UPSC PRELIMS 2026

Environment & Ecology

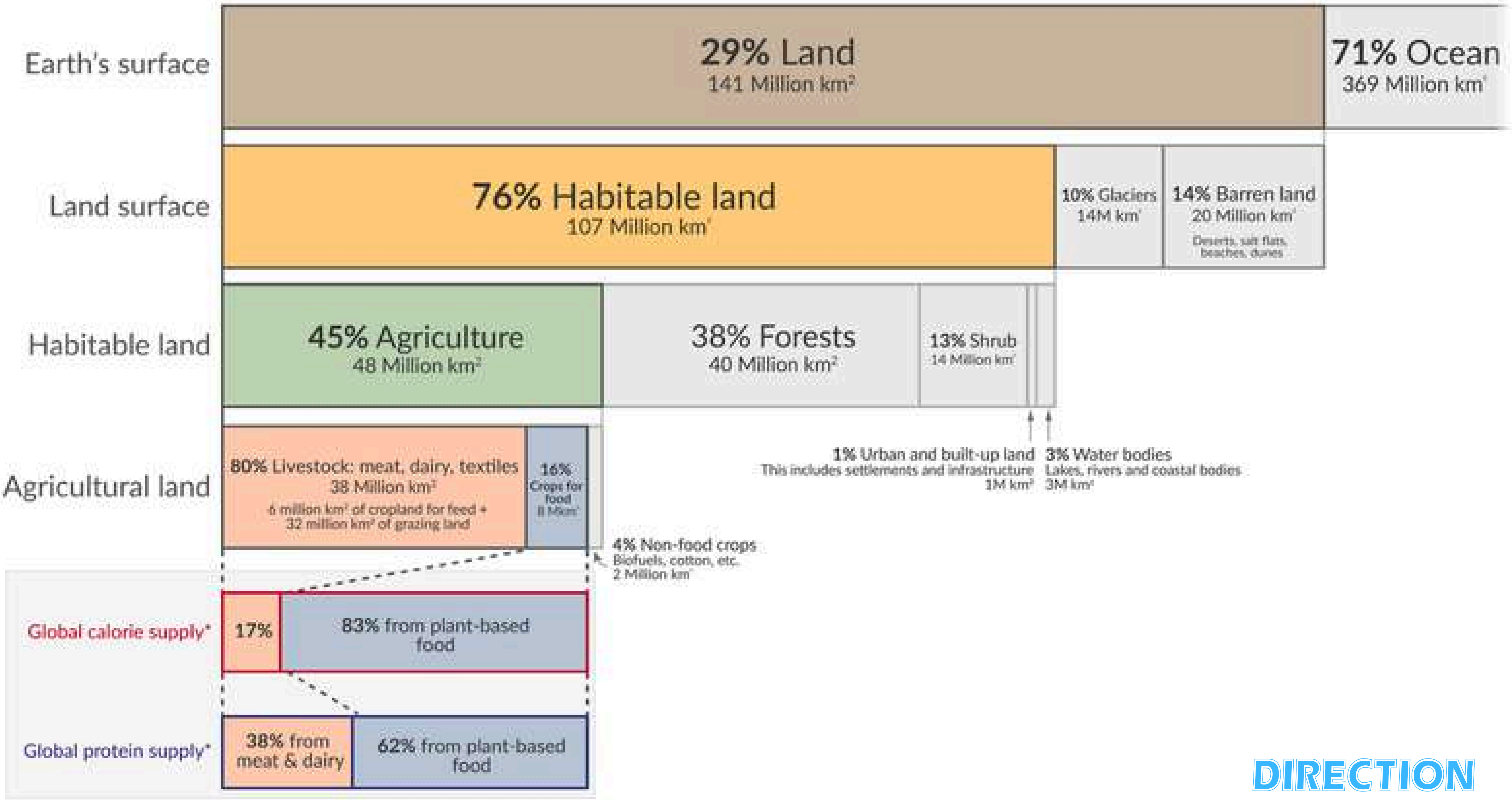
NOTES PART - 2

BIODIVERSITY

NEETU SINGH

DIRECTION

Global Land use for Food Production



DIRECTION

Arable Land and Permanent Crops

Arable Land

Land under temporary agricultural crops (multiple-cropped areas are counted only once), temporary meadows for mowing or pasture, and land temporarily fallow (less than five years).

Land for Grazing

Land covered with grass or herbage and suitable for grazing by livestock. This includes both permanent and temporary meadows and pastures.

Permanent Crops

Land cultivated with long-term crops which do not have to be replanted for several years (such as cocoa and coffee); land under trees and shrubs producing flowers, and nurseries (except those for forest trees).

Temporary Crops

Land used for crops with a less than one-year growing cycle and which must be newly sown or planted for further production after the harvest.

Fallow

Cultivated land that is not seeded for one or more growing seasons. The maximum idle period is usually less than five years.

Temporary Meadows and Pastures

Land temporarily cultivated with herbaceous forage crops for mowing or pasture. A period of less than five years is used to differentiate between temporary and permanent meadows.

Permanent Meadows and Pastures

Land used permanently (five years or more) to grow herbaceous forage crops, either cultivated or growing wild (wild prairie or grazing land).

Inland Water Bodies

Area occupied by major rivers, lakes and reservoirs.

Primary Forest

Naturally regenerated forest of native species, where there are no clearly visible indications of human activities and the ecological processes are not significantly disturbed.

Other Naturally Regenerated Forest

Naturally regenerated forest where there are clearly visible indications of human activities.

Planted Forest

Forest predominantly composed of trees established through planting and/or deliberate seeding.

Barren Land

Land in which less than one third of the area has vegetation or other cover. In general, Barren Land has thin soil, sand, or rocks. Barren lands include deserts, dry salt flats, beaches, sand dunes, exposed rock, strip

Urban / Built-up Land

Areas characterized by buildings, asphalt, concrete, suburban gardens, and a systematic street pattern. Urban development includes residential, commercial, industrial, transportation, utilities, and mixed urban.

Agricultural Area

The sum of areas under "Arable land and Permanent crops" and "Permanent meadows and pastures".

Forest

Forest area is the land spanning more than 0.5 hectares with trees higher than 5 metres and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ.

Other Land

Land not classified as Agricultural land and Forest area. It includes urban, built-up and barren land.

DIRECTION

Desertification, land degradation, and drought (DLDD) are a silent and invisible crisis that affects people and the planet. As human life requires fertile and productive lands for many essential activities, desertification represents an important obstacle to sustainable development and an aggravator of poverty, poor health, lack of food security, biodiversity loss, water scarcity, forced migration, and lowered resilience to climate change or natural disasters.

DIRECTION

Desertification

Desertification is defined as land degradation in arid, semi-arid, and dry sub-humid areas resulting from various factors, mostly climatic variations and human activities (UNCCD, 1994). Although the term can include the encroachment of sand dunes on land, it does not refer to the expansion of existing deserts. It occurs, however, because dryland ecosystems, which cover over one-third of the world's land area, are extremely vulnerable to overexploitation and inappropriate land use.

According to the IPCC, the major human drivers of desertification interacting with climate change are the expansion of croplands, unsustainable land management practices and increased pressure on land from population and income growth. On the other hand, desertification exacerbates climate change through several mechanisms such as changes in vegetation cover, sand and dust aerosols and greenhouse gas fluxes.

Drought

Meteorologically, drought is defined as a prolonged absence or marked deficiency of precipitation that can be characterized as a period of abnormally dry weather with a sufficiently prolonged lack of precipitation as to cause a serious hydrological imbalance (WMO, 1992).

Other definitions include impacts like hydrological imbalances that adversely affect land resource productions systems (UNCCD, 1994; Article 1).

Put into other words, drought is a climatic phenomenon that can occur almost anywhere in the world when there is a significant decrease in water availability (atmospheric, surface, soil, or groundwater) over a period of weeks to years. Climate change is increasing the frequencies and/or magnitudes of droughts in many regions of the world (IPCC, 2021).

DIRECTION

Land Degradation and Restoration

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) defines land degradation as “the many human-caused processes that drive the decline or loss in biodiversity, ecosystem functions or ecosystem services in any terrestrial and associated aquatic ecosystems”, and restoration as “any intentional activity that initiates or accelerates the recovery of an ecosystem from a degraded state”. Land degradation affects ecosystem functions worldwide disrupts rainfall patterns, exacerbates extreme weather like droughts or floods, and drives further climate change and it is connected with instability, which drives poverty, conflict, and migration.

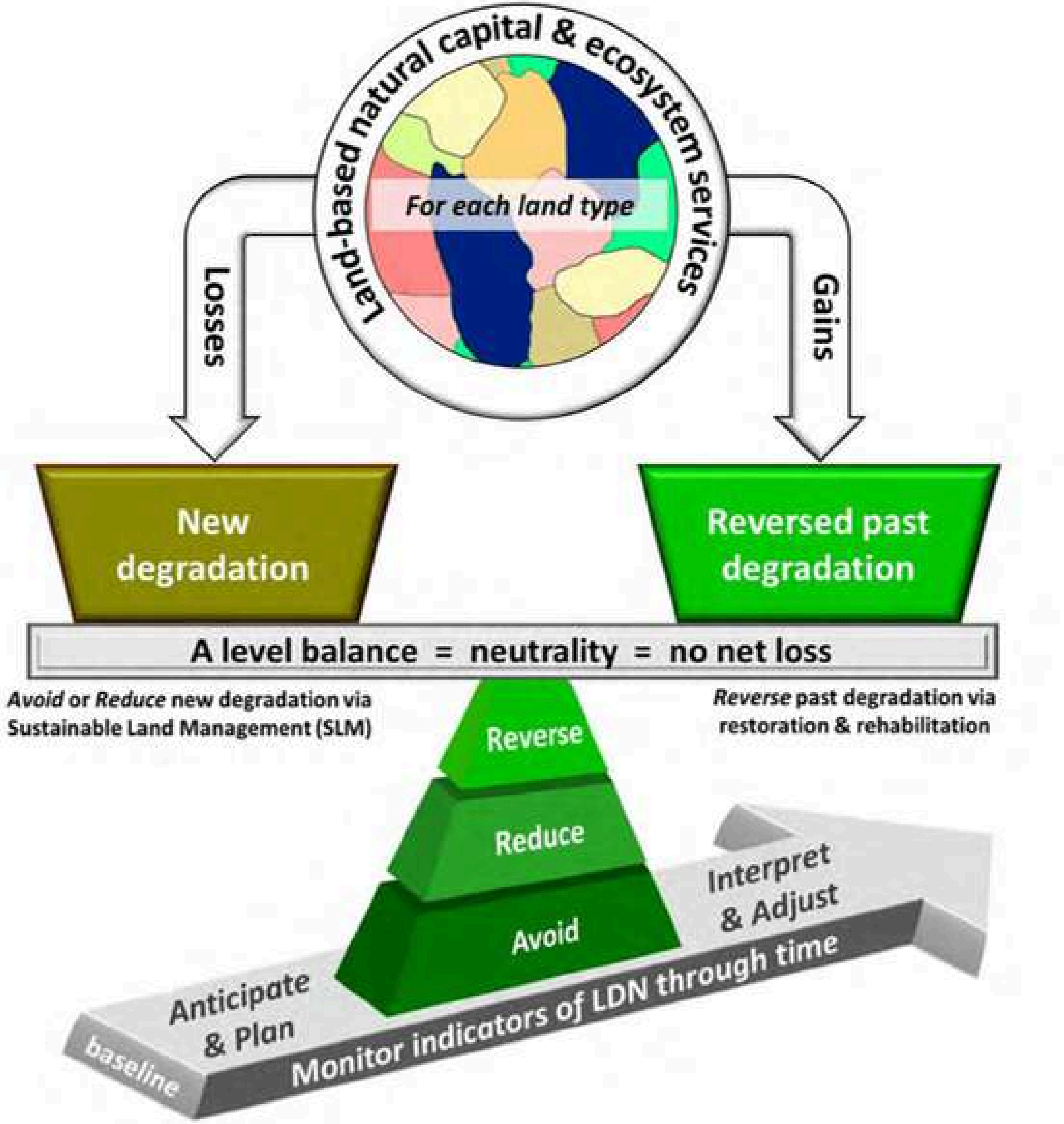
Global Responses to Desertification, Land Degradation, and Drought

UN Convention to Combat Desertification (UNCCD)

The United Nations Convention to Combat Desertification (UNCCD) was established in 1994 to protect and restore our land and ensure a safer, just, and more sustainable future.

The UNCCD is the only legally binding framework set up to address desertification and the effects of drought, and has 197 Parties to the Convention, including 196 country Parties and the European Union. The Convention – based on the principles of participation, partnership and decentralization – is a multilateral commitment to mitigate the impact of land degradation, and protect our land so we can provide food, water, shelter and economic opportunity to all people.

The Conference of the Parties (COP) — the Convention's main decision-making body to guide in responding to global challenges and national needs — has met biennially since 2001. The 16th session of the Conference of the Parties (COP16) ,Held under the theme, "Our Land. Our Future.", COP16 puts front and center cooperation and collaboration among the three Rio Conventions on biodiversity, climate change, and desertification.



Land-based natural capital & ecosystem services
For each land type
Losses
Gains
New degradation
Reversed past degradation
A level balance = neutrality = no net loss
Avoid or *Reduce* new degradation via Sustainable Land Management (SLM)
Reverse past degradation via restoration & rehabilitation
Reverse
Reduce
Avoid
Anticipate & Plan
Interpret & Adjust
baseline
Monitor indicators of LDN through time

DIRECTION

The United Nations Decade on Ecosystem Restoration

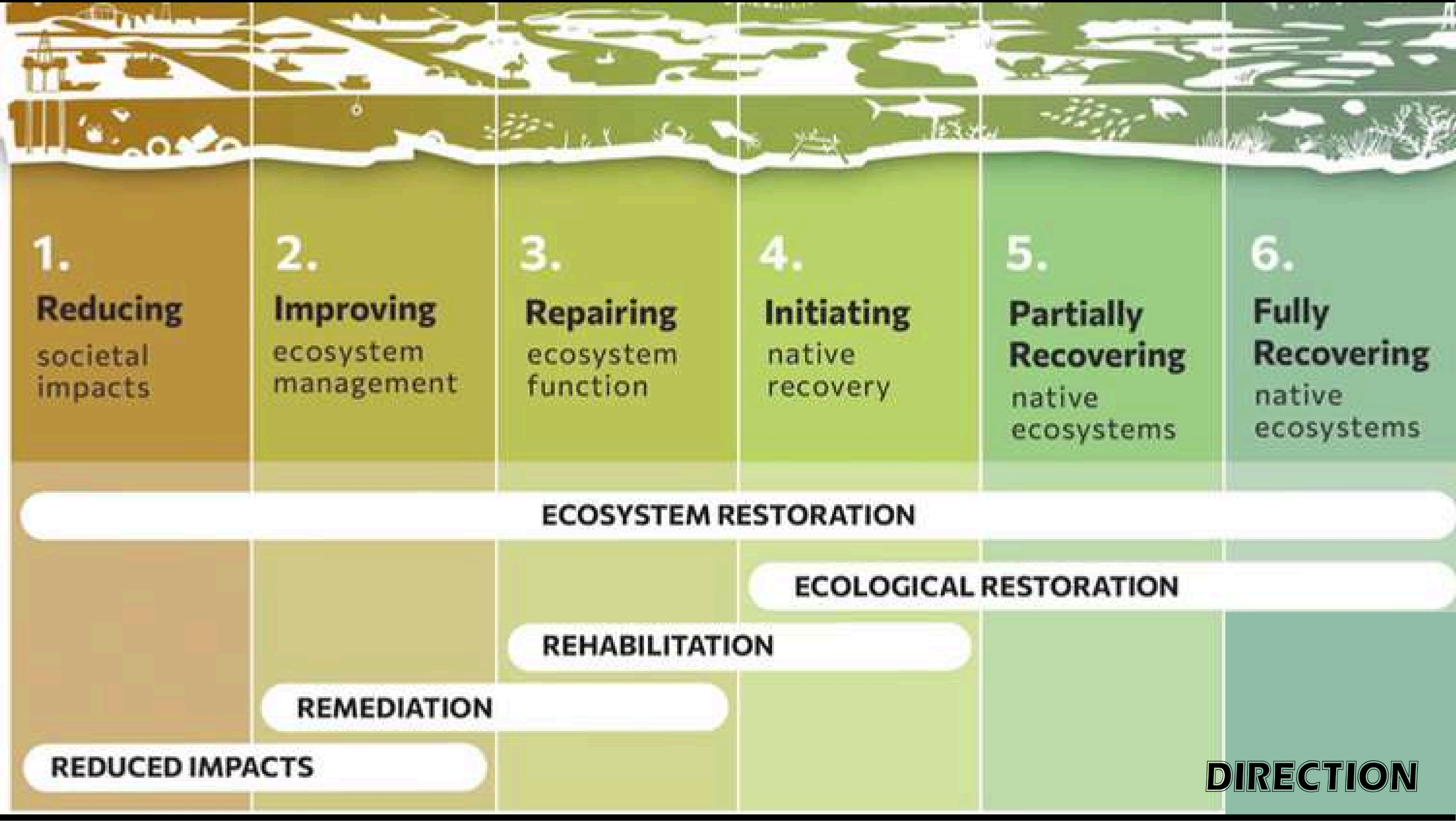
UNITED NATIONS DECADE ON
ECOSYSTEM
RESTORATION
2021-2030

The United Nations Decade on Ecosystem Restoration is a rallying call for the protection and revival of ecosystems all around the world, for the benefit of people and nature. It aims to halt the degradation of ecosystems and restore them to achieve global goals. Only with healthy ecosystems can we enhance people's livelihoods, counteract climate change, and stop the collapse of biodiversity.

a global movement coordinated by the United Nations Environment Programme (UNEP) and the United Nations Food and Agriculture Organization (FAO). It is designed to prevent and reverse the degradation of natural spaces across the planet

The initiatives were declared **World Restoration Flagships** and are eligible to receive UN-backed promotion, advice or funding.

