that failed first in 2026.
  - Demand per head is low and will rise, so savings are soon overtaken.
  - It does not store solar power for the evening peak.
- **The balance:** the country needs **more domestic production as well as conservation**, along with storage, transmission, reserves and diversified suppliers.

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04 Measures to Overcome the Energy Crisis

PYQ 2026 · 2020 · 2018 +4

Energy Security Measures

- **Strategic reserves:** stockpiles of crude and products buffer short shocks, for example the US Strategic Petroleum Reserve, Japan's large reserves and India's SPRs. Their weakness is **high cost and locked-up capital**.
  - **Energy security** means continuous energy for the economy at prices comparable with those other countries pay.
  - Storage needs huge facilities and blocks capital for long periods. If companies hold the stocks they pass the cost on to consumers, and if the state does, it must tax or borrow more.
  - China writes specific energy targets into its five-year plans.
- **Diversification:**
  - of **fuels**: gas, nuclear, renewables, biofuels;
  - of **suppliers and routes**: new pipelines, LNG terminals, bypass routes;
  - of **transport modes**: LNG shipping instead of fixed pipelines.
  - Disruption cannot hit every fuel and every supplier at once, which is the logic behind diversifying. Sweden's commission of 2005–06, under Göran Persson, set 2020 targets to cut oil use sharply, without ending it.
- **Long-term contracts and energy diplomacy:** equity oil abroad (ONGC Videsh), partnerships with producers, and bodies such as the **IEA**, the **International Solar Alliance** and the **Global Biofuels Alliance**.

Demand-Side Management and Efficiency

- **Energy efficiency is the "first fuel".** Japan's efficiency drive after the 1970s shocks cut the oil intensity of its economy sharply.
  - Dearer energy itself played a large part in Japan's gains.
- **"Negawatts":** power saved through efficiency is treated as a resource that frees supply.
- Tools: appliance standards (India's **BEE star labelling**, **PAT** scheme for industry, **UJALA** LED programme), smart meters, time-of-day tariffs, public transport and efficient buildings.

Diversification of Energy Sources

- **Renewables:** solar, wind, hydro, geothermal and biomass reduce import dependence. Their growth needs storage, grids and stable policy.
- **Nuclear power:** provides stable, low-carbon base load, despite concerns over safety, waste and cost. Small modular reactors are the new frontier.
- **Green hydrogen and biofuels:** serve hard-to-electrify sectors such as steel, fertiliser, shipping and aviation.
- **Cleaner use of coal:** supercritical plants, coal gasification and **CCUS**, which remain costly and limited.

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- **Other older steps:** discourage oil-intensive activities, replace oil with alcohol fuels from sugarcane and other crops, liquefy coal for cheaper long-distance transport, and develop safer and cheaper nuclear, wave, tidal and geothermal technology.
- The long-run path out of recurrent crises is the **energy transition** to a diversified, low-carbon mix.

Technology, Infrastructure and Policy

- **Storage** (batteries, pumped hydro), **smart grids** and inter-regional transmission let more renewables be absorbed.
- **Carbon pricing**, removal of fossil subsidies and long-term planning give investors stable signals.
- Safety and maintenance of mines, pipelines and grids, including steps against **fires and roof collapses in coal mines**, reduce accident-driven shortages.
- Better design of urban infrastructure in developing countries lowers long-run demand.
- Funding and technology transfer from developed to developing countries help close the access gap.

Sustainable Consumption

- Each crisis has strengthened **green energy and sustainable living** movements.
- Ecologist **David Pimentel** of Cornell University argued that cheap oil allowed human numbers to overshoot the Earth's carrying capacity. Such views echo the **Limits to Growth** debate on population, resources and development.
- The balanced view is that **efficiency, diversification and lower-carbon lifestyles**, not population control alone, can make energy supply secure and sustainable.

Previous Year Questions

2026	Efficient use of energy resources can resolve the energy crisis in India. Comment.
2020	Identify the causes and effects of energy crisis, and suggest suitable measures to solve the problem.
2018	Keeping the recent developments in view, how can the energy crisis of India be circumvented by harnessing non-conventional energy resources?
2017	"The intensity of energy crisis varies regionally." Explain.
2008	Suggest appropriate energy policy for minimising energy crisis in India.

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1991	Write short note: World energy crisis.
1988	Discuss the various sources of energy and their uses. Suggest the measures to overcome the present-day energy crisis.

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UNIT 05 | 3 CHAPTERS

Biotic and Marine Resources

Biotic and marine resources; forest and wildlife conservation.



CHAPTERS

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GEOGRAPHY OPTIONAL | PAPER II · RESOURCES

Marine Resources: Biotic, Mineral and Energy Resources



PYQ RADAR **16** questions Last asked **2025**
2025 ×3 · 2023 ×2 · 2020 · 2018 · 2016 · 2013 · 2011 ×2 · 2009 · 1997 · 1995 · 1993 · 1986

CONTENTS

01 Classification and Productivity
02 Biotic Resources
03 Abiotic Resources
04 Blue Economy and Sustainable Use
05 Previous Year Questions

- **Marine resources** are all the **living and non-living materials, and the energy**, that people can draw from sea water, the sea floor and the rocks beneath it. They range from fish and seaweed to salt, sand, oil, metal-rich nodules, tides and waves.
- The ocean covers about **71% of the Earth's surface** and holds most of its living space, yet it supplies a far smaller share of human needs than the land. Most of the ocean is a **biological desert**, and its richest minerals lie under thousands of metres of water.
- It also **regulates climate**, takes up carbon and releases oxygen, and its resources give **jobs, goods and services to billions of people**.
- Marine resources differ from land resources in three ways:
  - **Common property:** beyond national limits they belong to no one, so they are easily overused.
  - **Mobility:** fish, larvae and pollutants cross every boundary drawn on a chart.
  - **Frontier character:** fisheries are already pressed to their limits, while deep-sea minerals and most marine energy are barely tapped.
- Their use is governed by the maritime zones of **UNCLOS**: coastal states hold sovereign rights over resources within the **Exclusive Economic Zone (EEZ)** and the legal continental shelf; the deep sea-bed beyond them is the **"Area"**, the common heritage of mankind.

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01 Classification and Productivity

Bases of classification

BASIS	CLASSES	EXAMPLES
Nature	Biotic (living); abiotic (non-living)	Fish, seaweed; salt, nodules, oil
Renewability	Renewable; non-renewable	Fish, tides, waves; oil, placers, nodules
Use	Food; minerals; energy; water; services	Fisheries; manganese; OTEC; desalinated water; shipping, tourism
Location	Shelf; slope; deep-sea floor; water column	Placers and oil; gas hydrates; nodules; dissolved salts

- **Ocean services** are a resource class of their own: **shipping** carries over 80% of world trade by volume, and the ocean absorbs about a quarter of human carbon dioxide emissions and over 90% of excess heat.

Where marine life is concentrated

- **Marine life zones** are set by light and depth:
  - The **pelagic realm** (open water) is divided into the sunlit **photic (euphotic) zone**, down to about 200 m, and the dark **aphotic zone** below it (mesopelagic, bathypelagic, abyssopelagic).
  - The **benthic realm** (sea floor) runs from the **littoral** (between tide marks) and **sub-littoral** (the shelf floor) to the deep-sea floor.
  - Over the shelf the water is the **neritic** zone; beyond it is the **oceanic** zone.
- **Primary production** happens only in the photic zone, through **phytoplankton**, the "marine pasture".
  - Its supply of **nitrates and phosphates** is the limiting factor. Nutrients sink with dead matter, so the surface stays rich only where water is **mixed or upwelled**.
- **Productivity varies sharply.** Net primary productivity (Robert Whittaker and Gene Likens, 1975) is about:
  - **125 g/m²/yr** in the open ocean;
  - about 360 g/m²/yr over the **continental shelf**;
  - about 500 g/m²/yr in **upwelling zones**;
  - 1,500–2,500 g/m²/yr in **estuaries, algal beds and reefs**, which rival tropical forests.
- **John Ryther (1969)** showed what this means for fish: the **open ocean (about 90% of the area) yields almost nothing**, while coastal waters and **upwelling zones covering only about 0.1% of the ocean** each yield about half of the world's fish.

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02 Biotic Resources PYQ 1997

Plankton, nekton and benthos

COMMUNITY	WAY OF LIFE	MEMBERS	RESOURCE VALUE
Plankton	Drift with currents	Phytoplankton (diatoms, dinoflagellates, algae); zooplankton (copepods, krill, larvae)	Base of every food web; krill fishery; harmful algal blooms (red tides)
Nekton	Swim independently	Fish, squid, turtles, whales, dolphins, seals	Bulk of the fish catch; marine mammals
Benthos	Live on or in the floor	Seaweeds, seagrass, oysters, mussels, crabs, sponges, corals	Shellfish, seaweed, pearls, drugs, reef fisheries

- **Benthos** may be **epifauna** (on the floor) or **infauna** (buried in sediment), and fixed or mobile. Deep benthos lives on food sinking from above.
- **Phytoplankton** are **autotrophs**: floating micro-plants such as algae and diatoms that make their own food. **Zooplankton** are the floating micro-animals that graze on them.
- Biotic resources span **fish, crustaceans, molluscs, corals, reptiles such as sea turtles, and mammals**. Benthic communities run from tidal pools on the foreshore across the shelf to the abyssal depths.
- **Coral reefs** are the "rainforests of the sea". They nurse reef fisheries, protect coasts and draw tourists.

Fisheries

Kinds of fish and fisheries

- **Pelagic fish** live in the upper water, often in huge single-species **shoals**: herring, sardine, anchovy, mackerel, tuna.
- **Demersal fish** live on or near the bottom of the shelf, mostly within 200 m: cod, haddock, hake, halibut, flounder, pollock.
- **Anadromous fish** grow at sea and spawn in rivers: salmon, hilsa.
- By family, the herring-like **clupeoids** (herring, sardine, anchovy) form the largest share of the world catch, followed by the cod-like **gadoids**.
- **Fin fish** make up about nine-tenths of the catch; the rest is **crustaceans** (shrimp, lobster, crab), **molluscs** (squid, oysters) and other invertebrates.

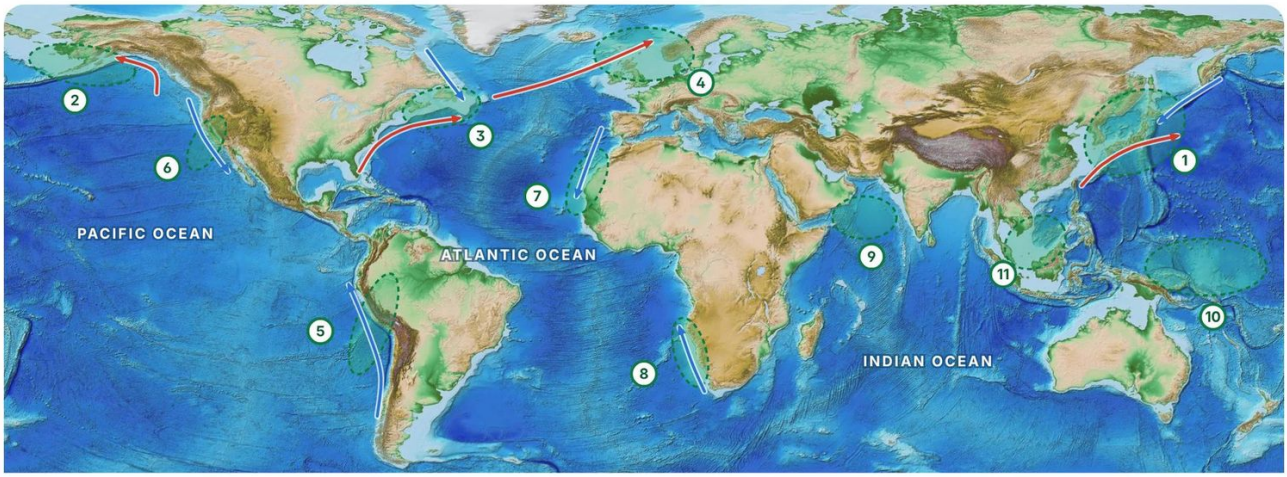
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Major fishing grounds of the world

OCEANOGRAPHY · MARINE RESOURCES

Major Fishing Grounds of the World

Where the world's fish catch is concentrated, and the shelves, current meetings and upwelling that make each ground productive.



1	North-west Pacific	Kuroshio meets Oyashio; broad shelves	
2	North-east Pacific	Bering shelf; salmon rivers; upwelling	
3	North-west Atlantic	Grand Banks: Labrador meets Gulf Stream	
4	North-east Atlantic	North Sea banks; North Atlantic Drift	
5	Peru–Chile	Humboldt upwelling: anchoveta	
6	California	Upwelling: sardine, anchovy	
7	North-west Africa	Canary upwelling	
8	Namibia–South Africa	Benguela upwelling: pilchard	
9	Arabian Sea	Monsoon upwelling, Somalia to SW India	
10	Tropical W. Pacific	Warm-pool tuna, the largest tuna catch	
11	South-East Asia	Sunda Shelf: shallow, warm, many species	

Fishing ground · Warm current · Cold current

Shelves and banks

- Light reaches the floor; fish spawn and feed
- Grand Banks, Dogger Bank, Bering and Sunda shelves
- Most demersal fish come from shelf waters

Meeting of currents

- Warm and cold water mix and lift nutrients
- Kuroshio–Oyashio off Japan
- Gulf Stream–Labrador off Newfoundland

Upwelling coasts

- Trade winds push surface water offshore
- Cold, nutrient-rich water rises on western coasts of continents
- About 0.1% of the ocean, about half of the fish

Generalised; grounds and currents simplified. Relief: NOAA ETOPO1.

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FISHING GROUND	LOCATION	WHY IT IS PRODUCTIVE	MAIN CATCH
North-west Pacific	Japan, Korea, China, Russian Far East	Kuroshio and Oyashio meet; broad Yellow and East China Sea shelves; indented coasts	Pollock, sardine, mackerel, squid, salmon
North-east Atlantic	North Sea, Norway, Iceland	Wide shelf and banks (**Dogger Bank**); North Atlantic Drift keeps ports ice-free	Herring, cod, mackerel, haddock

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FISHING GROUND	LOCATION	WHY IT IS PRODUCTIVE	MAIN CATCH
North-west Atlantic	**Grand Banks**, Georges Bank	Shallow banks where the cold **Labrador Current** meets the warm Gulf Stream	Cod, haddock, herring, scallops
North-east Pacific	Bering Sea to British Columbia	Broad Bering shelf; upwelling; salmon rivers	Pollock, salmon, halibut, crab
Upwelling coasts	Peru–Chile, Benguela, Canary, California	Trade winds drive surface water offshore; cold, nutrient-rich water wells up	Anchoveta, pilchard, sardine

- The **North-west Pacific** is the most productive fishing area in the world, and **China** is by far the largest producer.
- **Peru's anchoveta** fishery is usually the largest single-species fishery on Earth, but it swings with **El Niño**: warm water caps the upwelling, plankton fails and the catch crashes, as in 1972–73 and 1982–83.

Why some seas are rich: the controls

- **Physical controls:**
  - **Broad, shallow continental shelves and banks**, where light reaches the bottom and fish spawn.
  - **Mixing of warm and cold currents**, which overturns the water and lifts nutrients.
  - **Upwelling** along the western coasts of continents, driven by offshore Ekman transport.
  - **Cool temperate water**, which holds more dissolved oxygen and carbon dioxide and supports dense plankton.
- **Human controls:**
  - **Indented coasts** with sheltered harbours, and forested hinterlands that once supplied boat timber.
  - **Scarce farmland** that pushes people to the sea, as in Norway and Japan.
  - **Large markets, capital, cold storage and canning**, and modern fleets with sonar and satellite fish-finding.