Stages of Restorations



Trinational Atlantic Forest Pact

The Atlantic Forest once covered a swath of Brazil, Paraguay and Argentina. But it has been reduced to fragments by centuries of logging, agricultural expansion and city building. Hundreds of organizations are active in the decades-long effort to protect and restore the forest in all three countries. Their initiatives are creating wildlife corridors for endangered species, like the jaguar and the golden lion tamarin, securing water supplies for people and nature, countering and building resilience to climate change, and creating thousands of jobs.

Some 700,000 hectares have already been restored with the 2030 target at 1 million hectares and the 2050 target at 15 million hectares.

Abu Dhabi Marine Restoration

Safeguarding the world's second-largest dugong population is a goal of the drive in the United Arab Emirates to restore beds of seagrass – the vegetarian dugong's preferred food – coral reefs and mangroves along the Gulf coast.

The project in the emirate of Abu Dhabi will improve conditions for many other plants and animals, including four species of turtle and three kinds of dolphin. Local communities will benefit from the revival of some of the 500 species of fish, as well as greater opportunities for eco-tourism.

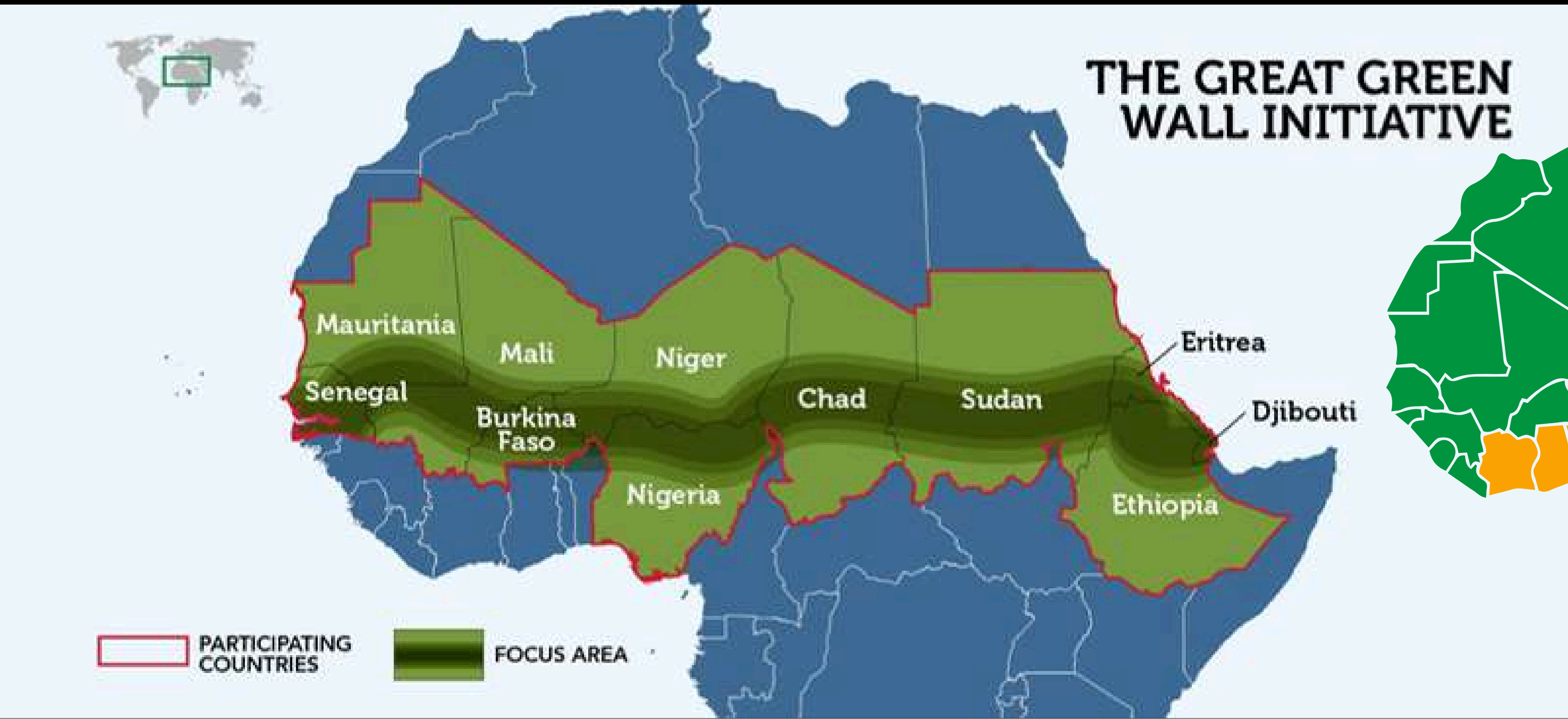
Abu Dhabi wants to ensure its coastal ecosystems are resilient in the face of global warming and rapid coastal development in what is already one of the world's warmest seas.

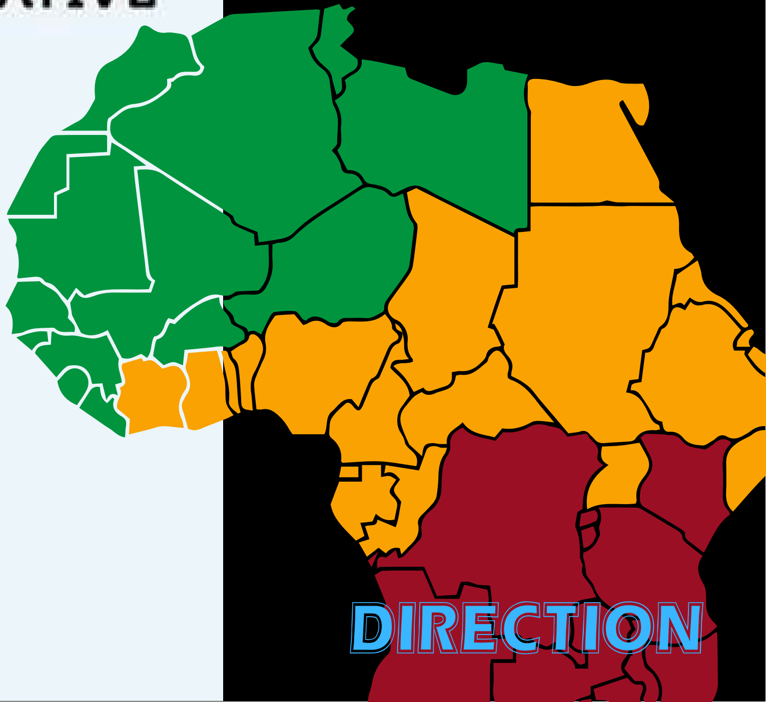
Some 7,500 hectares of coastal areas have already been restored with another 4,500 hectares under restoration for 2030.

DIRECTION

Great Green Wall for Restoration and Peace

The Great Green Wall is an ambitious initiative to restore savannas, grasslands and farmlands across Africa to help families and biodiversity cope with climate change and keep desertification from further threatening already-vulnerable communities.
Launched by the African Union in 2007, this flagship seeks to transform the lives of millions in the Sahel region by creating a belt of green and productive landscapes across 11 countries.
The 2030 goals of the Great Green Wall are to restore 100 million hectares, sequester 250 million tons of carbon and create 10 million jobs.
While the Great Green Wall targets degraded land stretching right across the continent, the UN Decade flagship has a particular focus on Burkina Faso and Niger.





Ganges River Rejuvenation

Restoring the health of the Ganges, India's holy river, is the focus of a major push to cut pollution, rebuild forest cover and bring a wide range of benefits to the 520 million people living around its vast basin.

Climate change, population growth, industrialization and irrigation have degraded the Ganges along its arcing 2,525-kilometre course from the Himalayas to the Bay of Bengal.

Launched in 2014, the government-led Namami Gange initiative is rejuvenating, protecting and conserving the Ganges and its tributaries, reforesting parts of the Ganges basin and promoting sustainable farming.

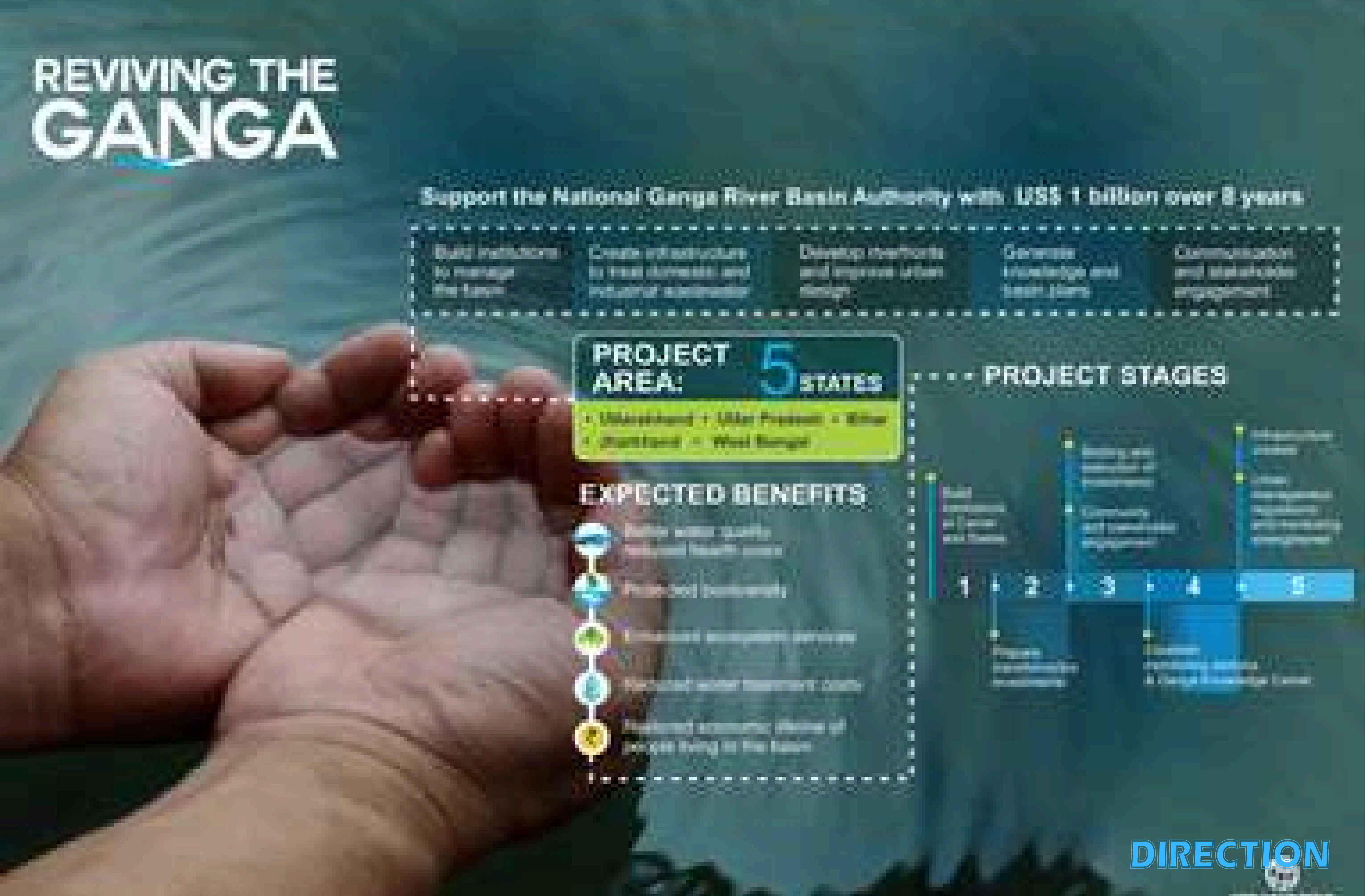
It also aims to revive key wildlife species, including river dolphins, softshell turtles, otters, and the hilsa shad fish.

Investment by the Indian government is up to $4.25 billion so far. The initiative has the involvement of 230 organisations, with 1,500km of river restored to date.

Additionally, there has been 30,000 hectares of afforestation so far, with a 2030 goal of 134,000 hectares.


THE MIGHTY
GANGA
BASIN
7,000
Millions congregate
religious and cultural activities
500 million people
Among top 10 most polluted rivers in the world
Largest Mangrove forest
Sundarbans
US$ 700 billion
200 million people
The Ganga is home to
140
2
5
DIRECTION


THE POLLUTED
GANGA
Over 40% of India depends upon the Ganga basin
for drinking water, irrigation and ecosystem services
CRITICALLY POLLUTED STRETCH
WHAT'S POLLUTING THE GANGA?
POLLUTION IN THE GANGA LEADS TO
DIRECTION



REVIVING THE
GANGA
Support the National Ganga River Basin Authority with US$ 1 billion over 8 years
PROJECT AREA: 5 STATES
Uttarakhand • Uttar Pradesh • Bihar
Jharkhand • West Bengal
EXPECTED BENEFITS
PROJECT STAGES
1
2
3
4
5
DIRECTION

Multi-Country Mountain Initiative

Mountain regions face unique challenges. Climate change is melting glaciers, eroding soils and driving species uphill – often toward extinction. The water that mountains supply to farms and cities in the plains below is becoming unreliable. The initiative – based in Serbia, Kyrgyzstan, Uganda and Rwanda – showcases how projects in three diverse regions are using restoration to make mountain ecosystems more resilient so they can support their unique wildlife and deliver vital benefits to people.

Uganda and Rwanda are home to one of only two remaining populations of the endangered mountain gorilla. Thanks to the protection of their habitat, gorilla numbers have doubled in the last 30 years. In Kyrgyzstan, herders are managing grasslands more sustainably so that they provide better food for both livestock and Asiatic ibex. Snow leopards are slowly bouncing back. In Serbia, authorities are expanding tree cover and revitalizing pastures in two protected areas. Brown bears have returned to the forests, where restoration is also helping ecosystems recover from wildfires.

Small Island Developing States Restoration Drive

Focused on three small island developing states – **Vanuatu, St Lucia and Comoros** – this flagship is scaling up ridge-to-reef restoration of unique ecosystems and tapping blue economic growth to help island communities rebound from the COVID-19 pandemic.

Goals include a reduction in pressures on coral reefs, which are vulnerable to storm damage, so that fish stocks can recover. Ecosystems under restoration also include seagrass beds, mangroves and forests.

As well as creating a “toolbox” of solutions for sustainable island development, this flagship aims to amplify the voice of island nations facing rising sea levels and intensifying storms as a result of climate change.

Altyn Dala Conservation Initiative

Like many grasslands around the world, the vast steppes of Central Asia are in decline due to factors like overgrazing, conversion to arable land and the shifting climate. In Kazakhstan, the Altyn Dala Conservation Initiative has been working since 2005 to restore the steppe, semi-desert and desert ecosystems within the historic range of the Saiga, a once abundant antelope critically endangered by hunting and habitat loss.

In fact, the Saiga population had plunged to 50,000 in 2006 but rebounded to 1.3 million in 2022. As well as reviving and protecting the steppe, the initiative has helped conserve wetlands that are a vital stopover for an estimated 10 million migratory birds. Among the key bird species are the sociable lapwing, the red-breasted goose, the white-headed duck and the Siberian crane.

DIRECTION

Central American Dry Corridor

Exposed to heatwaves and unpredictable rainfall, the ecosystems and peoples of the Central American Dry Corridor are especially vulnerable to climate change. As recently as 2019, a fifth year of drought left 1.2 million people in the region needing food aid.

Tapping traditional farming methods to build the productivity of landscapes, including their biodiversity, is at the heart of this restoration flagship covering six countries: Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama.

By 2030, the goal is to have 100,000 hectares under restoration and create 5,000 permanent jobs.

Building with Nature in Indonesia

Demak, a low-lying coastal community on Indonesia's main island of Java, has been plagued by erosion, flooding and land loss caused by the removal of mangroves for aquaculture ponds, land subsidence and infrastructure.
Rather than replanting mangrove trees, this innovative World Restoration Flagship has built fence-like structures with natural materials along the shore to calm waves and trap sediment, creating conditions for mangroves to rebound naturally. The total length of permeable structures built is 3.4 km and 199 ha of mangroves have been restored.

In return for letting mangroves regenerate, farmers have been schooled in sustainable techniques that have increased their shrimp production. With mangroves providing habitat for a plethora of marine organisms, fishers have also seen their near-shore catches improve.

Shan-Shui Initiative in China

This ambitious initiative combines 75 large-scale projects to restore ecosystems, from mountains to coastal estuaries, across the world's most populous nation.

Launched in 2016, the initiative results from a systematic approach to restoration. Projects dovetail with national spatial plans, work at the landscape or watershed scale, include agricultural and urban areas as well as natural ecosystems, and seek to boost multiple local industries. All include goals for biodiversity.