Why tropical fisheries lag

- **Warm, stratified water:** a strong thermocline traps nutrients below the photic zone, so plankton stays thin except where upwelling breaks it.
- **Many species, few shoals:** tropical seas hold great diversity but few dense single-species shoals, which makes bulk catching and processing harder.
- **Narrow shelves and reef or mangrove coasts** in many places hinder trawling.
- **Fish spoil quickly in heat**, and cold chains, harbours and processing capacity are limited.
- **Small-scale, labour-intensive fleets** with little capital, and weak local demand for some species.
- **Exceptions:** monsoon upwelling in the **Arabian Sea** (Somali and Oman coasts, India's south-west coast) and the **western and central Pacific tuna grounds**, which now produce the largest tuna catch in the world.

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World fish production today

- In the most recent global assessment (June 2026, for 2024), world fisheries and aquaculture reached a **record 235 million tonnes**, including algae.
  - **Aquatic animals:** 195 million tonnes, of which **aquaculture supplied 103 million tonnes (53%)**. This is the first time farming has passed 100 million tonnes.
  - **Capture fisheries:** about 92 million tonnes, of which about 80 million tonnes was marine. The marine catch has hovered near this level since the late 1980s.
    - The round figure of about **200 billion pounds a year**, long quoted for the catch of fish and shellfish, is the same order: roughly 91 million tonnes.
  - **Food supply:** about 21 kg of aquatic food per person a year.
  - **Food value:** fish give protein and vitamins A, B and D. Inedible fish feed livestock, and scales and fishery waste serve as organic manure.
- **Stock health is slipping:** in 2023 only about **62% of marine fish stocks were fished within biologically sustainable levels**, down from about 64.5% in 2021.
- **Grand Banks cod** is the warning case. Decades of overfishing led Canada to close the fishery in **1992**, and the stock has still not fully recovered.

Aquaculture and mariculture

- **Aquaculture** is the farming of aquatic organisms with control over their breeding, feeding and protection. **Mariculture** is aquaculture in sea or brackish water.
  - **Molluscs** (oysters, mussels, scallops) are the easiest to farm. They feed on natural plankton and are grown on ropes, racks or sea-bed plots. Japan's suspended-rope oyster culture is the model.
  - **Shrimp** are farmed in coastal ponds in India, Thailand, Vietnam and Ecuador.
  - **Cage fish** such as Atlantic salmon (Norway, Chile) and sea bass need large inputs of feed.
  - **Brackish-water polyculture** of milkfish and mullet is centuries old in Indonesia and the Philippines.
  - **India:** coastal aquaculture divides into **sea farming** in open bays and **brackish-water farming** on land, using salt water from creeks and estuaries.
    - Impounded wetlands called **bheries** in West Bengal and salt-tolerant paddy fields called **pokkali** in Keralam (Kerala) are old brackish systems.
    - **Shrimp farming** has grown in Andhra Pradesh, above all Nellore district, and in Odisha and Tamil Nadu, helped by hatcheries and the Marine Products Export Development Authority.
    - **Mariculture** began with milkfish trials at the Mandapam centre of the Central Marine Fisheries Research Institute in 1958-59, and later took in oysters, mussels and clams.
    - **Integrated multi-trophic aquaculture** recycles the waste of fed fish or shrimp through seaweed and shellfish, to balance the system.
- **Problems:** shrimp ponds have **cleared mangroves**; farms release wastes, antibiotics and disease; escaped fish dilute wild stocks; and carnivorous fish are fed on wild-caught fishmeal.

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Ocean ranching and aqua-cowboys PYQ 2023

- **Ocean ranching** (sea ranching, ocean husbandry) controls marine animals at only some stages of their life and leaves the rest to the open sea, as a rancher leaves cattle on open range.
  - **Fisheries sense (now dominant):** juveniles bred in hatcheries are marked and released, grow on natural food and are caught when they return.
    - **Pacific salmon** suit this best, because they **home to their natal stream**. Hatcheries in Japan, the USA (Alaska), Russia, Canada and Korea release about **5 billion juveniles a year** into the North Pacific.
    - China and Japan add **artificial reefs and seagrass beds** to create "marine ranches".
    - India's Central Marine Fisheries Research Institute is releasing hatchery-raised **green tiger shrimp** in Palk Bay and the Gulf of Mannar to rebuild depleted stocks.
  - **Older, wider sense:** the **taming and training of sea mammals** (porpoises, dolphins, small whales) to work in the sea.
- **Aqua-cowboys** link the two senses.
  - In the original usage they are **porpoises and dolphins trained to herd fish** and to help divers, carry tools to underwater stations and assist in rescue. In 1965 the US Navy dolphin Tuffy carried tools to the Sealab II habitat.
  - Wild dolphins at **Laguna in southern Brazil** drive mullet towards cast-net fishers, a natural version of the same partnership.
  - The label now also covers the **people and the sound signals** that release, track and round up ranched stock. In Japan, released red sea bream are conditioned to gather at an underwater sound.
- **Concerns:** hatchery fish compete with wild fish for food (hatchery-origin fish form a large share of North Pacific salmon biomass), weaken wild genetic stock, spread disease and return at uncertain rates.

SYSTEM	CONFINEMENT	FEEDING	EXAMPLE
Capture fishery	None	Natural	Trawling, purse-seining
Ocean ranching	Hatchery stage only	Natural during growth	Salmon ranching, shrimp stock release
Mariculture	Whole life	Natural (molluscs) or artificial	Oyster ropes, salmon cages

Whales and other marine mammals

- **Whales** are of two groups: **toothed whales** (sperm whale, killer whale, dolphins, porpoises) and **baleen whales** (blue, fin, humpback, grey, minke), which filter krill.
- **Industrial whaling** with steam catchers, explosive harpoons and factory ships drove the great whales towards extinction in the 20th century.
  - The **International Whaling Commission (IWC)**, set up under the 1946 whaling convention, at first fixed catch quotas in **blue whale units**, a system abandoned in 1972.

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  - The **commercial whaling moratorium** took effect in **1986**. Norway and Iceland whale under objection, and Japan left the IWC in 2019 to resume commercial whaling in its own waters.
- Seals, sea otters and sea cows (dugongs, manatees) were also hunted heavily. The **dugong** of the Gulf of Mannar and Palk Bay is now protected in India.

Seaweeds, drugs and marine biotechnology

- **Seaweeds** are the largest farmed marine crop by volume, grown mostly in China, Indonesia, Korea and Japan.
  - They are eaten as food (nori, kombu) and yield **agar, alginates and carrageenan** for food, medicine and industry. They are also used as fertiliser and feed, and studied as biofuel.
  - India farms the red seaweed *Kappaphycus* along the Tamil Nadu coast, and a multipurpose seaweed park is being developed in Ramanathapuram district.
  - Seaweeds need light, so most grow in **shallow water around shores and reefs**, above about 15 m. They fall into **brown, green and red** groups, and are rich in vitamins, minerals and trace elements.
- **Marine biotechnology** turns sea organisms into drugs and industrial products:
  - **cytarabine**, an anti-leukaemia drug, was modelled on compounds from a Caribbean sponge;
  - **ziconotide**, a painkiller, comes from cone-snail venom;
  - **trabectedin**, an anti-cancer drug, comes from a sea squirt;
  - **horseshoe-crab blood** is used to test vaccines and injectable drugs for bacterial toxins;
  - **cod-liver and shark-liver oils** have long been sold as vitamin sources.
- **Other products** are pearls, sponges, ornamental fish, shells, chitin from crustacean waste, and fishmeal and fish oil for feed.