Examples include the Oujiang River Headwaters Project in Zhejiang province, which integrates scientific knowledge with traditional farming methods, like slope terracing and combining crops with fish- and duck-rearing, to make land use more sustainable.

Some 3.5 million hectares have been restored so far. The 2030 target is 10 million hectares.

Oil cinnamon plantations developed under the Shan-Shui Initiative in Guang'an City, Sichuan Province, southwest China

DIRECTION

Milankovitch (Orbital) Cycles and Their Role in Earth's Climate

A century ago, Serbian scientist Milutin Milankovitch hypothesized the long-term, collective effects of changes in Earth's position relative to the Sun are a strong driver of Earth's long-term climate, and are responsible for triggering the beginning and end of glaciation periods (Ice Ages).

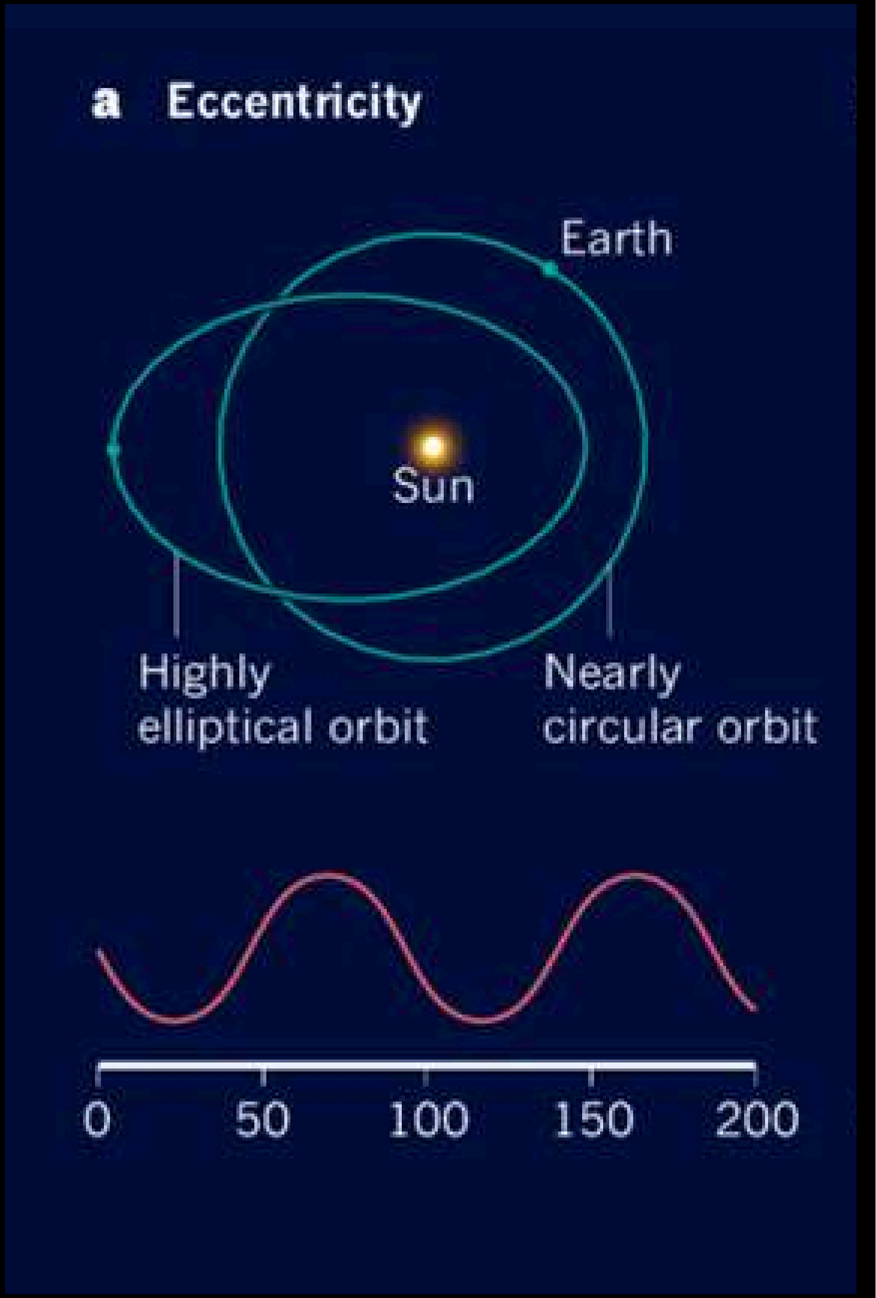
Specifically, he examined how variations in three types of Earth orbital movements affect how much solar radiation (known as insolation) reaches the top of Earth's atmosphere as well as where the insolation reaches. These cyclical orbital movements, which became known as the Milankovitch cycles, cause variations of up to 25 percent in the amount of incoming insolation at Earth's mid-latitudes (the areas of our planet located between about 30 and 60 degrees north and south of the equator).

The Milankovitch cycles include:

1. The shape of Earth's orbit, known as eccentricity;
2. The angle Earth's axis is tilted with respect to Earth's orbital plane, known as obliquity; and
3. The direction Earth's axis of rotation is pointed, known as precession.

Eccentricity – Earth's annual pilgrimage around the Sun isn't perfectly circular, but it's pretty close. Over time, the pull of gravity from our solar system's two largest gas giant planets, Jupiter and Saturn, causes the shape of Earth's orbit to vary from nearly circular to slightly elliptical. Eccentricity measures how much the shape of Earth's orbit departs from a perfect circle. These variations affect the distance between Earth and the Sun.

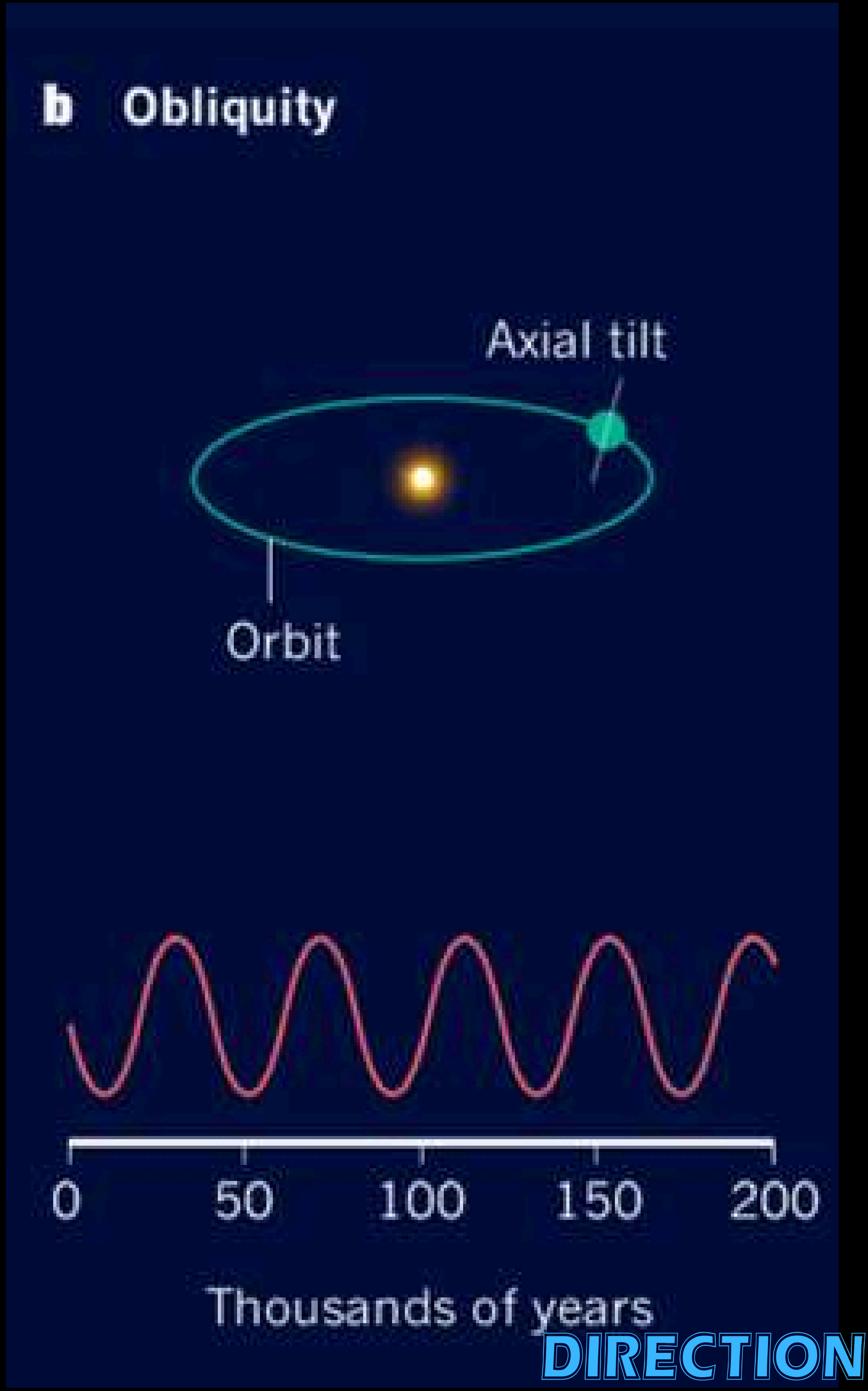
Currently, Earth's eccentricity is very slowly decreasing and is approaching its least elliptic (most circular), in a cycle that spans about 100,000 years. The total change in global annual insolation due to the eccentricity cycle is very small. Because variations in Earth's eccentricity are fairly small, they're a relatively minor factor in annual seasonal climate variations.



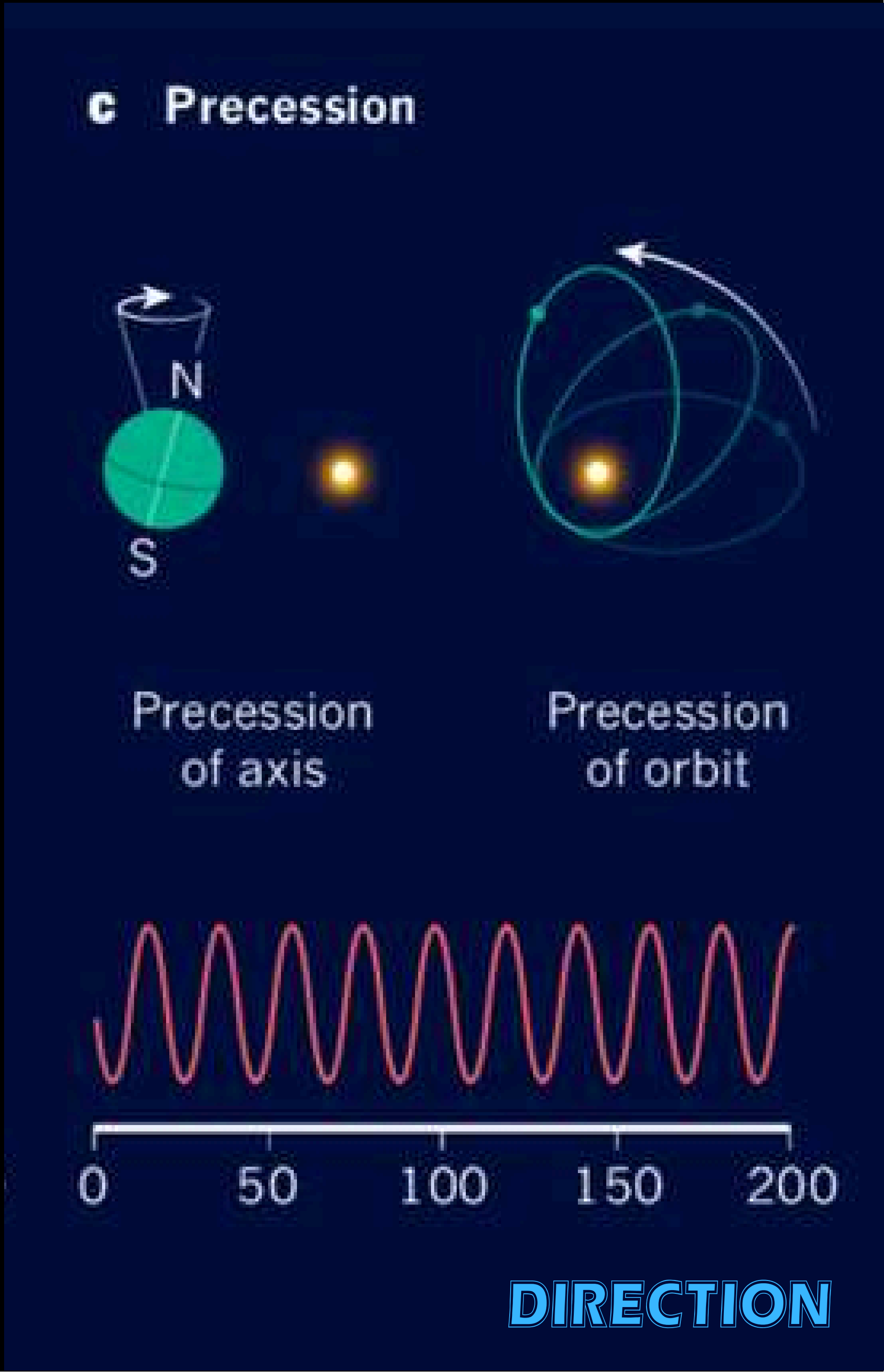
DIRECTION

Obliquity – The angle Earth's axis of rotation is tilted as it travels around the Sun is known as obliquity. Obliquity is why Earth has seasons. Over the last million years, it has varied between 22.1 and 24.5 degrees with respect to Earth's orbital plane. The greater Earth's axial tilt angle, the more extreme our seasons are, as each hemisphere receives more solar radiation during its summer, when the hemisphere is tilted toward the Sun, and less during winter, when it is tilted away. Larger tilt angles favor periods of deglaciation (the melting and retreat of glaciers and ice sheets). These effects aren't uniform globally -- higher latitudes receive a larger change in total solar radiation than areas closer to the equator.

Earth's axis is currently tilted 23.4 degrees, or about half way between its extremes, and this angle is very slowly decreasing in a cycle that spans about 41,000 years.



Precession – As Earth rotates, it wobbles slightly upon its rotational axis, like a slightly off-center spinning toy top. This wobble is due to tidal forces caused by the gravitational influences of the Sun and Moon that cause Earth to bulge at the equator, affecting its rotation. The trend in the direction of this wobble relative to the fixed positions of stars is known as axial precession. The cycle of axial precession spans about 25,771.5 years.

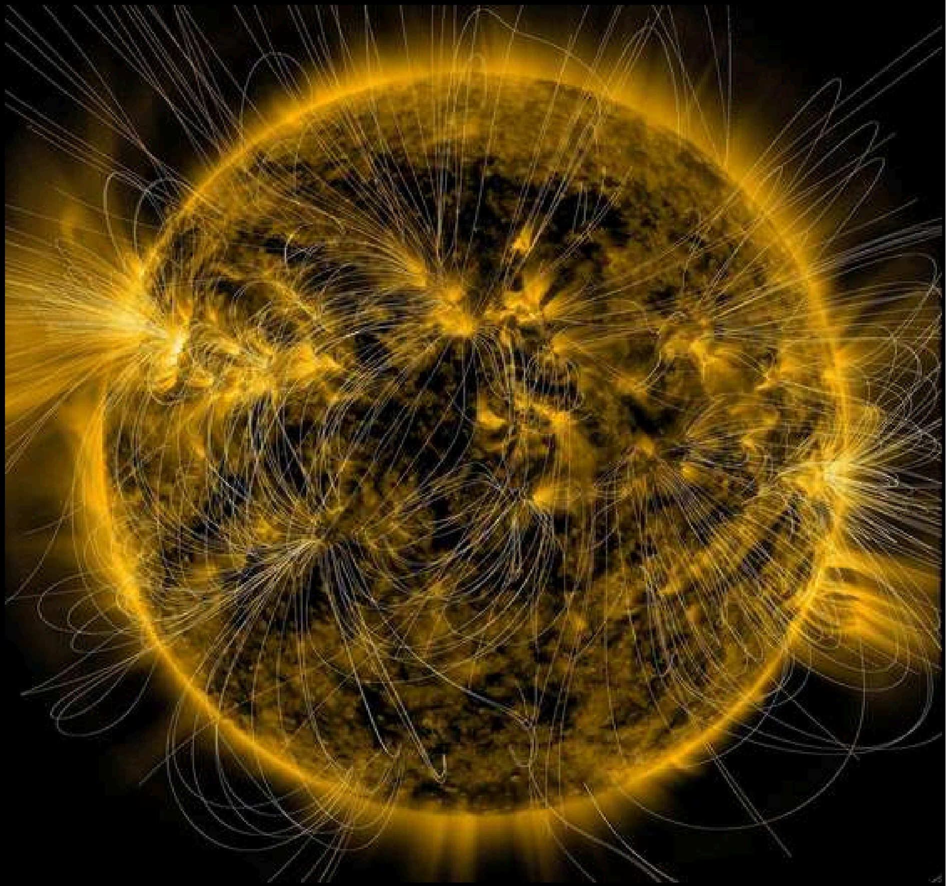


Solar Storms

A solar storm is a sudden explosion of particles, energy, magnetic fields, and material blasted into the solar system by the Sun.

When directed toward Earth, a solar storm can create a major disturbance in Earth's magnetic field, called a geomagnetic storm, that can produce effects such as radio blackouts, power outages, and beautiful auroras. They do not cause direct harm to anyone on Earth, however, as our planet's magnetic field and atmosphere protect us from the worst of these storms.

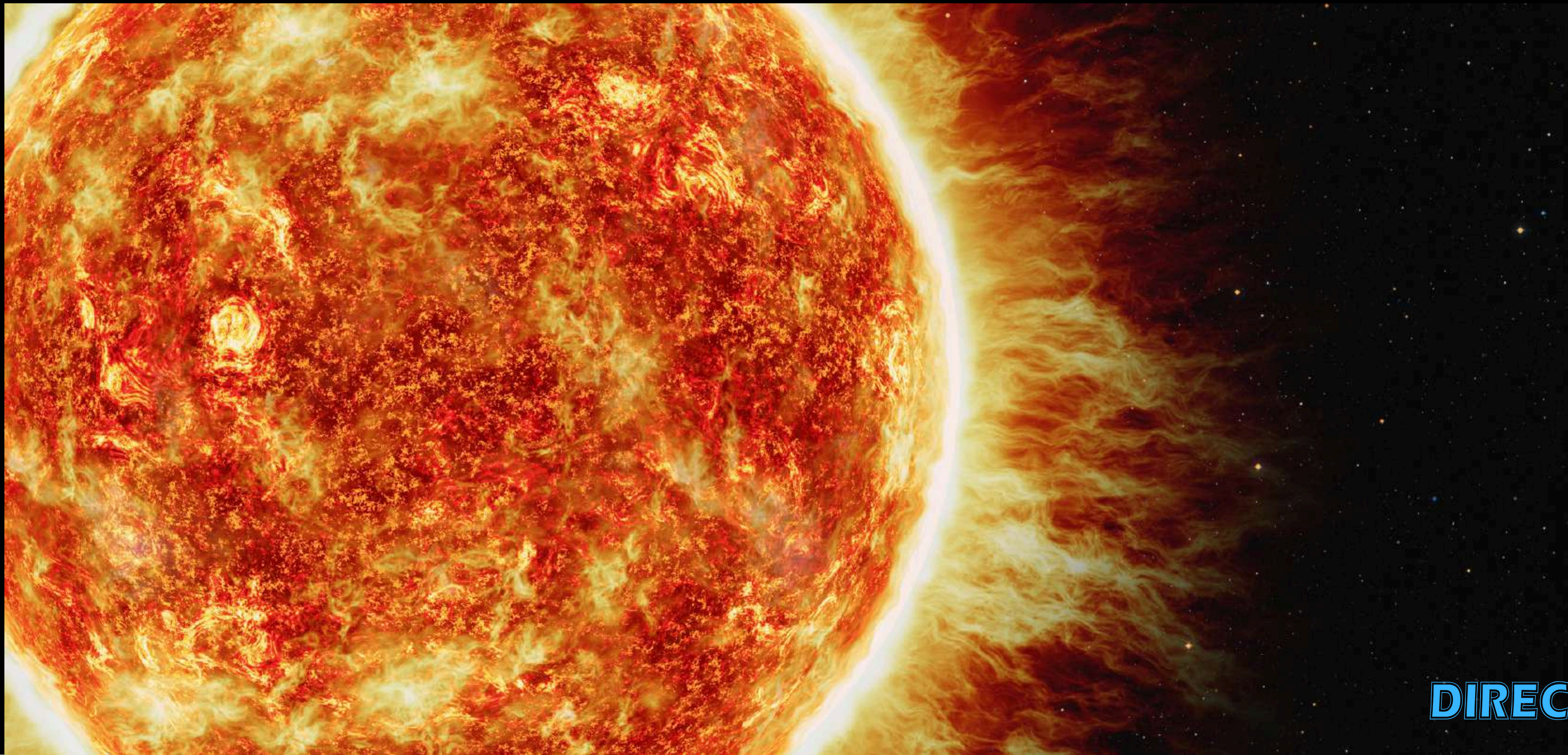
The Sun creates a tangled mess of magnetic fields — kind of like a disheveled head of hair after a fitful night of sleep. These magnetic fields get twisted up as the Sun rotates — with its equator rotating faster than its poles. Solar storms typically begin when these twisted magnetic fields on the Sun get contorted and stretched so much that they snap and reconnect (in a process called magnetic reconnection), releasing large amounts of energy.



DIRECTION

These powerful eruptions can generate any or all of the following:

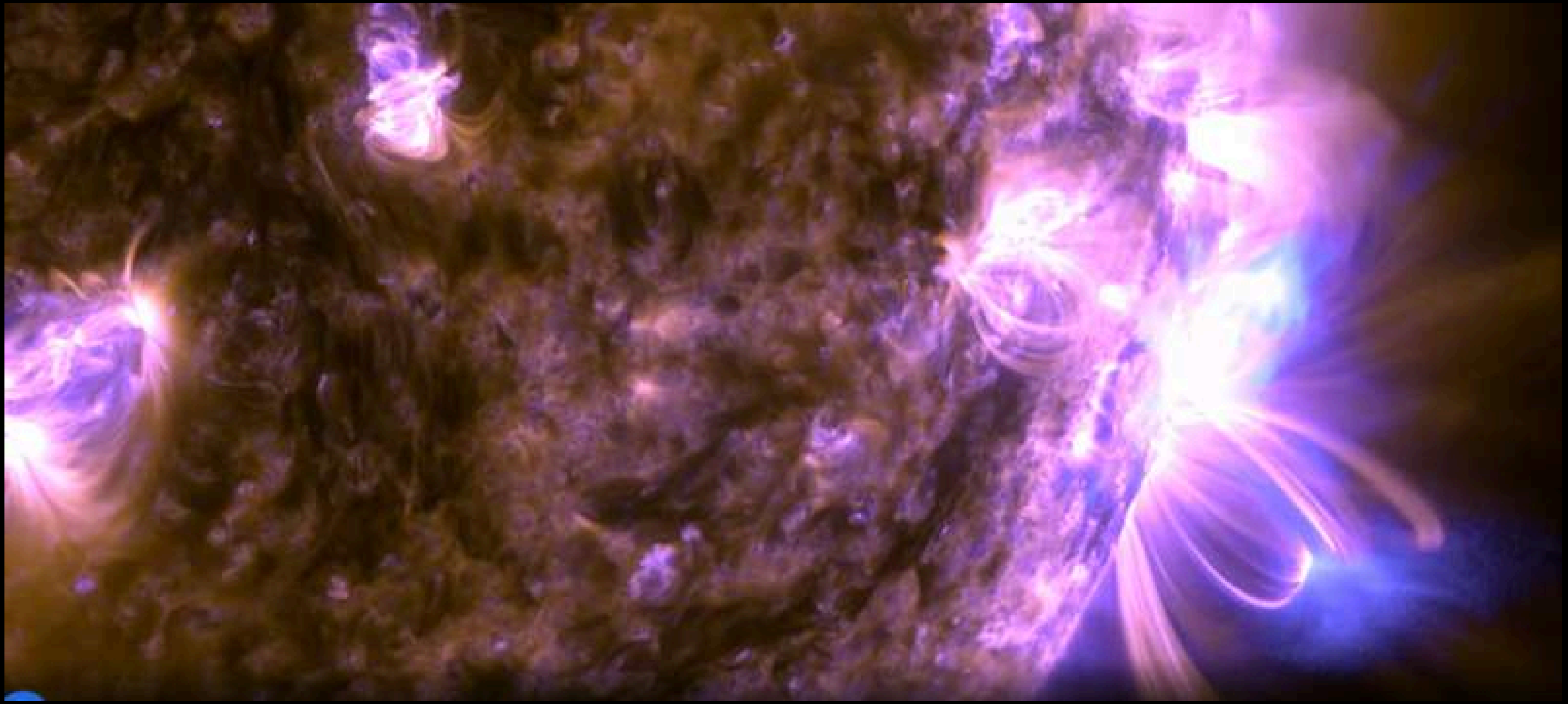
- a bright flash of light called a solar flare.
- a radiation storm, or flurry of solar particles propelled into space at high speeds.
- an enormous cloud of solar material, called a coronal mass ejection, that billows away from the Sun.



Solar Flares

A solar flare is an intense burst of radiation, or light, on the Sun. These flashes span the electromagnetic spectrum — including X-rays, gamma rays, radio waves, and ultraviolet and visible light.

Solar flares are the most powerful explosions in the solar system — the biggest ones can have as much energy as a billion hydrogen bombs.



DIRECTION

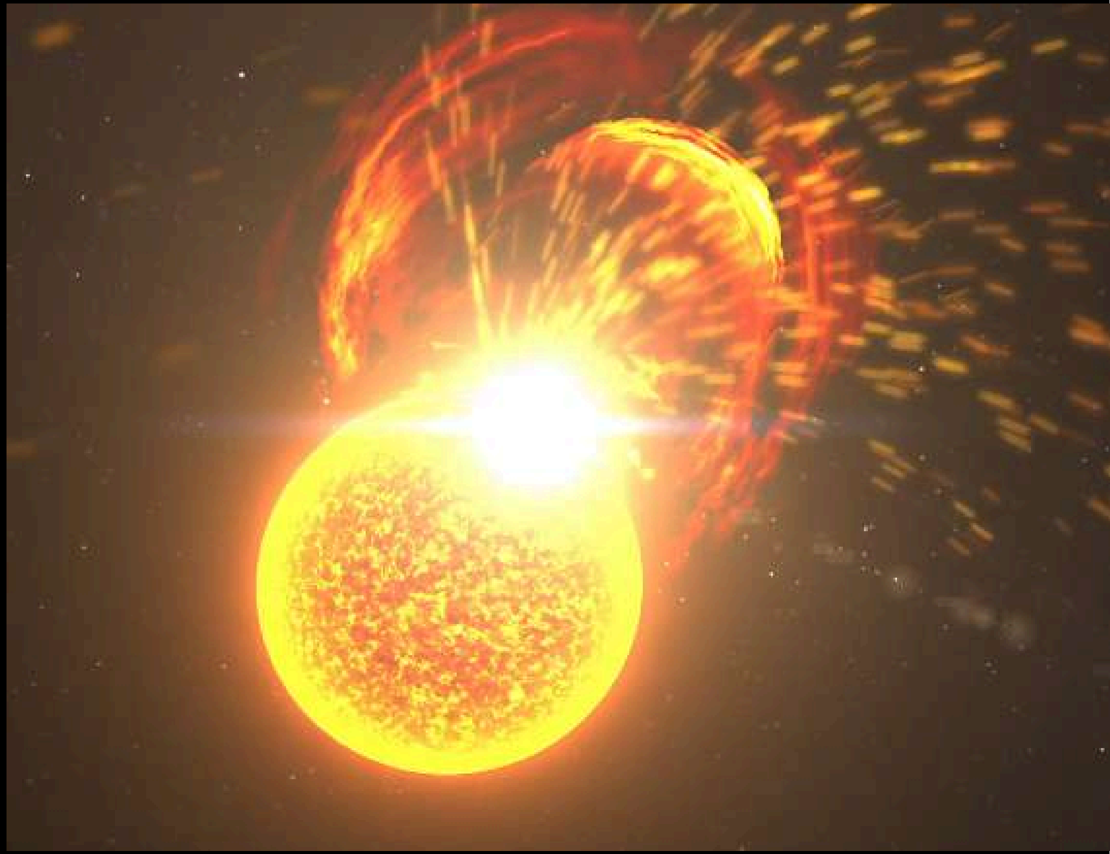
Radiation Storms

Solar eruptions can accelerate charged particles — electrons and protons — into space at incredibly high speeds, initiating a radiation storm.

The fastest particles travel so quickly they can zip across roughly 93 million miles from the Sun to Earth in about 30 minutes or less.

High-speed particles from solar eruptions can sometimes:

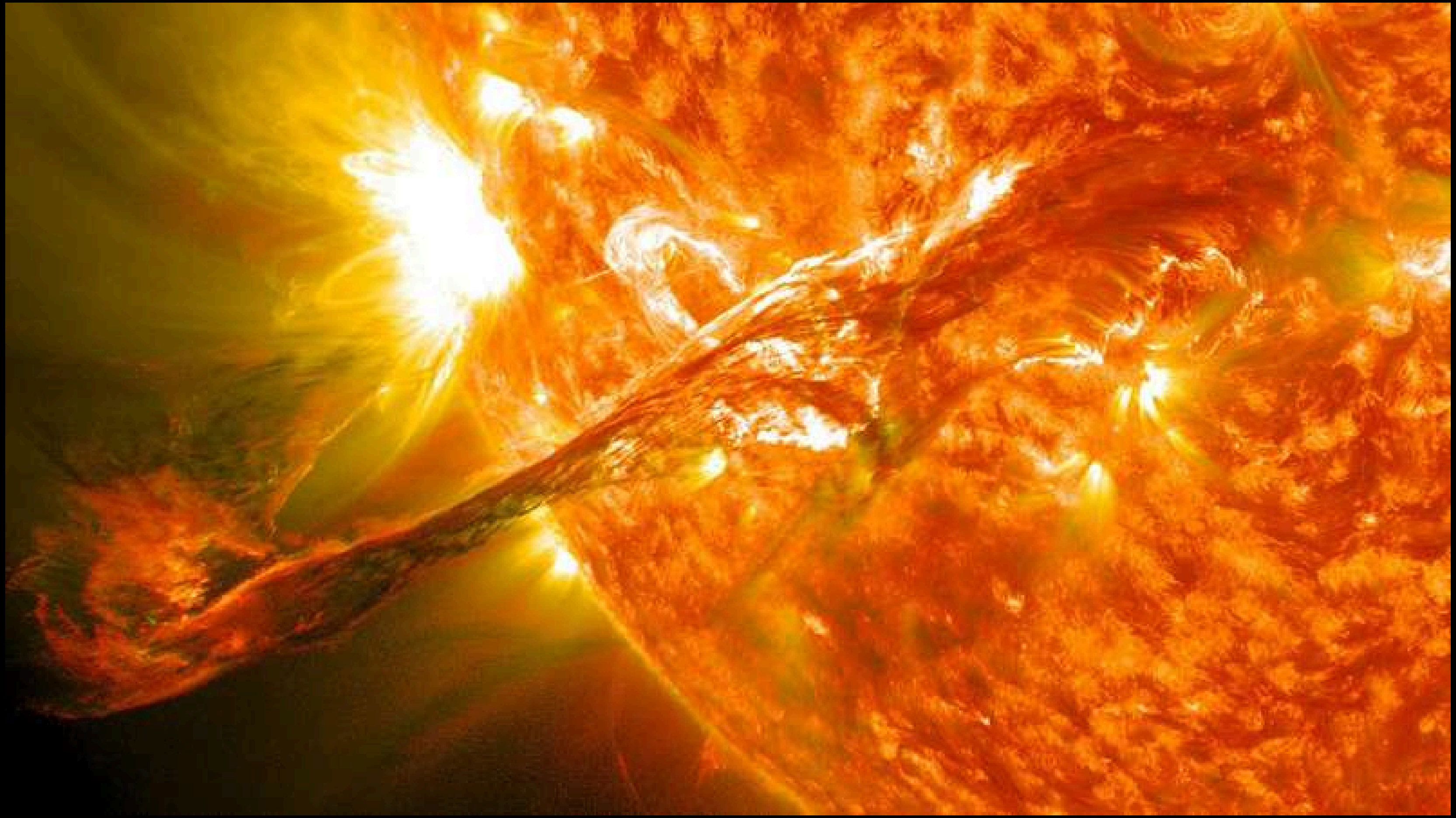
- get past most of Earth's magnetic defenses, following Earth's magnetic field lines toward the north and south poles, where they enter our atmosphere and possibly even hit the ground (but don't harm anyone on the ground).
- knock electrons off of atoms and molecules in our atmosphere (ionizing them), altering high-frequency radio communication.
- pierce deep into satellite hardware, degrading solar panels and damaging circuits.
- pass through human tissue, posing radiation risks to astronauts in space or to crewmembers and passengers in high-flying polar aircraft.



DIRECTION

Coronal Mass Ejections

A coronal mass ejection (CME) is an enormous cloud of electrically charged gas, called plasma, that erupts from the Sun. A single coronal mass ejection can blast billions of tons of material into the solar system all at once. CMEs occur in the outer atmosphere of the Sun, called the corona, and often look like giant bubbles bursting from the Sun.