03 Abiotic Resources

Minerals dissolved in sea water and fresh water

- **Every natural element** occurs dissolved in sea water, at an average salinity of about 35 g per kilogram. Only a few are worth extracting:
  - **Common salt (sodium chloride):** about one-third of the world's salt comes from sea water by solar evaporation. In India, **Gujarat** produces most of it, followed by Tamil Nadu and Rajasthan.
  - **Magnesium and bromine** are extracted commercially from sea water and brines.
  - **Gold, zinc, uranium, thorium and lithium** are present in vast total amounts but at such low concentrations that recovery is uneconomic.
- **Fresh water by desalination** (reverse osmosis, multi-stage flash distillation) is now a major resource in arid coastal states, above all in the Persian Gulf countries.
  - In India, Chennai's plants at **Minjur and Nemmeli** supply city water.
  - **Low-temperature thermal desalination (LTTD)** plants in Lakshadweep (Kavaratti since 2005, then Agatti and Minicoy, and now eight islands) flash-evaporate warm surface water under low pressure and condense it with cold water pumped up from depth.

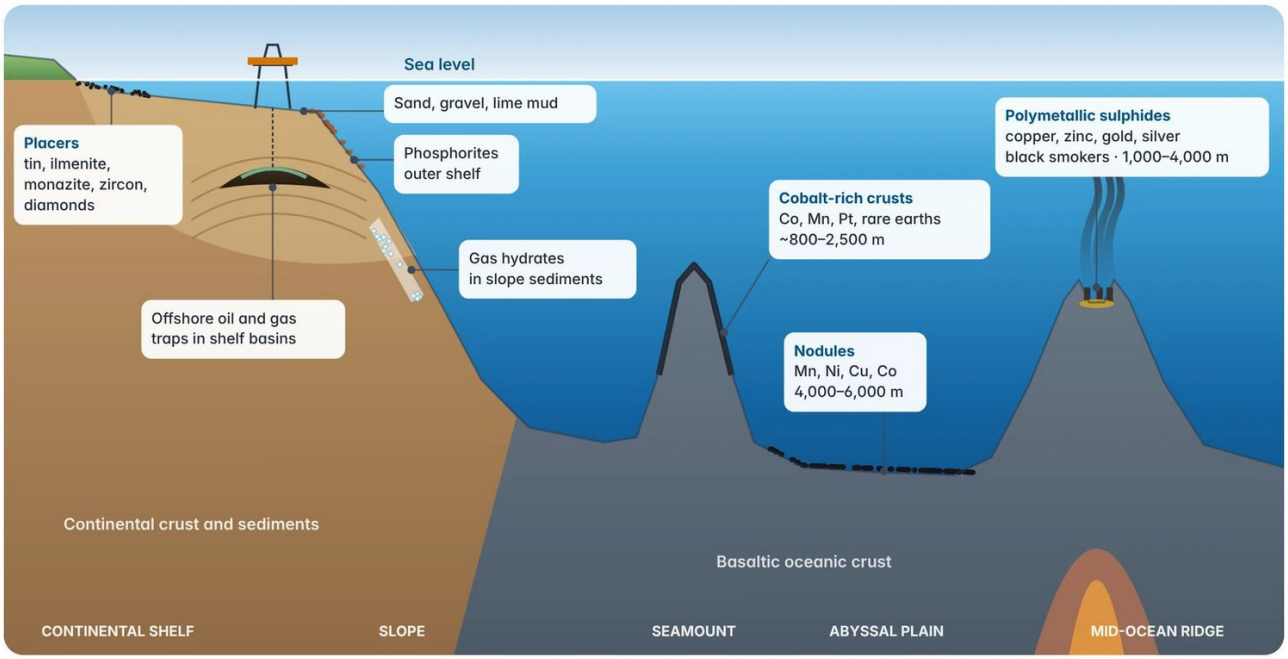
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Mineral resources by depth zone

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Marine Mineral Resources by Depth Zone

Each zone of the sea floor holds its own minerals, from shelf placers and oil to deep-sea nodules, crusts and sulphides.



Continental shelf
- Oil and gas: the most valuable sea-bed resource
- Placers, sand and gravel dredged in shallow water
- Within national jurisdiction

Slope and seamounts
- Gas hydrates: methane in ice cages
- Phosphorites under upwelling coasts
- Cobalt crusts on current-swept rock

Deep floor and ridges
- Nodules on abyssal plains (Clarion–Clipperton Zone)
- Sulphides at hydrothermal vents
- Beyond the EEZ: regulated by the ISA

Schematic; vertical scale greatly exaggerated.

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Continental shelf and slope

- **Oil and natural gas** are the **most valuable marine minerals by far**. Offshore fields supply over a quarter of world oil and gas.
  - Major provinces: the **Persian Gulf**, North Sea, **Gulf of Mexico**, offshore Brazil (pre-salt), West Africa (Gulf of Guinea), the Caspian and South-East Asia.
    - The **Persian Gulf** is shallow, sheltered from the open ocean and relatively free of hazards. Off **Indonesia and Malaysia**, output has been shifting from land to sea, and **Western Australia** developed its offshore fields from the 1970s.
  - In India: **Mumbai High**, discovered in 1974 and producing since 1976, about 160 km off Mumbai; the Bassein gas field; and the deep-water gas of the **Krishna–Godavari basin**.
- **Placers** are heavy minerals concentrated by waves and currents in beach and shelf sands. They are the easiest sea-bed minerals to mine, by dredging in shallow water.

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PLACER	USE	MAIN LOCATIONS
Tin (cassiterite)	Solder, tinplate	Off Indonesia (Bangka–Belitung), Thailand, Malaysia
Diamonds	Gems	Off Namibia and South Africa
Ilmenite, rutile (titanium), zircon	Pigments, alloys, ceramics	Keralam (Chavara), Tamil Nadu (Manavalakurichi), Odisha (Chatrapur); Australia; Brazil; Mozambique
Monazite	Thorium, rare earths	Keralam and Tamil Nadu beach sands; Brazil; Sri Lanka
Gold	Bullion	Nome, Alaska
Magnetite (iron sands)	Iron	Volcanic coasts of the Pacific (Japan, New Zealand)

- **Sand and gravel** are the bulk sea-bed resource by tonnage, dredged for construction and beach nourishment off the UK, the Netherlands and Japan.
- **Lime shell and calcareous sands** (off Gujarat) feed cement plants.
- **Phosphorites** form as nodules and crusts on the outer shelf and upper slope beneath upwelling zones, as off Namibia, Peru and California. Few are mined.
  - The *Challenger* voyage of 1872–76 first dredged sea-floor phosphorite, from South Africa's **Agulhas Bank**. It occurs mostly at depths under 500 m, between 40°N and 40°S.
  - In the Indian Ocean it lies along the **Arabian coast, India's east coast**, near the Andaman and Nicobar Islands and south of Sri Lanka. The Peruvian coast adds calcareous deposits to its phosphate.
- **Sulphur** occurs in salt domes under the Gulf of Mexico shelf, and around submarine volcanoes.