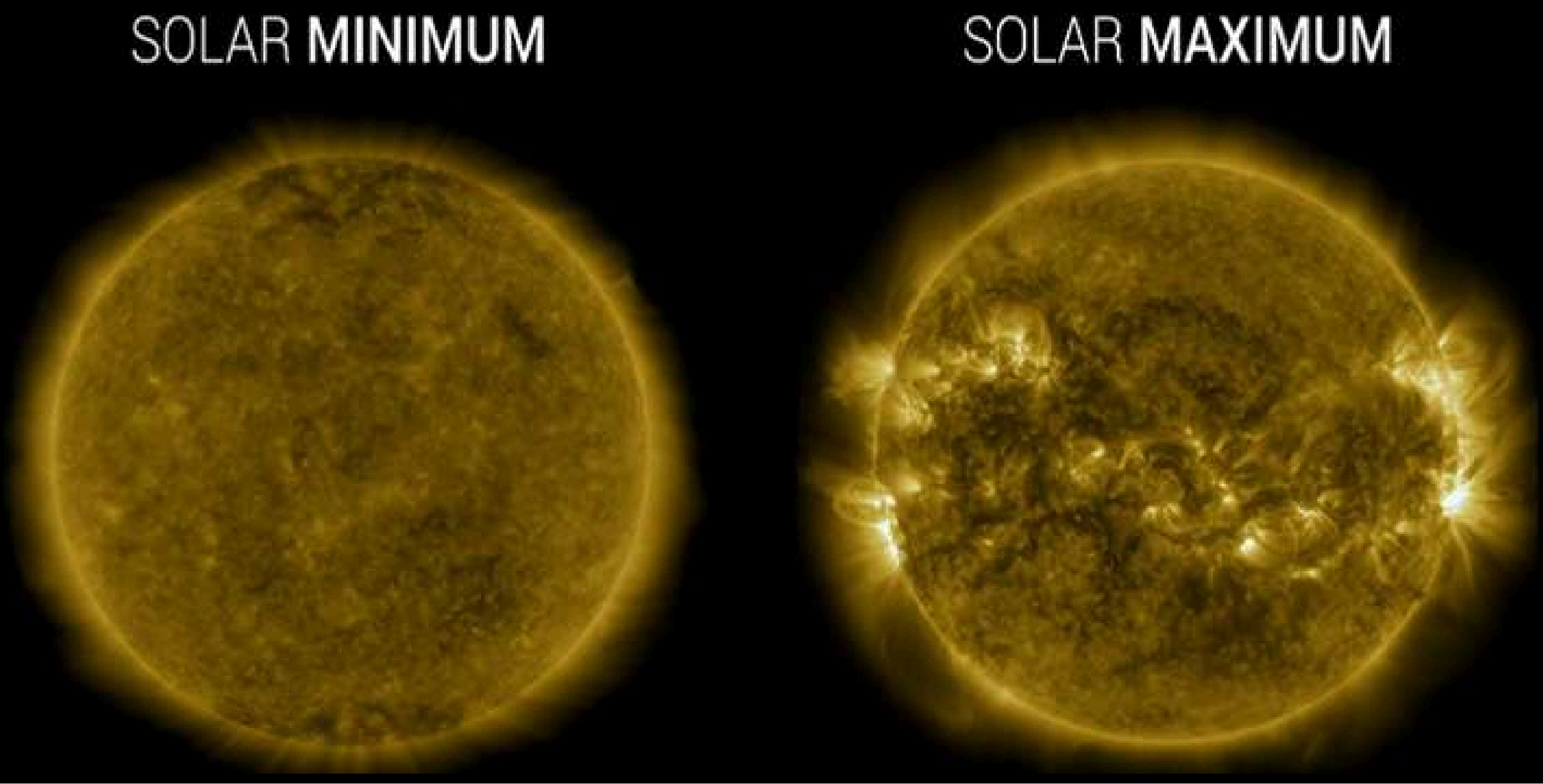


DIRECTION

Solar Activity Cycle

Solar storms and their related phenomena all wax and wane with the Sun's 11-year cycle of activity. Such events are more common during solar maximum (or peak of the solar cycle) but are less frequent during solar minimum (or low point of the cycle).

Sunspots, or dark "blemishes" on the Sun, also increase during solar maximum and mark magnetically active regions on the Sun, which give rise to solar eruptions. When a large group of sunspots or a particularly active region on the Sun comes into view, it's a good time to be on the lookout for solar storms that could be headed our way.



DIRECTION

Volcanic eruptions

Volcanic eruptions can affect climate in two main ways.

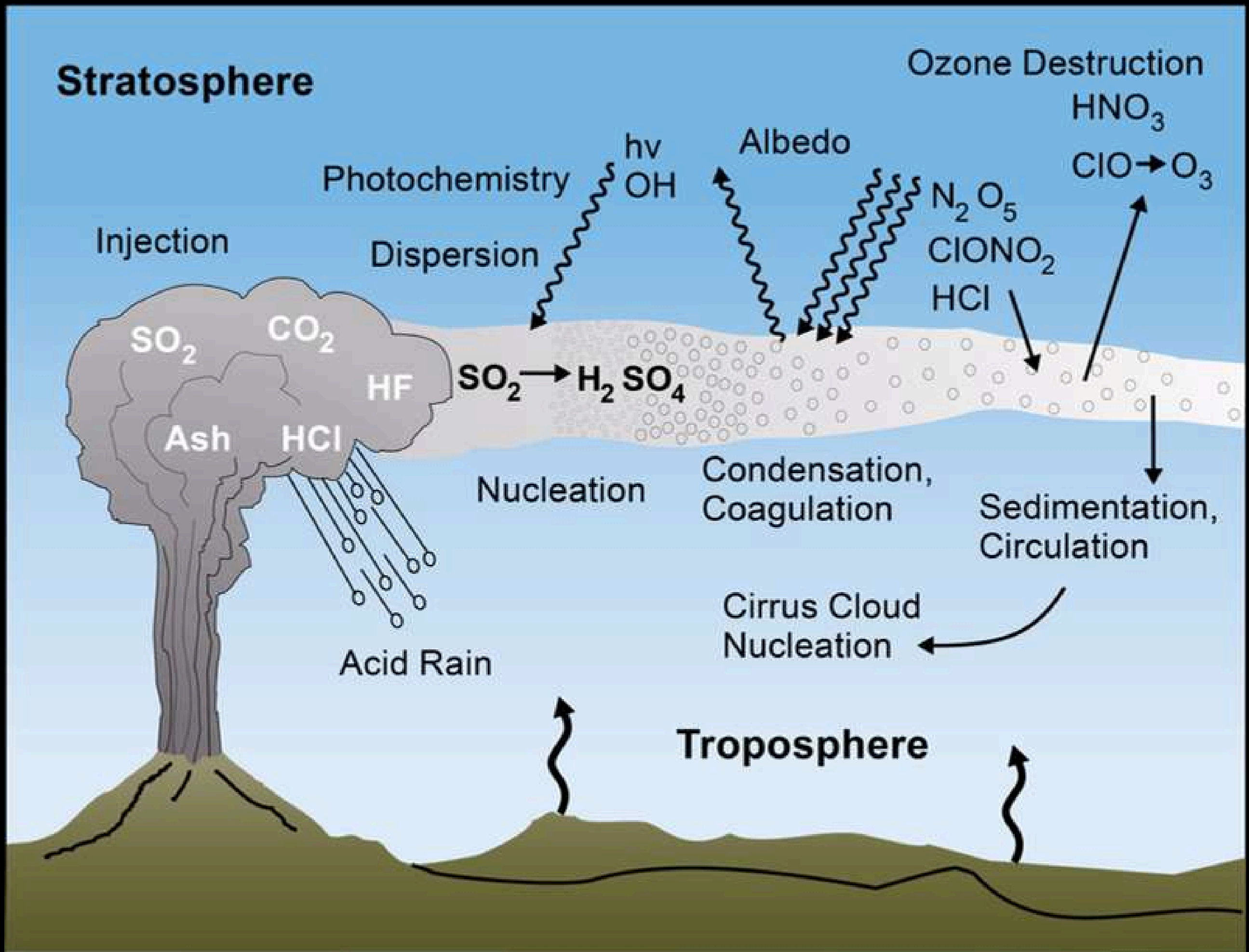
First, they release the greenhouse gas carbon dioxide, contributing to warming of the atmosphere. But the effect is very small. Emissions from volcanoes since 1750 are thought to be at least 100 times smaller than those from fossil fuel burning.

Second, sulphur dioxide contained in the ash cloud can produce a cooling effect, “Sulphur dioxide is quickly converted into sulphate aerosol which then alongside the fine volcanic ash forms a partial barrier to incoming solar radiation”

DIRECTION

Sulfate aerosols can cool the climate and deplete Earth's ozone layer

The most significant climate impacts from volcanic injections into the stratosphere come from the conversion of sulfur dioxide to sulfuric acid, which condenses rapidly in the stratosphere to form fine sulfate aerosols. The aerosols increase the reflection of radiation from the Sun back into space, cooling the Earth's lower atmosphere or troposphere.



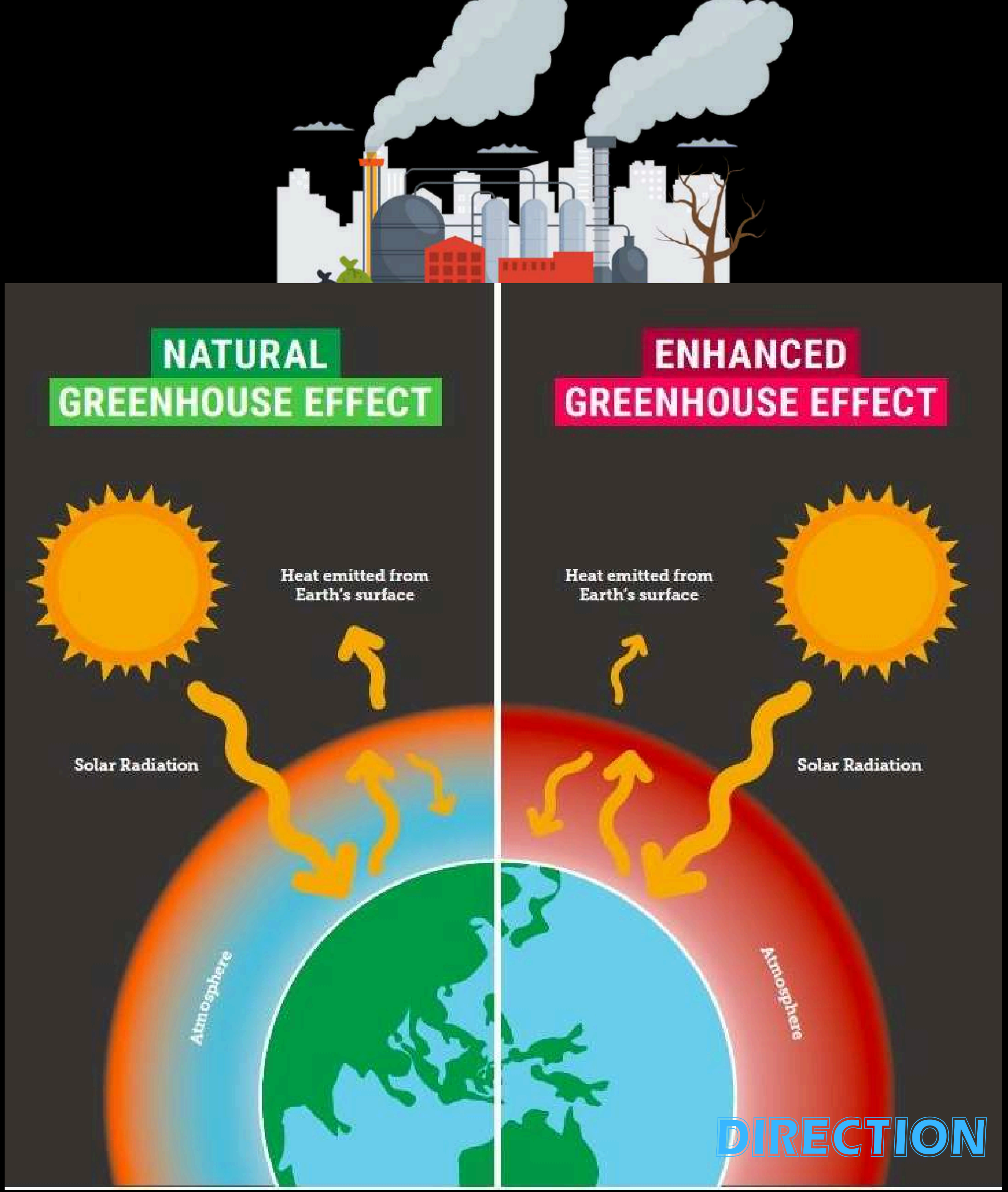
Volcanic gases react with the atmosphere in various ways; the conversion of sulfur dioxide (SO2) to sulfuric acid (H2SO4has the most significant impact on climate.

DIRECTION

GREENHOUSE EFFECT

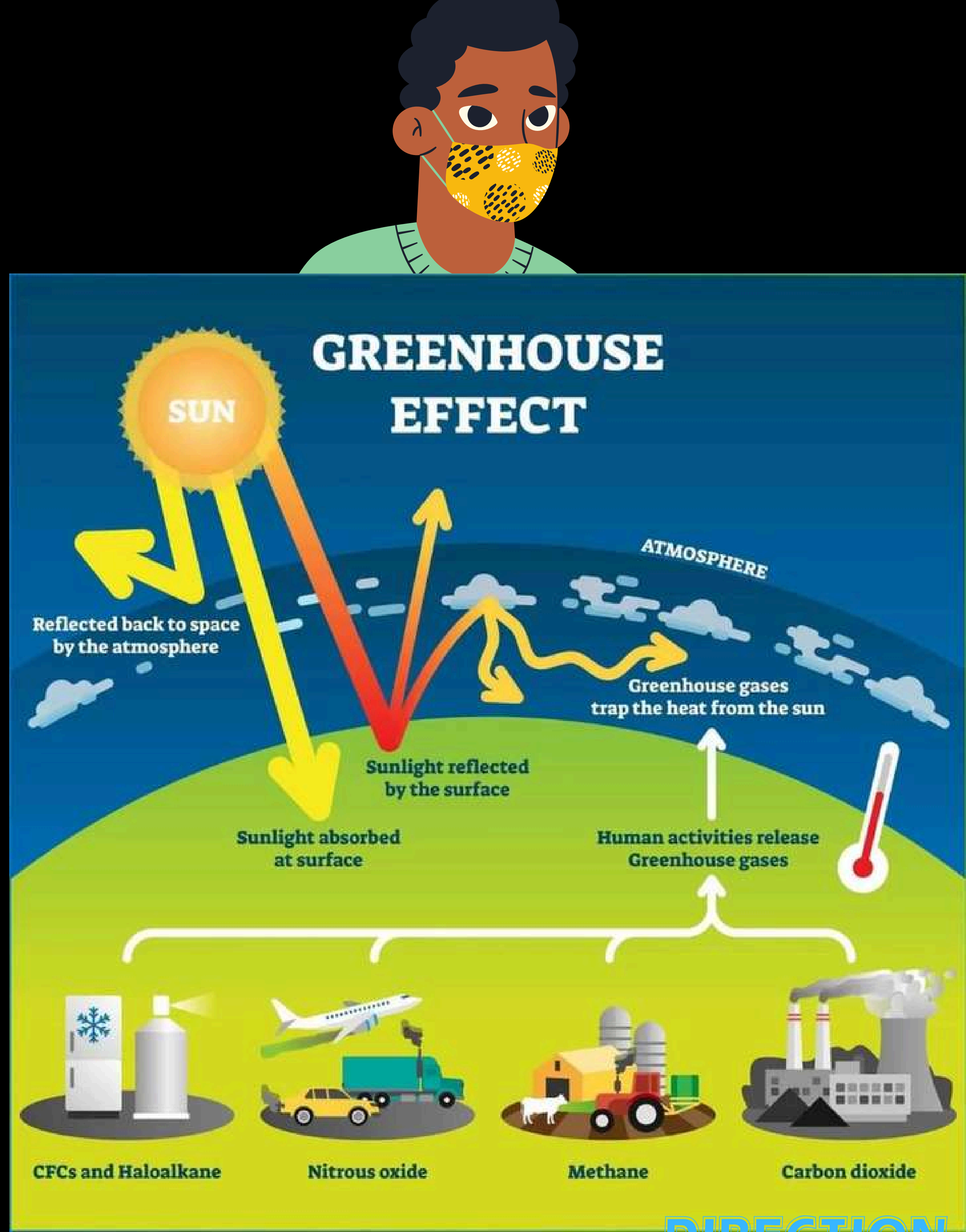
The greenhouse effect is a warming of the earth's surface and lower atmosphere caused by substances such as carbon dioxide and water vapour which let the sun's energy through to the ground but impede the passage of energy from the earth back into space.

The **atmosphere** mainly consists of these **six Greenhouse gases:** Carbon Dioxide, Nitrous Oxide, Ozone, Methane, Water Vapour and Chlorofluorocarbons. These gases not only have positive but also negative impacts on our planet.



GREENHOUSE GASES

Carbon dioxide is made up of two atoms of oxygen and an atom of carbon. Its chemical formula is represented as CO2. It is released through volcanoes, forest fires, and decaying of dead animals and plants. It is emitted from the burning of fossil fuels like coal, oil and petroleum. Factories and vehicles emit this greenhouse gas. Deforestation is yet another cause that leads to excessive carbon dioxide in the atmosphere



- The next gas, Nitrous Oxide (N_2O) also called 'the laughing gas' is released from power plants and fertilizers. N2O is found in nature in oceans and soil. This greenhouse gas is a part of the nitrogen cycle.
- The most powerful greenhouse gas of all, Methane is also known as CH_4. It is a natural greenhouse gas that is released through cattle and wetlands. Mining coal and growing rice are manmade causes of adding Methane to our environment.
- Ozone, O_3 blocks the sun's harmful ultraviolet radiation to reach us. It is the layer of the atmosphere where the planes fly. It is released from burning gas from cars and factories.
- Chlorofluorocarbons are the only manmade greenhouse gas. There is no natural source for this greenhouse gas, CFCs. It damages the Ozone layer.Excess CFCs are released by manmade devices like refrigerators, fire extinguishers, air conditioners, and aerosol sprays, etc.
- Water Vapour is water in a gaseous form. This gas condenses into liquid form and rains back on Earth. H_2O, the water which we drink is a part of this natural cycle. Water Vapour blocks heat from escaping the atmosphere making it more warmer.