Deep-sea floor

DEPOSIT	SETTING AND DEPTH	METALS	FORMATION	MAIN AREAS
Polymetallic (manganese) nodules	Abyssal plains, 4,000–6,000 m	Manganese, iron, **nickel, copper, cobalt**	Slow precipitation round a nucleus, a few mm per million years	**Clarion–Clipperton Zone** (Pacific); Central Indian Ocean Basin
Cobalt-rich ferromanganese crusts	Flanks of seamounts and guyots, about 800–2,500 m	**Cobalt**, manganese, nickel, platinum, rare earths	Precipitation on bare rock swept clean by currents	Western Pacific seamounts; Afanasy Nikitin Seamount (Indian Ocean)

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DEPOSIT	SETTING AND DEPTH	METALS	FORMATION	MAIN AREAS
Polymetallic sulphides	Mid-ocean ridges and back-arc basins, about 1,000–4,000 m	**Copper, zinc, lead, gold, silver**	Hot vent fluids meet cold sea water (**black smokers**)	Mid-Atlantic Ridge; Central, South-West Indian and Carlsberg Ridges; western Pacific
Metalliferous muds	Hot-brine deeps	Zinc, copper, silver	Brines rising through young rift	Atlantis II Deep, Red Sea

- **Nodules** are potato-sized and lie loose on the sediment of the **abyssal plains**. Manganese and iron make up most of their weight, and nickel, copper and cobalt together only about 2.5–3%.
  - They also hold traces of lead and zinc. The *Challenger* voyage of 1872–76 first found them, and systematic study began in the late 1950s.
  - The main technical hurdle is recovering them **without lifting the sediment beneath**, from depths of over 4,000 m.
  - The **Clarion–Clipperton Zone (CCZ)**, between Hawaii and Mexico, covers about 4.5 million km². Its nodules are estimated to hold more nickel and cobalt than all known land reserves.
  - The **Blake Plateau** off the south-eastern USA is another nodule field, at shallower depth.

Deep-sea mining PYQ 2025

The legal regime

- Part XI of UNCLOS declares the **Area and its minerals the common heritage of mankind**. The **International Seabed Authority (ISA)**, set up in 1994 at Kingston, Jamaica, regulates all activity there.
  - The ISA has issued more than 30 **exploration contracts** (for nodules, sulphides and crusts), but **no exploitation contract**, because the exploitation regulations (the "**Mining Code**") are unfinished.
  - In 2021 **Nauru triggered the "two-year rule"** of the 1994 Implementing Agreement, demanding rules by July 2023. The deadline passed without them.

The 2025–26 regime debate

- **ISA Council, 2025–26:** the Council again failed to adopt the Mining Code at its 30th (2025) and 31st (March and July 2026) sessions.
  - In July 2026 it asked for a roadmap, a list of outstanding issues and an advanced negotiating text for the **32nd session in 2027**.
  - It also extended three exploration contracts, including that of **Nauru Ocean Resources Inc.** (NORI), a subsidiary of The Metals Company, while a compliance inquiry into contractors continued. India's Mayank Joshi presided over the Council in 2026.
  - By July 2026, **46 countries** had called for a moratorium or precautionary pause.

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- **The US unilateral move:** the United States has never ratified UNCLOS.
  - An executive order of **24 April 2025**, *Unleashing America's Offshore Critical Minerals and Resources*, directed the National Oceanic and Atmospheric Administration (NOAA) to speed up permits under the **Deep Seabed Hard Mineral Resources Act of 1980**, a law that bypasses the ISA.
  - A NOAA rule effective **21 January 2026** let firms apply for exploration and commercial recovery in a single consolidated application.
- **The Metals Company (TMC):** its US arm applied in April 2025 for a commercial recovery permit in the CCZ.
  - It filed a consolidated application on **6 February 2026**, covering about 65,000 km².
  - NOAA found the application in full compliance with information requirements in **August 2026**. Its public comment period closed on 19 October 2026.
  - **No permit has been issued.** Certification and an environmental impact statement must come first.
  - ISA members and many scientists regard such permits as a **breach of the common-heritage principle**.
- **National waters:** Norway opened part of its shelf to exploration in 2024, but in **December 2025 it paused licensing until the end of 2029**.

Benefits and risks

BENEFITS	RISKS
Critical minerals for batteries, grids and electronics (nickel, cobalt, copper, manganese, rare earths)	**Permanent habitat loss:** nodules are the only hard surface on the abyssal plain and take millions of years to regrow
Diversified supply: land cobalt is concentrated in the DR Congo and nickel in Indonesia	**Sediment plumes** from collectors and discharge smother life far beyond the mined strip and may cloud the mid-water food web of tuna
No overburden, blasting or displaced communities on land	**Little-known biology:** about 5,500 species have been recorded from the CCZ, nine in ten new to science; a 1979 test track was still scarred 44 years later (studies of 2023 and 2025)
Strategic and technological gains and deep-sea science	**Noise, light and unknown functions**, including carbon storage and the disputed "dark oxygen" made at nodule surfaces (2024)
Revenue sharing for developing states through the ISA	**Governance gap:** no binding code, and a parallel unilateral route

India's deep-sea programme

- India was the **first country registered as a pioneer investor (1987)** and has held a **75,000 km² nodule contract in the Central Indian Ocean Basin** since 2002.
  - An early allotment of 1,50,000 km² in the basin has since narrowed to the present contract. The **National Institute of Oceanography, Goa**, did much of the early survey work.

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- It holds **two sulphide contracts of 10,000 km² each**:
  - on the **Central and South-West Indian Ridges (2016)**;
  - on the **Carlsberg Ridge (2025)**.
  - It is the first state to hold two such contracts.
  - Its application for **cobalt crusts on the Afanasy Nikitin Seamount** is pending, complicated by Sri Lanka's overlapping continental-shelf claim.
- The **Deep Ocean Mission (2021)** of the Ministry of Earth Sciences covers mining technology, the crewed submersible **Matsya-6000** (Samudrayaan, designed for 6,000 m, now in trials), biodiversity surveys and ocean-climate services.
  - The vehicle carries three people and is built by the **National Institute of Ocean Technology, Chennai**. Targets set in early 2026 were a first dive to 500 m that year and the 6,000 m dive in 2027.
- **Offshore blocks in India's own EEZ:**
  - The first auction under the amended Offshore Areas Mineral Act (launched November 2024) offered 13 blocks: construction sand off Kerala, lime mud off Gujarat, and nodules and crusts off Great Nicobar.
  - Fishers in Kerala protested against it.
  - It was **annulled in December 2025 for lack of bidders**.
  - **A second attempt opened on 1 October 2026:** two **Andaman Sea blocks** offered for composite licences, which cover both exploration and mining.
  - The Offshore Areas Mineral (Auction) Amendment Rules of 24 September 2026 had cut the technically qualified bidders needed at a first attempt from three to two.

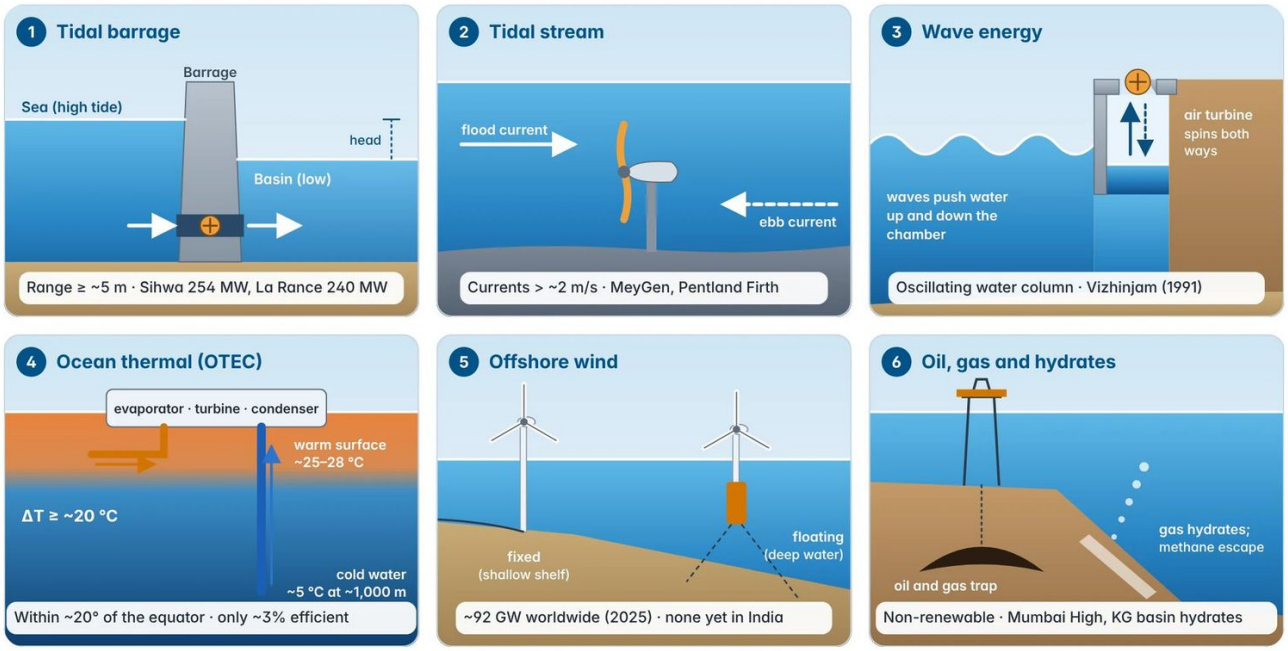
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Energy resources PYQ 2018 · 1997

OCEANOGRAPHY · MARINE RESOURCES

Energy from the Sea: How Each Technology Works

Six ways of drawing energy from tides, waves, temperature layers, sea winds and the sea floor.



Benefits

- Renewable, carbon-free and inexhaustible (1–5)
- Tides are fully predictable; OTEC gives steady base load and fresh water
- Offshore wind is strong and steady, far from homes

Harvestability

- Only offshore wind and oil–gas are commercial at scale
- Tidal barrages need rare high-range sites; OTEC needs tropical deep water
- Waves and currents are still at pilot stage

Environmental impacts

- Barrages change estuarine tides, silt and fish passage
- Turbines and cables affect birds, fish and navigation
- Oil spills; hydrates may release methane or trigger slope failure

Schematic; not to scale. Capacity figures to 2025.

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SOURCE	PRINCIPLE	CONDITIONS NEEDED	EXAMPLES	LIMITS AND IMPACTS
Tidal barrage	Dam across an estuary; water runs turbines as tide rises and falls	Tidal range of about 5 m or more; narrow inlet	**Sihwa Lake, South Korea (254 MW, 2011); La Rance, France (240 MW, 1966)**	Few sites; costly; silting; blocks fish and alters estuary ecology
Tidal stream	Underwater rotors in fast tidal currents	Currents above about 2 m/s	MeyGen, Pentland Firth (Scotland)	Harsh conditions; small scale so far

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SOURCE	PRINCIPLE	CONDITIONS NEEDED	EXAMPLES	LIMITS AND IMPACTS
Wave	Oscillating water column, floats or overtopping devices convert wave motion	Strong, steady swell (westerly coasts at 40–60°)	Mutriku breakwater (Spain); Vizhinjam pilot, Keralam (1991)	Storms damage devices; energy irregular; high cost
Ocean thermal (OTEC)	Warm surface water evaporates a working fluid (ammonia) or flashes sea water; cold deep water condenses it	**Temperature difference of at least about 20 °C** between surface and about 1,000 m, mostly within 20° of the equator	Georges Claude's first plant, Cuba (1930); Kumejima, Okinawa (100 kW)	Efficiency only about 3%; huge pipes; costly; bonus of fresh water and nutrient-rich water
Offshore wind	Turbines on fixed foundations or floating platforms	Strong, steady winds; shallow shelves for fixed bases	About **92 GW installed worldwide by end-2025**, led by China and the North Sea	Cost; grid links; bird, fish and navigation conflicts
Ocean currents	Turbines in steady currents	Strong permanent currents	Experiments in the Florida Current and Kuroshio	Experimental
Salinity gradient	Osmotic pressure where fresh and salt water meet	Large river mouths	Statkraft prototype, Norway (2009–13)	Membranes costly; experimental

- How the main renewable forms behave:
  - **Wave** output depends on wave height, speed, wavelength and water density, and the power often runs desalination plants and water pumps.
  - **Tidal** turbines capture the kinetic motion of the tides in places with strong tidal movement.
  - **OTEC** has low thermal efficiency because the temperature gap is small, which is what makes it hard to justify economically.
  - **Offshore wind** gains from wind speeds that are stronger than on land.
- **Non-renewable marine energy** consists of **offshore oil and gas** and **gas hydrates**.
  - **Gas hydrates** are methane trapped in ice-like crystal cages. They are stable under high pressure and low temperature in sediments of the continental slope, below a few hundred metres of water.
  - Their total resource is very large but poorly known. Japan ran the first offshore production tests in the Nankai Trough (2013, 2017).
  - India's National Gas Hydrate Programme found rich hydrate-bearing sands in the **Krishna–Godavari basin** (NGHP-01, 2006; NGHP-02, 2015). Hydrates are also known off the Mahanadi and the Andamans.
  - **Risks:** destabilising slopes and releasing methane, a powerful greenhouse gas.

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- **India** has large **tidal** potential in the **Gulfs of Khambhat and Kachchh** and the Sundarbans, and offshore wind potential off Gujarat and Tamil Nadu, but **no operating tidal or offshore wind plant**.
  - **Estimates:** tidal long stood at 8,000–9,000 MW and now at 12,455 MW identified; wave at 40,000 MW; ocean thermal at 50,000 MW in older work and 1,80,000 MW as the official theoretical figure.
  - Older plans for a 900 MW tidal plant in the Gulf of Kachchh and a 100 MW ocean thermal plant off Tamil Nadu were never built.
  - The first offshore wind tenders, backed by viability-gap funding for 1 GW, drew no bids and were cancelled in August 2025. A fresh Tamil Nadu tender is planned.
  - The **150 kW Vizhinjam wave plant** ran from 1991 until it was decommissioned in 2011. The Lakshadweep LTTD plants are now the main working step in **ocean energy in India**.

04 Blue Economy and Sustainable Use PYQ 2025

The Blue Economy PYQ 2025

- The **Blue Economy** is the **sustainable use of ocean resources for growth, livelihoods and jobs while keeping ocean ecosystems healthy**. Gunter Pauli popularised the term in his 2010 book *The Blue Economy*, and small island states pushed it at the Rio+20 summit (2012).
  - Pauli's full title was *The Blue Economy: 10 Years, 100 Innovations, 100 Million Jobs*.
  - It seeks the **greening of ocean development**: higher productivity with conservation, joined to social inclusion and new business models.
- **Its sectors:** fisheries and aquaculture, shipping and ports, offshore energy, sea-bed minerals, coastal tourism, marine biotechnology, desalination, waste management on land, and **blue carbon** (mangroves, seagrass and salt marshes that store carbon).
- **Sustainable Development Goal 14** (Life below Water) sets its targets.
- **Why it matters:**
  - Oceans hold about **97% of the Earth's water** and about 99% of its living area, and they absorb a quarter to 30% of carbon dioxide emissions.
  - Oceans yield an estimated **3–5% of world GDP**, and the sector is often called the next sunrise sector.
  - It offers food security and new sources of energy, drugs, chemicals, protein and deep-sea minerals.
- **What threatens it:**
  - **Sea-borne insecurity:** piracy and armed robbery, maritime terrorism, illicit trade in crude and arms, and human and drug trafficking.
  - **Natural disasters:** tsunamis, cyclones, hurricanes and typhoons strand people and destroy property.
  - **Man-made harm:** oil spills, climate change, and changes in sea temperature and acidity that threaten habitats.
  - **Pollution and overuse:** excess nutrients from sewage and farm run-off, plastic debris, and illegal or unregulated extraction.

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- **Recent global rules:**
  - The **WTO Agreement on Fisheries Subsidies** came into force on 15 September 2025, banning subsidies for illegal fishing and for fishing overfished stocks.
  - The **High Seas Treaty (BBNJ Agreement)** came into force on 17 January 2026. It allows marine protected areas and benefit-sharing from marine genetic resources on the high seas.
    - India signed it on 25 September 2024. In December 2025 it was still shaping the domestic framework needed for ratification.