DIRECTION

Greenhouse gases all contribute to global warming, but they differ in two keyways; how powerful their warming effect is, and how long they last in the atmosphere.

Converting all these gases to one standardised measure (CO2e: carbon dioxide equivalent) makes it easier to count and compare emissions , the measures used to do this is GWP

Global Warming Potential (GWP) describes how much impact a gas will have on atmospheric warming over a period of time compared to carbon dioxide. Each greenhouse gas has a different atmospheric warming impact, and some gases remain in the atmosphere for longer than others.

Carbon dioxide (CO_2) has the lowest warming potential, is the most abundant and lasts for thousands of years, so it is used as the baseline.

GWP100 is The established metric under the 2015 Paris Agreement, and is used by countries for their emissions accounting, as agreed at the United Nations level. However, when using a blanket calculation such as GWP100 we need to be mindful of its limitations when making decisions around short-lived gases

DIRECTION

Common chemical name or industrial designation	Chemical formula	GWP values for 100-year time horizon		
		Fourth Assessment Report (AR4)	Fifth Assessment Report (AR5)	Sixth Assessment Report (AR6)
Major Greenhouse Gases				
Carbon dioxide	CO_2	1	1	1
Methane – non-fossil	CH_4	25	28	27.0
Methane – fossil	CH_4	N/A	30	29.8
Nitrous oxide	N_2O	298	265	273
Nitrogen trifluoride	NF_3	17,200	16,100	17,400
Sulfur hexafluoride	SF_6	22,800	23,500	24,300

Certain synthetic gases are often classified as high-GWP gases, these include substances such as hydrofluorocarbons (HFCs), Chlorofluorocarbons (CFCs), Hydrochlorofluorocarbons (HCFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF6), all of which have GWP values up in the thousands of even tens of thousands.

On the other hand, some gases have a GWP value equal to or even lower than CO2. Ammonia, used in refrigeration and agriculture, has a GWP(X) of 0 and breaks down in the atmosphere rather quickly. Other hydrocarbons, like propane (C3H8) and butane (C4H10), usually used as fuel and refrigerants, also have a GWP well below 1 (GWP100 of 0.02 and 0.006, respectively), making them much less impactful than CO2.

DIRECTION

Greenwashing has a long history, with several high-profile cases taking place in the public sphere. Greenhushing is the newer approach to sustainability misinformation but is just as harmful to global climate action. Understanding both strategies is critical to keeping companies accountable for their corporate sustainability aspirations.

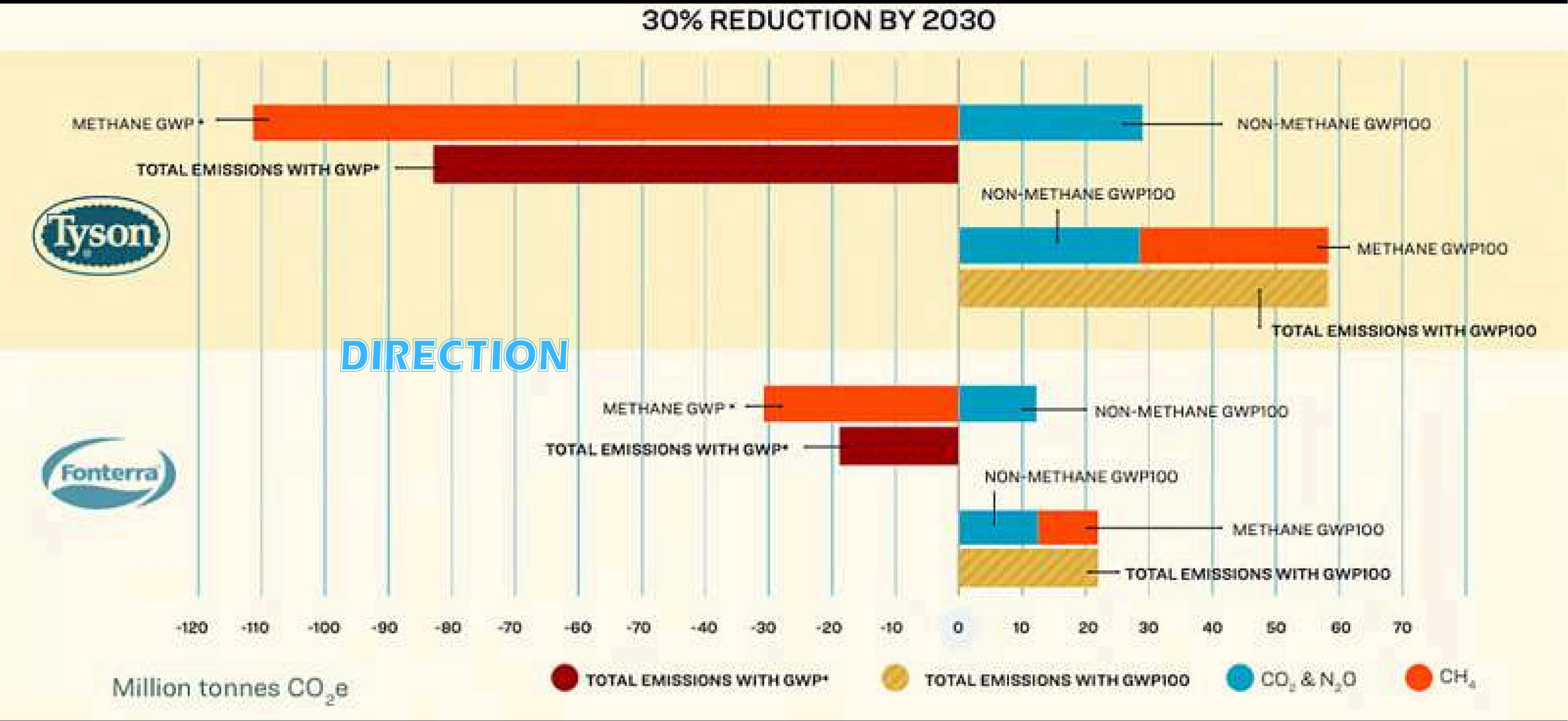
Greenwashing is the act of misleading stakeholders into believing that a company's products, aims or policies are more environmentally friendly than they are. It's a deceptive marketing ploy that can involve exaggerating or fabricating sustainability claims. For instance, a company may claim that their products are made with 100% recycled materials when they only contain a tiny fraction.

On the other hand, greenhushing is when companies under-communicate their genuine green initiatives. It's a quieter strategy whereby companies claim to have noteworthy sustainability practices and measures but choose not to promote or mention them. A company might have significantly reduced its carbon footprint but won't publicise this achievement, fearing further scrutiny or the responsibility of upholding such standards in every business area

DIRECTION

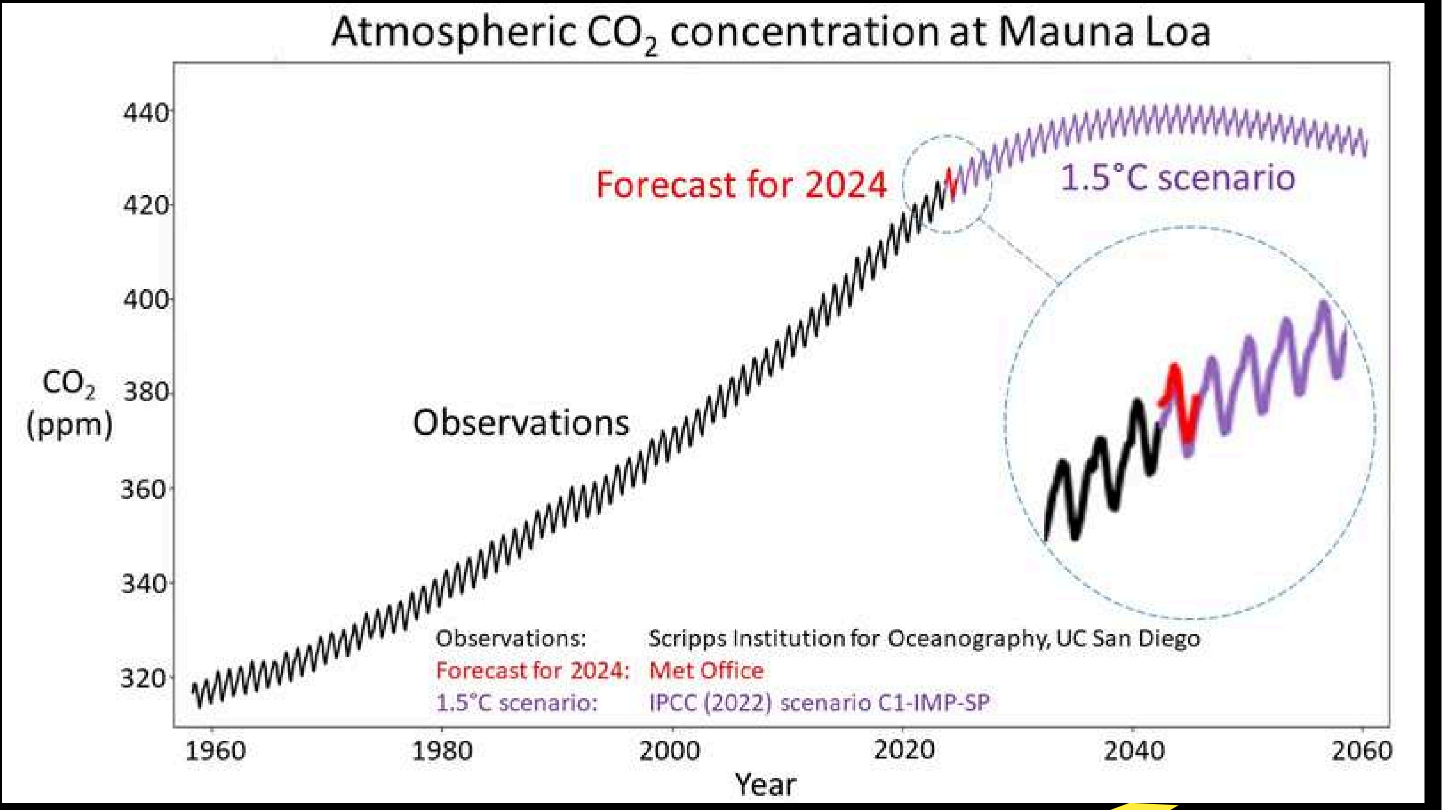
Some of the world's big, industrialised meat and dairy companies have been promoting a new metric for measuring methane emissions, called GWP* (pronounced as GWP star), which they argue is a more accurate way to calculate emissions from the greenhouse gas (GHG).

The application of GWP* at a national or corporate level requires setting certain parameters that can radically alter how the impact of the same emissions is presented. Depending on the choice of baseline year, the same volume of methane emissions can be described as causing warming, no warming or even cooling. This has meant it can be used by major methane emitters to justify continuing business as usual, resulting in lack of action to cut methane emissions



Carbon dioxide levels in 2024

Based on the annual analysis from NOAA’s Global Monitoring Lab, global average atmospheric carbon dioxide was 422.8 parts per million (“ppm,” for short) in 2024, a new record high. The increase during 2024 was 3.75 ppm—the largest one-year increase on record. the annual average carbon dioxide in 2024 was 424.61 ppm, also a new record.



Atmospheric CO2 Jump in 2024 off Track With Trajectory Needed to Meet 1.5C Goal

NO (Nitric Oxide)

Role in the atmosphere: NO is a short-lived gas that participates in the formation and breakdown of ozone (O_3) in both the troposphere and stratosphere.

Climate impact: It indirectly affects climate by influencing ozone levels, which are important greenhouse gases. However, NO itself is not a significant greenhouse gas.

NO_2 (Nitrogen Dioxide)

Role in the atmosphere: NO_2 is part of the nitrogen oxides (NO_x) group and contributes to the formation of tropospheric ozone and secondary aerosols.

Climate impact:

Indirectly warms the atmosphere by promoting ozone formation (a greenhouse gas).

Can also contribute to cooling by forming aerosols that reflect sunlight.

Overall, its net effect depends on local atmospheric conditions.

N_2O (Nitrous Oxide)

Role in the atmosphere: N_2O is a long-lived greenhouse gas produced mainly by agricultural activities, such as fertilizer use and livestock waste.

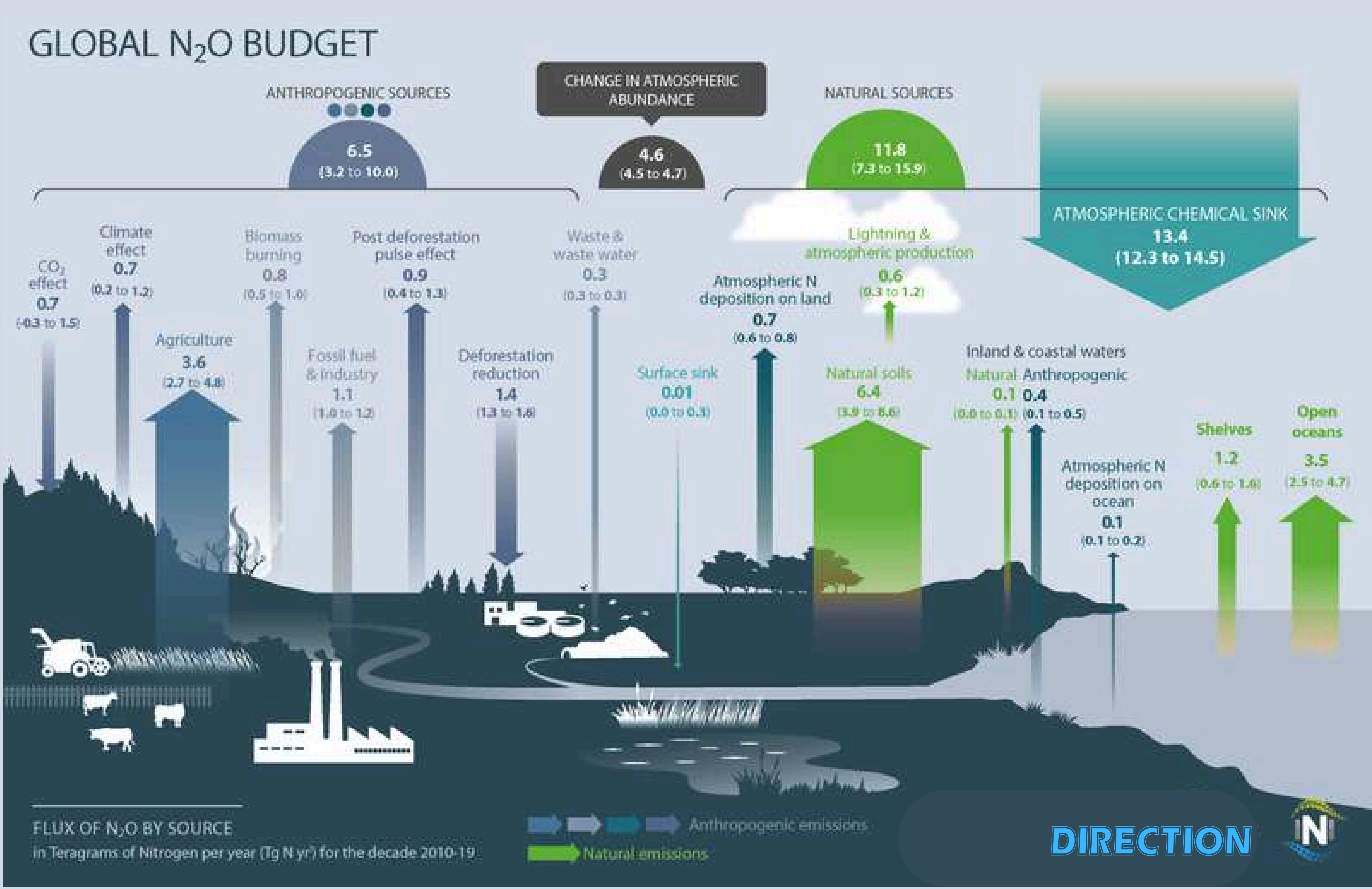
Climate impact:

It is the third most important long-lived greenhouse gas after CO_2 and CH_4.

Has a global warming potential about 265–300 times greater than CO_2 over 100 years.