Ecological problems of exploitation PYQ 2016

- **Overfishing:** fleets are too large and too heavily subsidised. Fishing down the food web removes the large predators first. Examples are the collapse of Grand Banks cod and stress on tuna and sharks.
- **Destructive gear:**
  - **bottom trawling** scrapes up sea-bed habitats;
  - **bycatch** kills turtles, dolphins, sharks and juvenile fish;
  - lost "**ghost nets**" go on fishing for years.
- **Illegal, unreported and unregulated (IUU) fishing** undermines quotas, especially in poorly patrolled waters off West Africa and in the Indian Ocean.
- **Habitat loss:** mangroves are cleared for shrimp ponds and ports, reefs are mined for lime or blasted, and estuaries are reclaimed. These are the nurseries of most coastal fish.
- **Mining and drilling:** oil spills and blowouts (Deepwater Horizon, 2010); sand dredging and coastal erosion; and the plumes and habitat loss of deep-sea mining.
- **Energy works:** barrages change estuarine tides and salinity, and wind farms affect birds and shipping.
- **Pollution** and **climate change** degrade the resource base itself:
  - nutrient run-off creates **dead zones**;
  - plastics and heavy metals enter food chains;
  - warming bleaches reefs and shifts fish poleward;
  - **acidification** weakens shellfish.
- **Management responses:**
  - catch quotas based on **maximum sustainable yield**;
  - closed seasons, such as India's **monsoon fishing ban** of 61 days on each coast;
  - mesh-size and gear rules;
  - **marine protected areas**;
  - ecosystem-based and community co-management;
  - satellite vessel monitoring and the FAO Port State Measures Agreement against IUU fishing;
  - environmental impact assessment for mining and energy projects.

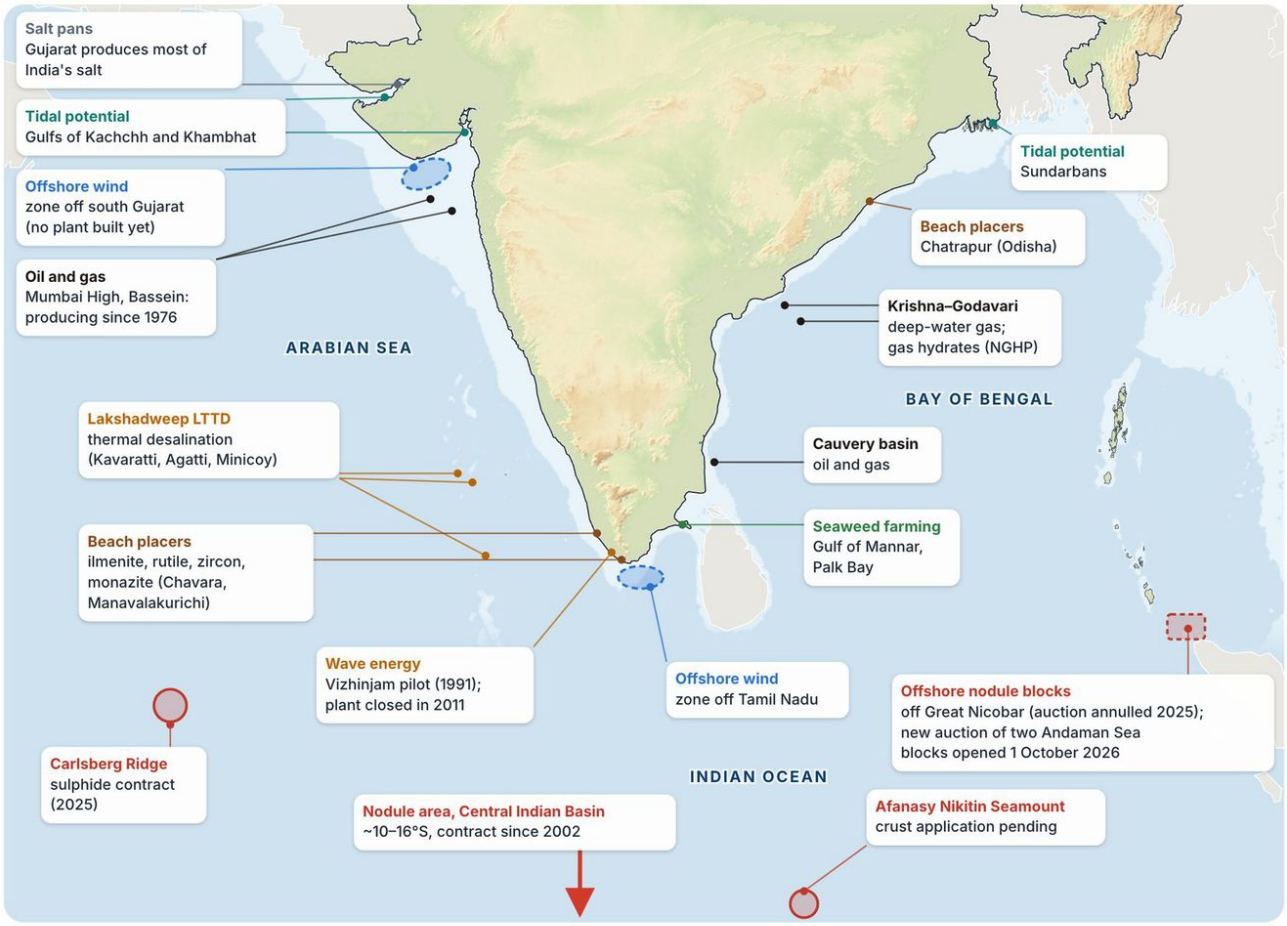
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India’s marine resources and Blue Economy PYQ 2025 · 2023 · 2020 +4

OCEANOGRAPHY · MARINE RESOURCES

India's Marine Resources

Oil and gas, placers, salt, seaweed, tidal and wind sites around India's coasts, and its deep-sea mineral areas.



The base

- Coastline 11,098 km (remeasured)
- EEZ about 2.02 million km²
- Widest shelf off Gujarat and Maharashtra

Fisheries

- Landings: 34.7 lakh t (2024), 35.7 (2025)
- 2024: Gujarat 7.5, Tamil Nadu 6.8, Keralam 6.1 lakh t
- 2025: Tamil Nadu first at 6.85 lakh t; Gujarat second
- Top species, 2024: Indian mackerel, oil sardine

Deep sea (red)

- ISA contracts: nodules (2002) and two sulphide areas (2016, 2025)
- Deep Ocean Mission (2021), Matsya-6000
- Crust application pending

Schematic: locations are generalised and contract areas approximate. Boundaries: Survey of India outline (datameet). lotusarise.com

- **The base:**
  - a **coastline long given as 7,516.6 km and re-assessed in 2025 at 11,098.81 km**, running through 13 States and Union Territories (an older count gave nine States and two Union Territories);
  - an **EEZ of about 2.02 million km²**, given as about 24 lakh sq km in a 2026 government statement, of which the Andaman and Nicobar Islands supply about 6 lakh sq km;
  - a **continental shelf of about 0.5 million km²** (0.31 million km² in another count);

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- a claim to an extended continental shelf beyond 200 nautical miles, lodged with the UN commission.

- **Fisheries:**
  - India is the **second largest producer of fish and of aquaculture** in the world, with total production of about **197.75 lakh tonnes in 2024–25**. About three-quarters of this now comes from inland waters and farms.
  - **Marine landings** were about **34.7 lakh tonnes in 2024**, led by Gujarat (7.54 lakh tonnes), Tamil Nadu (6.79) and Keralam (6.10); Indian mackerel and oil sardine were the top species.
  - **In 2025 landings rose 3% to 35.7 lakh tonnes** (Central Marine Fisheries Research Institute, released 30 April 2026).
    - **Tamil Nadu took first place at 6.85 lakh tonnes.** Gujarat fell about 15% to second, and Keralam stayed third.
    - Indian mackerel (2.70 lakh tonnes) led, followed by cephalopods (2.57) and oil sardine (2.53). Pelagic fish made up 54% of the catch.
    - Landings were worth about ₹69,254 crore at landing centres.
  - The Department of Fisheries, on its own count, gives marine production of about 46 lakh tonnes for 2024-25.
  - The estimated sustainable marine potential of the EEZ is about 5.3 million tonnes, against older estimates as high as 20–25 million tonnes. Inshore waters are fully fished, so growth lies in **deep-sea tuna**, mariculture and better post-harvest handling.
  - The **west coast lands most of the catch**: about three-quarters in older accounts and about **62.5% in 2024**, thanks to its wider shelf and the monsoon upwelling off Keralam and Karnataka.
  - **Why the deep-sea catch stays low:** the **Blue Revolution** has come mostly from inland farms, while sea fishing faces its own limits.
    - Heat spoils fish fast, so freezing adds to its price, and the monsoon and cyclones make the season short.
    - The coast has few of the gulfs and estuaries that shelter Norway's fleets.
    - Much of the fleet is small: about 60% of fishers in older counts used non-mechanised boats, keeping within about 10 km of the shore and 18 m of water.
    - Landing, freezing, canning and market links are thin, and a large vegetarian population limits local demand.
  - **Institutions and rules:**
    - The **Fishery Survey of India** (Mumbai) assesses EEZ stocks, the Central Institute of Fisheries Nautical and Engineering Training (Kochi) trains crews, and the **National Fisheries Development Board** (Hyderabad, 2006) funds development.
    - The harbour scheme has taken up 6 major and 62 minor harbours, with 194 landing centres.
    - The **Marine Fishing Policy of 2004** aimed at sustainable deep-sea fishing and security for artisanal fishers.
    - The **EEZ fishing rules of 4 November 2025** require an access pass for motorised vessels of 24 m and over, ban destructive and juvenile fishing, and focus on tuna around the Andaman and Nicobar and Lakshadweep islands.

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- **Minerals and energy:**
  - oil and gas from Mumbai High, the **Krishna–Godavari** and Cauvery basins;
  - beach placers of ilmenite, rutile, zircon, garnet and monazite in Keralam, Tamil Nadu, Andhra Pradesh and Odisha, worked by Indian Rare Earths Limited;
  - lime mud off Gujarat;
  - gas hydrates in the Krishna–Godavari basin;
  - deep-sea nodules and sulphides under ISA contracts.
- The **economic significance of the Indian Ocean shelf** lies in its oil and gas, placers, fisheries, salt and building sands, together with the sovereign rights the **UNCLOS** shelf regime gives over them.
  - **Aggregates:** sand, gravel and shell, mined mainly on the shelves, are the largest offshore commodity by quantity. Calcareous deposits feed cement plants.
  - **Placers:** titanium sands off Sri Lanka, India and Australia, and tin off Malaysia and Indonesia, one of the main offshore placer areas in the world.
  - **Oil and gas:** India, the Persian Gulf states, Indonesia, Malaysia and Western Australia lead. Small Gulf states gain most, since their land area is limited.
  - **Fisheries:** the Indian Ocean has long been regarded as the least fished of the main oceans, though its tuna and inshore stocks are now under pressure.
  - **Rivalry:** this wealth adds to the contest described in **the geopolitics of the Indian Ocean**.
  - **Trade:** a large part of the world's seaborne oil crosses this ocean, so better regional connectivity cuts transport costs and waste.
- **Policies:**
  - **Sagarmala** (2015) for port-led development, modernised with IT-enabled services, with inland waterways, coastal shipping and Coastal Economic Zones (CEZ) where sea-dependent industry and townships cluster;
  - the **Pradhan Mantri Matsya Sampada Yojana** (2020) for fisheries, the core of the **Blue Revolution**;
  - O-SMART, an umbrella scheme for ocean services, technology and regulated use of the sea;
  - the **Deep Ocean Mission** (2021);
  - the **draft Blue Economy Policy** (2021);
  - Integrated Coastal Zone Management, for conservation and coastal livelihoods;
  - the national fisheries policy's Blue Growth Initiative, for sustainable use of fisheries wealth;
  - **SAGAR (2015)**, widened to **MAHASAGAR (2025)**, for maritime cooperation in the Indian Ocean.
- **National aims:** the Blue Economy serves livelihoods, energy security, ecological resilience and the 2030 goals on hunger and poverty. Marine services were cast as a backbone of the drive to a **$5 trillion economy**, a target first set for 2025; GDP for 2026 is about $4.06 trillion (IMF, October 2026).
- **Challenges:**
  - an ageing, small-boat fishing fleet and post-harvest losses;
  - conflict over fishing rights in the **Palk Bay** with Sri Lanka;
  - mangrove and coastal-erosion pressures;
  - pollution off industrial coasts;

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- weak deep-sea technology;
- the vulnerability of the **island territories** to cyclones and **sea-level rise**.
- the contest over the **Great Nicobar** port and township between strategic aims and ecology and tribal rights. The National Green Tribunal declined to interfere with its environmental clearance in February 2026, and a forest-clearance challenge was pending before the Calcutta High Court in late 2026.

Coral Reefs of India PYQ 2025

- **Distribution:** the four main reef areas are the **Gulf of Kachchh, Gulf of Mannar, Lakshadweep, and Andaman and Nicobar**. Lakshadweep has atolls, and the others mainly fringing reefs.
- **Why they matter:**
  - They are among the richest marine ecosystems, with very high biodiversity.
  - They support fisheries and tourism, and sustain coastal communities.
  - They break waves and protect shores from erosion and storm surges.
  - They also supply sand to the low coral islands of Lakshadweep.
- **A dynamic ecosystem:** corals live with symbiotic algae, and the reef grows or shrinks with temperature, light, sediment and water chemistry.
- **Threats:** warmer seas cause **bleaching**, as in 1998, 2010, 2016 and 2024. Coastal pollution, sedimentation and destructive fishing add to the stress.
- **Protection:** corals are protected under the Wild Life (Protection) Act, 1972, and the Gulf of Mannar Marine National Park and Biosphere Reserve protect a key reef area.

Previous Year Questions

2025	What is deep-sea mining? What are the potential benefits and risks associated with it?
2025	Examine the validity of the Blue Economy initiatives of India. Elaborate the impacts of this economy on the country's development.
2023	What is ocean ranching? How are aqua-cowboys related to such activities?
2023	Give an account of marine resources and their economic significance. How has marine pollution affected such resources?
2020	Marine resources are economically very significant. Discuss citing suitable examples.

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2018	Describe the potential marine energy resources with reference to their benefits, harvestability and environmental impacts.
2016	Bring out the various ecological problems associated with the exploitation and use of oceans and their resources.
2013	Analyse the reasons for a comparatively poorer development of fishing grounds in tropical areas.
2011	Give an account of potentiality and prospects of development of marine resources of India.
2009	Examine economic significance of the resource of the Continental shelf of the Indian Ocean.
1997	Write short note: Marine resources, biotic mineral and energy resources.
1995	Write short note: Food from the sea.
1993	Critically examine the marine resources of India and discuss the problems encountered in their development.
1986	Give an account of marine resources and discuss their present-day utilization.
2025	Why are coral reefs in India most important with respect to its dynamic ecosystem? Explore.
2011	Give an account of potentially and prospects of development of marine resources of India.

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25	5	128	372
Chapters	Units	Previous year questions	Pages

IN THE COMPLETE BOOK

01 **Land Resources** 1 chapter · from page 6

02 **Water Resources** 2 chapters · from page 20

03 **Mineral Resources** 8 chapters · from page 64

04 **Energy Resources and the Energy Crisis** 11 chapters · from page 156

05 **Biotic and Marine Resources** 3 chapters · from page 322

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