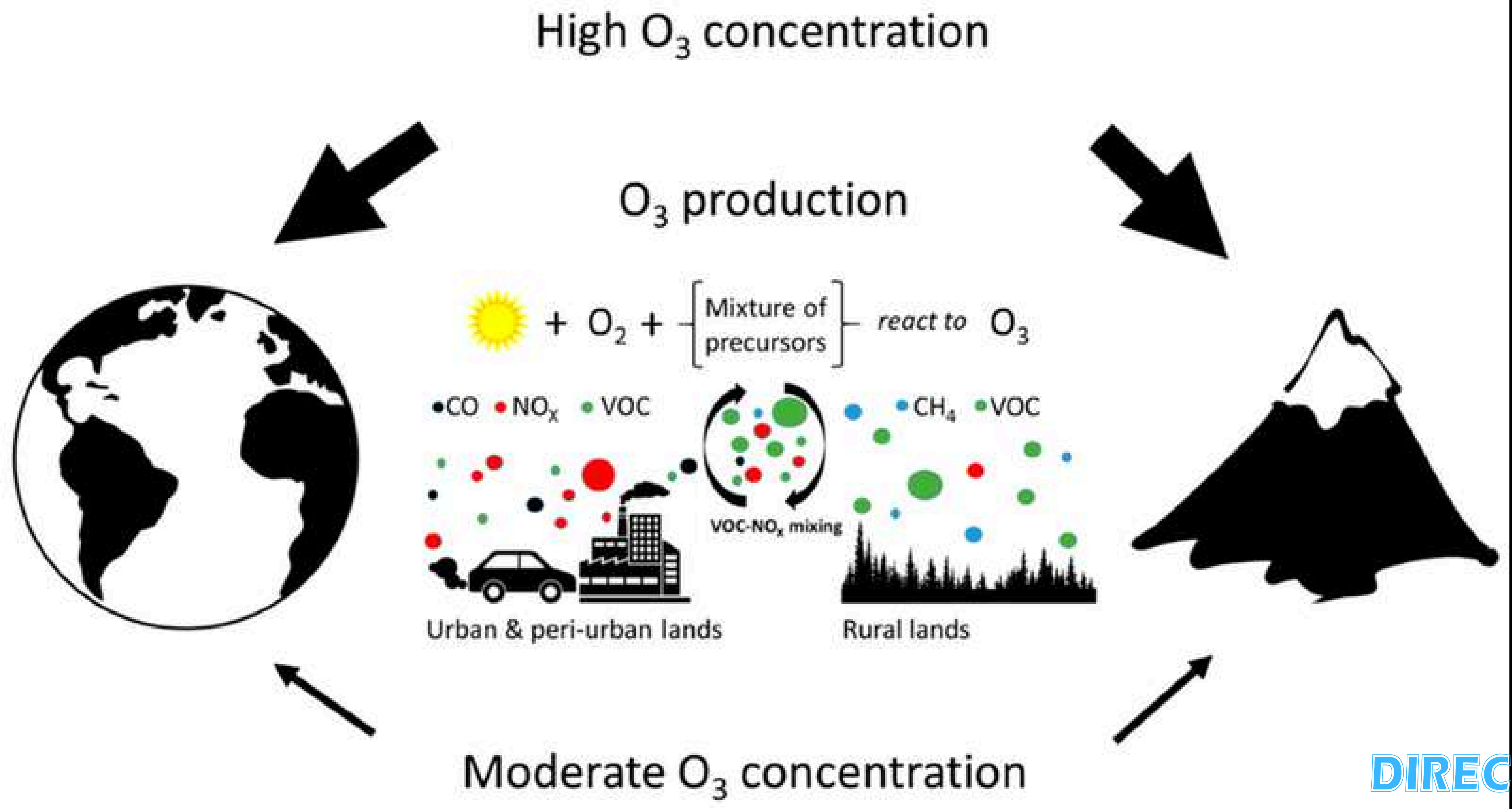
Also contributes to stratospheric ozone depletion when it breaks down into reactive nitrogen species.

DIRECTION



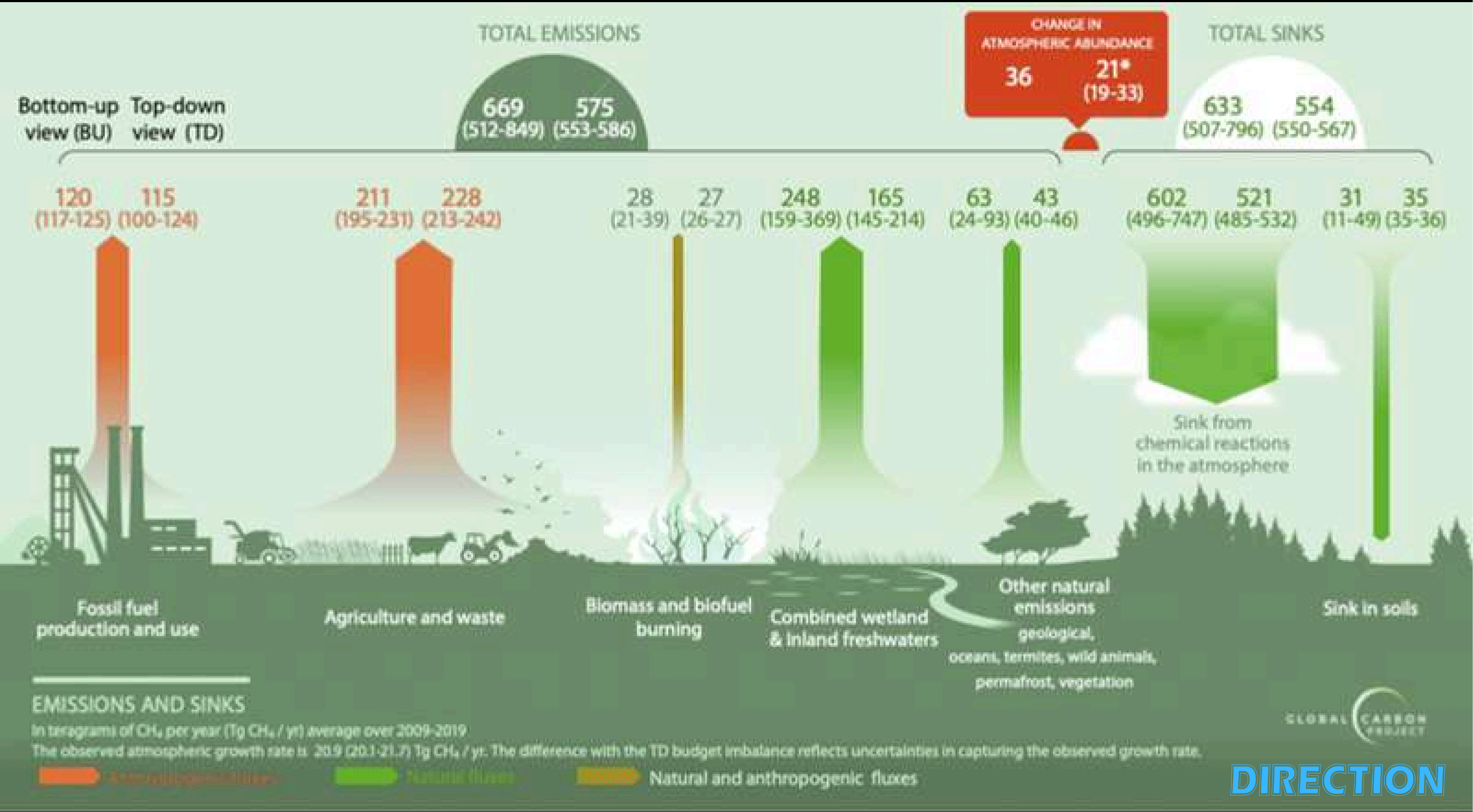
GLOBAL N_2O BUDGET
ANTHROPOGENIC SOURCES
6.5
(3.2 to 10.0)
CHANGE IN ATMOSPHERIC ABUNDANCE
4.6
(4.5 to 4.7)
NATURAL SOURCES
11.8
(7.3 to 15.9)
ATMOSPHERIC CHEMICAL SINK
13.4
(12.3 to 14.5)
CO_2 effect
0.7
(-0.3 to 1.5)
Climate effect
0.7
(0.2 to 1.2)
Agriculture
3.6
(2.7 to 4.8)
Biomass burning
0.8
(0.5 to 1.0)
Fossil fuel & industry
1.1
(1.0 to 1.2)
Post deforestation pulse effect
0.9
(0.4 to 1.3)
Deforestation reduction
1.4
(1.3 to 1.6)
Waste & waste water
0.3
(0.3 to 0.3)
Surface sink
0.01
(0.0 to 0.3)
Atmospheric N deposition on land
0.7
(0.6 to 0.8)
Lightning & atmospheric production
0.6
(0.3 to 1.2)
Natural soils
6.4
(3.9 to 8.6)
Inland & coastal waters
Natural
0.1
(0.0 to 0.1)
Anthropogenic
0.4
(0.1 to 0.5)
Atmospheric N deposition on ocean
0.1
(0.1 to 0.2)
Shelves
1.2
(0.6 to 1.6)
Open oceans
3.5
(2.5 to 4.7)
FLUX OF N_2O BY SOURCE
in Teragrams of Nitrogen per year (Tg N yr^{-1}) for the decade 2010-19
Anthropogenic emissions
Natural emissions
DIRECTION

Tropospheric (or ground-level) ozone is a short-lived climate pollutant that remains in the atmosphere for only hours to weeks.
It does not have any direct emissions sources, rather it is a compound formed by the interaction of sunlight with volatile organic compounds (VOCs) – including methane – and nitrogen oxides (NOX) emitted largely by human activities.



DIRECTION

Global Methane Budget -2024



Carbon footprint

According to the United Nations Framework Convention on Climate Change, a carbon footprint is a change in climate attributed directly or indirectly to human activity that alters the composition of the world's atmosphere.A carbon footprint is an environmental indicator that represents the amount of greenhouse gases (GHGs), expressed as CO_2 equivalents, that are emitted directly or indirectly as a result of a specific activity

Individual carbon footprint

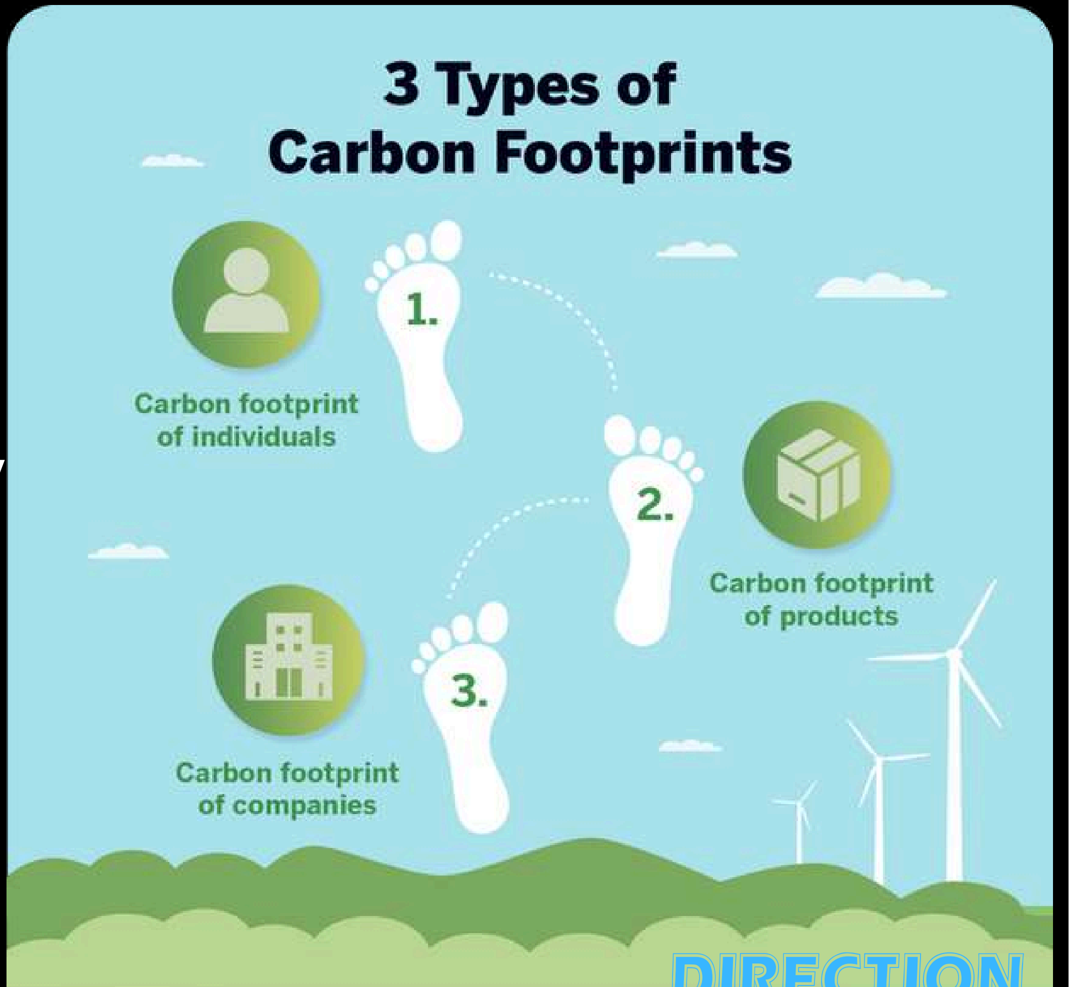
It's based on the consumption habits of the person and takes into account GHG emissions associated with their means of transportation, electricity use for heating and cooling at home, eating habits, and consumption of goods.

Product footprint

This includes the GHG emissions from the stages of raw material extraction, production process, required energy generation, the transportation between stages, the customer's usage, and its treatment as waste.

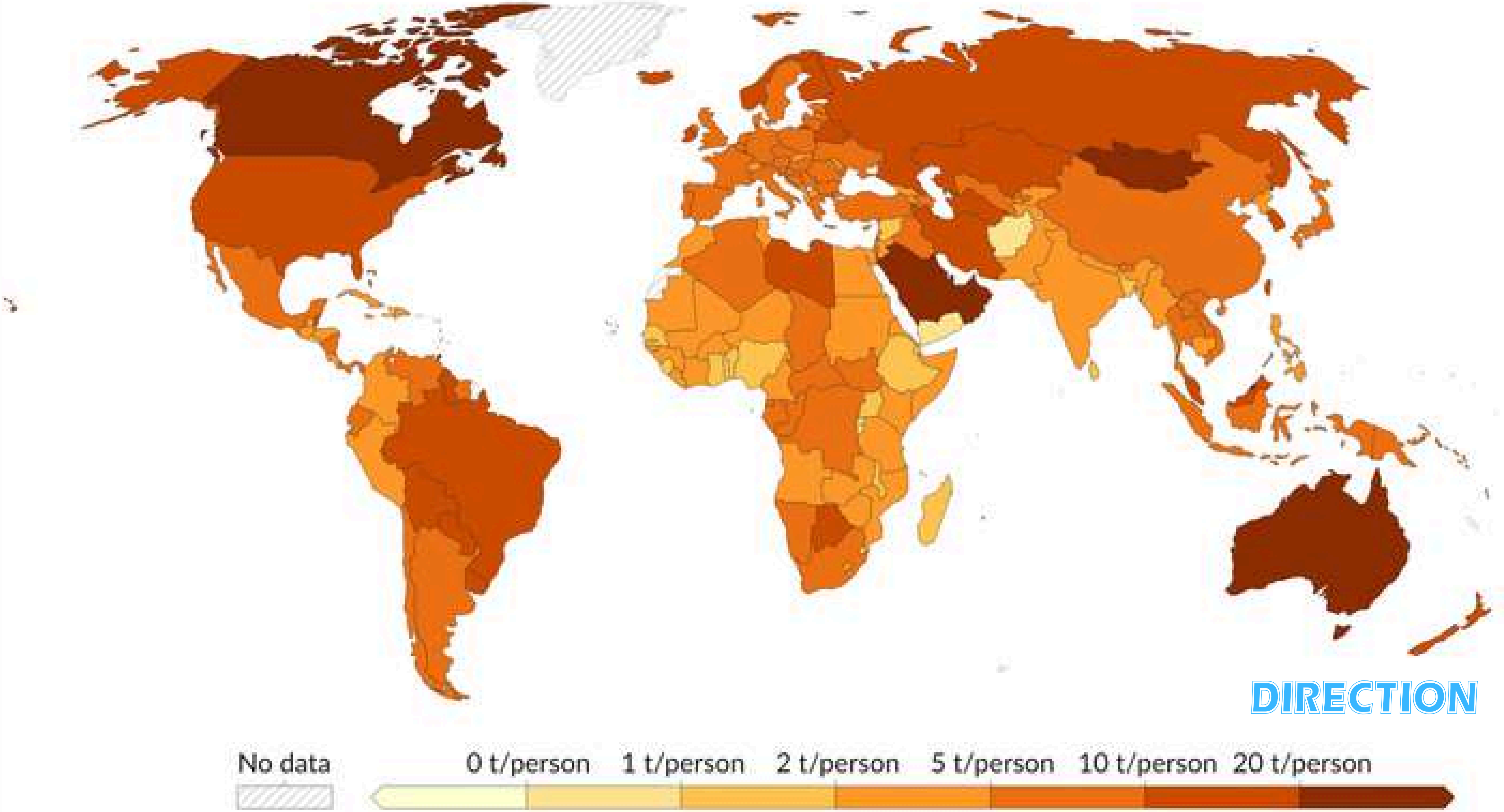
Corporate footprint

It includes the GHG emissions inventory related to a company or organization's operations. It serves to identify energy efficiency measures within the organization, as well as action measures with other companies in the sector.



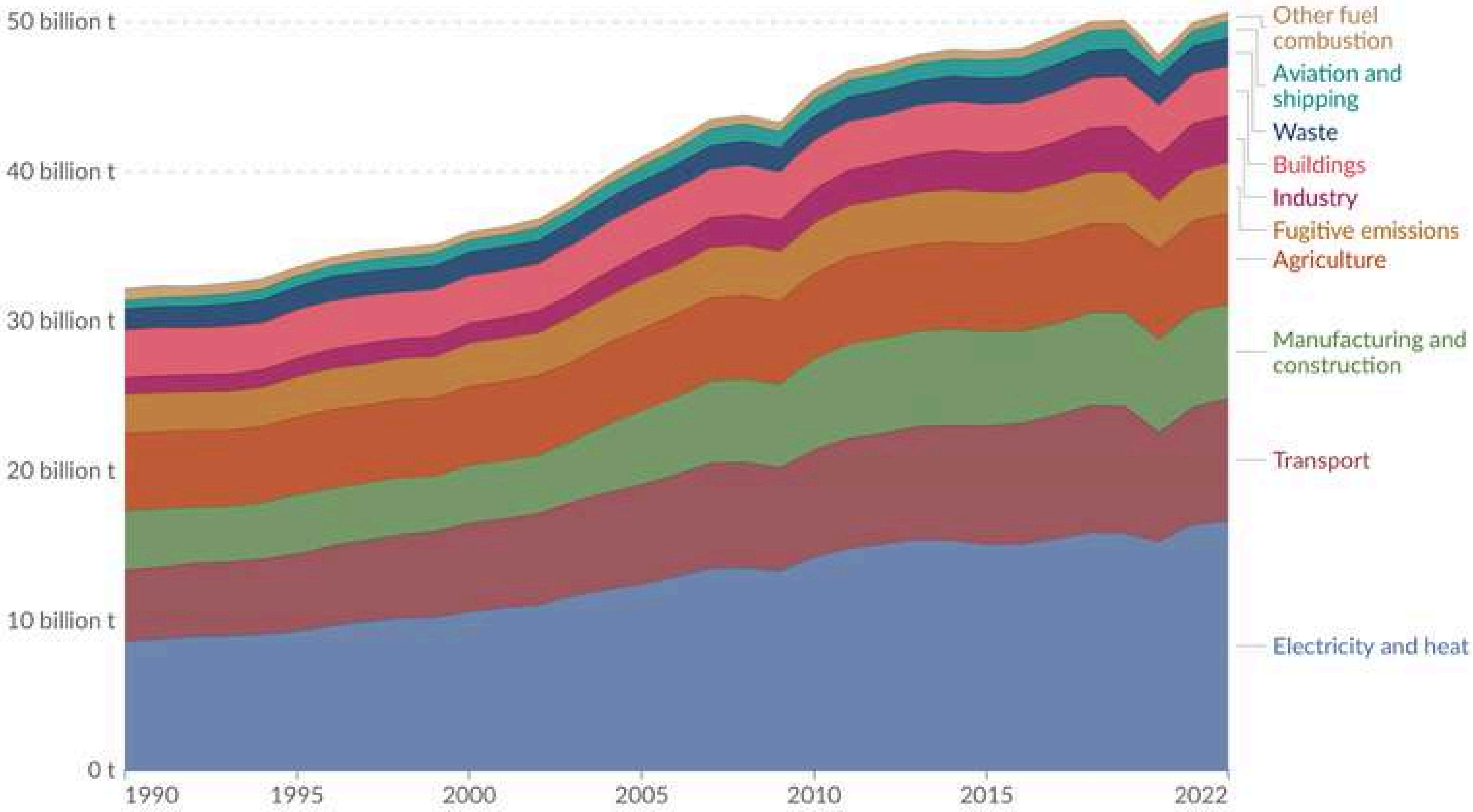
Per capita greenhouse gas emissions, 2023

Greenhouse gas emissions[1] include carbon dioxide, methane and nitrous oxide from all sources, including land-use change. They are measured in tonnes of carbon dioxide-equivalents[2] over a 100-year timescale.



Rank	Country	$MtCO_2$ (million tons of CO_2)	Percentage of World CO2 Emission
1	China	12,667	32.88%
2	United States of America	5,057	12.6%
3	India	2,830	6.99%
4	Russia	2,032	4.96%
5	Japan	1,083	2.81%
6	Indonesia	729	1.8%
8	Iran	691	1.78%
7	Germany	673	1.75%
9	Saudi Arabia	663	1.66%
10	South Korea	636	1.53%

Greenhouse gas emissions[1] are measured in tonnes of carbon dioxide-equivalents[2] over a 100-year timescale. Land-use change emissions are not included.



Carbon Bombs

A coal, oil or fossil gas project with a potential to emit over a Gigaton of CO_2 is a carbon bomb. There are 425 of them around the world. The Guardian reported about the global picture of the oil & gas carbon bombs (excluding coal), here in May 2022.

Over a third of the carbon bombs are currently being prepared and have not yet started extraction. Defusing them is essential for meeting the Paris Agreement temperature targets.

The four countries with the biggest number of carbon bombs are China, the United States, Russia and Saudi-Arabia.

. **"Leave fossil fuels in the ground"** is a call to action to stop extracting and burning oil, gas, and coal to prevent catastrophic climate change. It is based on the scientific understanding that burning existing reserves will release more greenhouse gases than the atmosphere can safely absorb, requiring a significant portion of these fuels to remain unburned to meet climate targets like limiting warming to 1.5- 2°C

DIRECTION

Key findings of Leave fossil fuels in the ground

- 1,400 Gt CO_2 – Total potential emissions from carbon bombs plus post-2021 extraction projects, about 11× the remaining 1.5 °C budget of ~130 Gt.
- 601 carbon bombs are identified in the database. Since identification, oil and methane gas bombs alone have emitted 54+ Gt CO_2.
- Nearly 30 new carbon bombs have started operating since 2021, while only 3 have been officially cancelled.
- 2,343 new extraction projects have been approved since 2021 – 1,979 large oil and methane gas fields, and 364 large coal mines – despite 1.5 °C pathways calling for no new fossil expansion.
- US$1.6 trillion in bank financing has flowed to companies behind carbon bombs and new extraction projects since 2021. Most of this is corporate finance; project finance is ~4% of total fossil support.

Climate sensitivity

Climate sensitivity is the measure of how much Earth's average surface temperature will change in response to a doubling of atmospheric carbon dioxide concentration. It is a key factor in climate science, with current estimates placing the likely warming at around ,3 degrees C for a doubling of CO2 levels, though the range is uncertain, generally between 2.5 and 4 degree C. This warming is influenced by various feedback loops within the climate system,

There are several ways of defining climate sensitivity, depending on the timescales of interest. Two of those are:

Transient Climate Response (TCR): The temperature increase at the instant that atmospheric CO_2 has doubled (following an increase of 1% each year) gives us the Transient Climate Response. This is useful as a gauge for what we might expect over the current century when atmospheric concentrations of CO_2 are changing.

Equilibrium Climate Sensitivity (ECS): The climate system will continue to warm for some time after the TCR point, largely as the oceans are very slow to respond. Therefore we can also consider the temperature increase that would eventually occur (after hundreds or even thousands of years) when the climate system fully adjusts to a sustained doubling of CO_2 – this is called the Equilibrium Climate Sensitivity. The long timescales involved here mean ECS is arguably a less relevant measure for policy decisions around climate change.

DIRECTION

Climate Feedback Loops can be Positive or Negative

Positive feedback loop

A positive feedback loop is a self-reinforcing cycle where the output of a process amplifies the original process, leading to a snowball effect or exponential response

Ice-albedo feedback: As ice and snow melt, they expose darker land or ocean surfaces. The darker surfaces have a lower albedo (reflectivity), so they absorb more solar energy, leading to further warming and more melting.

Water vapor feedback: A warmer atmosphere can hold more water vapor, which is a potent greenhouse gas. This increases the greenhouse effect, leading to further warming and even more evaporation, creating a self-reinforcing cycle.

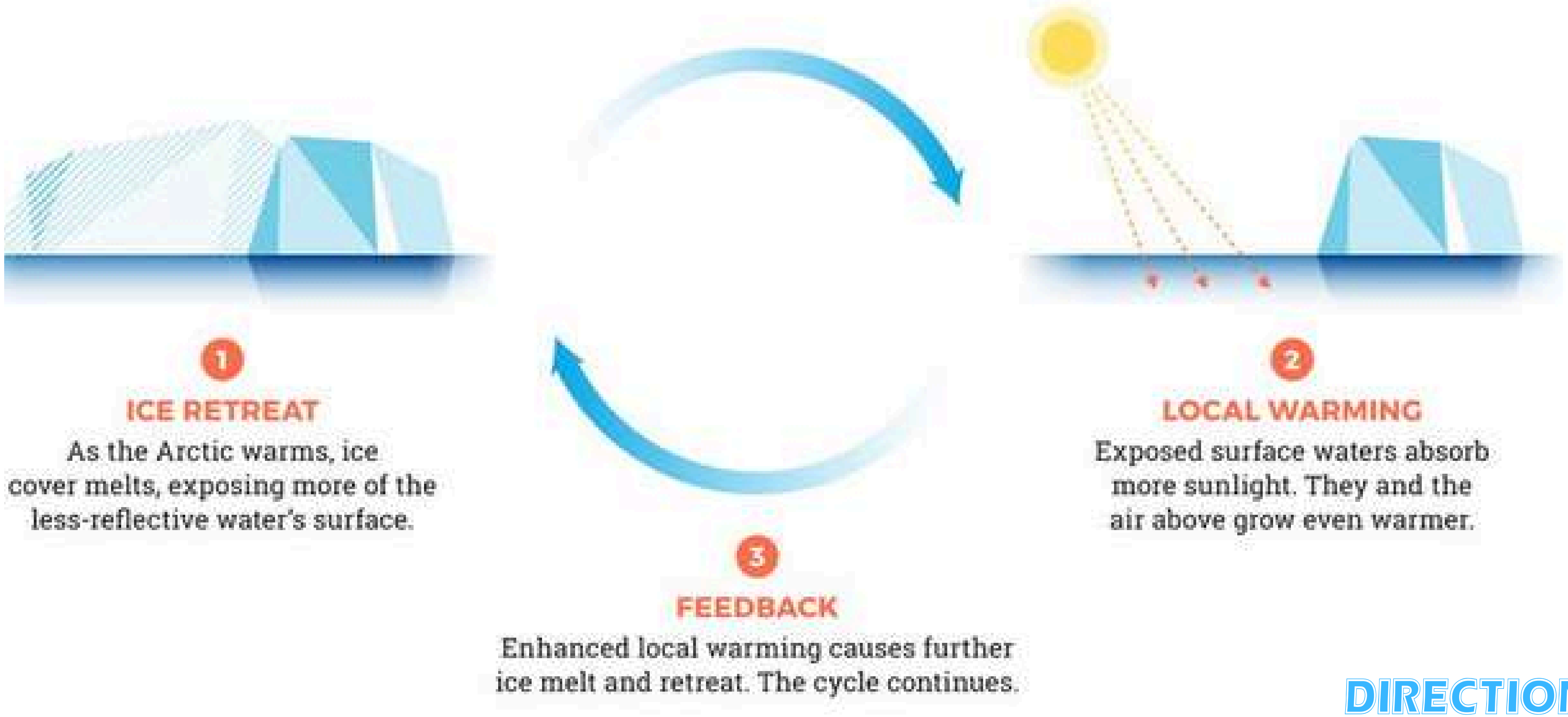
Permafrost thaw: As global temperatures rise, permafrost (permanently frozen soil) thaws. This releases large amounts of stored methane and carbon dioxide into the atmosphere, which are powerful greenhouse gases that accelerate warming.

Forest fires: Drier conditions, a result of warming, increase the frequency and severity of forest fires. The fires release large amounts of CO2 into the atmosphere and destroy trees that would otherwise absorb CO2, further amplifying warming.

DIRECTION

Sea Ice Albedo Feedback Cycle

A major factor in the rapid warming of icy places like the Arctic is sea ice albedo feedback, a cycle that makes warming more severe where ice is lost. A surface's "albedo" is how reflective it is of sunlight.



Negative feedback loop

A negative feedback loop is a process where the output of a system is used to reduce or counteract the stimulus that produced it, thereby stabilizing the system

Ocean heat absorption: The ocean absorbs a significant amount of the excess heat in the atmosphere, which helps to keep global temperatures from rising as fast as they otherwise would.

Plant growth and CO_2 absorption: Higher atmospheric CO_2 levels can stimulate plant growth, and as plants grow, they take up more CO_2 from the atmosphere through photosynthesis.

Increased cloudiness: Increased evaporation from warmer oceans could lead to more clouds. Some types of clouds can reflect incoming solar radiation back into space, which has a cooling effect.

DIRECTION

Causes and Effects of Climate Change

Causes

- Rapid industrialization
- Energy use
- Agricultural practices
- Deforestation
- Consumer practices
- Livestock
- Transport
- Resource extraction
- Pollution

Effects

- Rising temperatures
- Rising sea levels
- Unpredictable weather patterns
- Increase in extreme weather events
- Land degradation
- Loss of wildlife and biodiversity

What are the social impacts of climate change?

Displaced people. Poverty. Loss of livelihood. Hunger. Malnutrition. Increased risk of diseases. Global food and water shortages.

DIRECTION

Heat Wave

A persistent period of unusually hot days is referred to as an extreme heat event or a heat wave.A heatwave can be defined as a period where local excess heat accumulates over a sequence of unusually hot days and nights. Heat waves are more than just uncomfortable: they can lead to illness and death, particularly among older adults, the very young, and other vulnerable populations . Prolonged exposure to excessive heat can lead to other impacts as well—for example, damaging crops, injuring or killing livestock, and increasing the risk of wildfires. Prolonged periods of extreme heat can lead to power outages as heavy demands for air conditioning strain the power grid.

- Heatwaves amplify many risks, such as health-related or economic risks, including increased human mortality, drought and water quality, wildfire and smoke, power shortages and agricultural losses.
- In 2022, a heatwave in China lasted over 70 days, making it the country's worst on record.
- Devastating heatwaves in India and Pakistan in 2022 were made 30 times more likely due to climate change.
- In 2018, more than 220 million vulnerable people were exposed to heat wave the elderly and infirm, pregnant women, infants, outdoor workers and athletes.
- Urban areas can be up to 5°C to 10°C warmer than surrounding areas, increasing the heatwave intensity and associated risks.

Indian Meteorological Department (IMD)

A **Heat Wave** is a period of abnormally high temperatures, more than the normal maximum temperature that occurs during the summer season in the North-Western parts of India. Heat Waves typically occur between March and June, and in some rare cases even extend till July. The extreme temperatures and resultant atmospheric conditions adversely affect people living in these regions as they cause physiological stress, sometimes resulting in death.

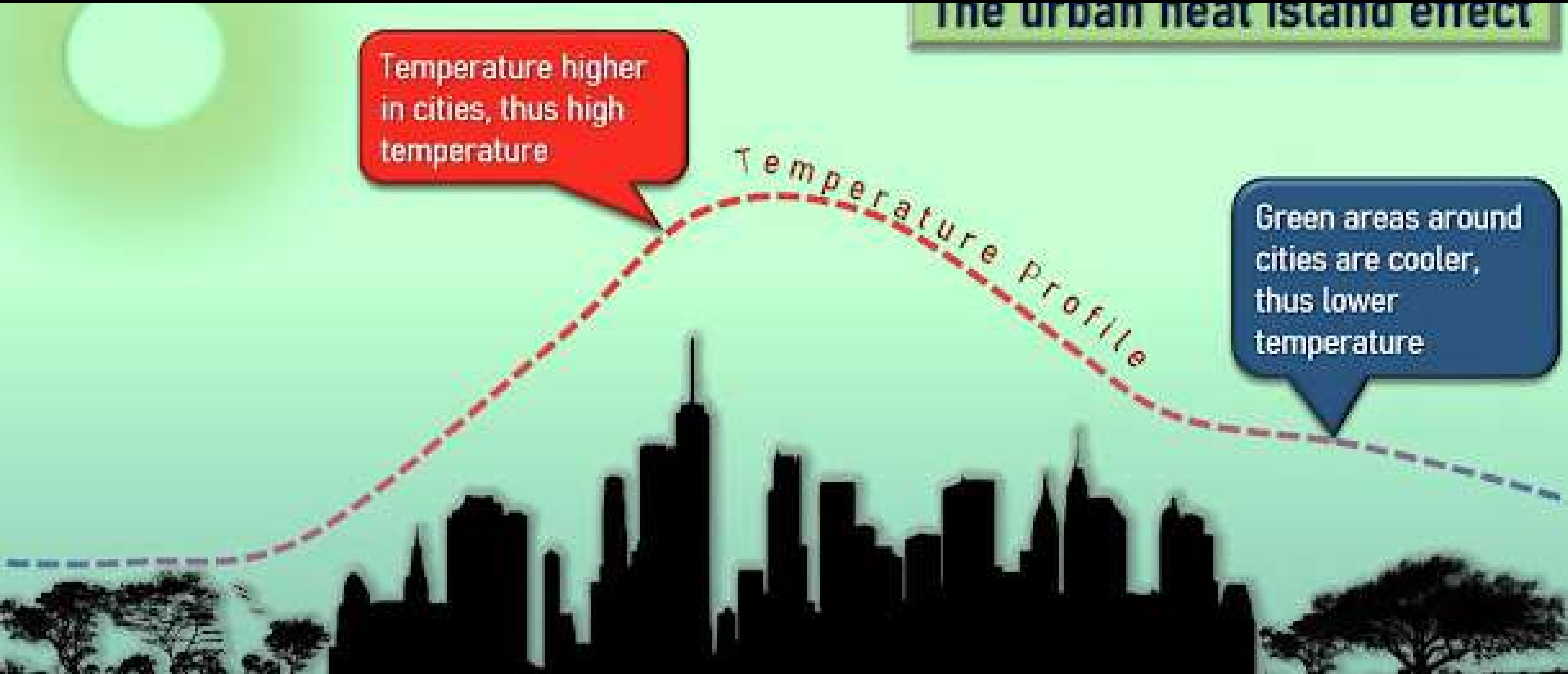
The **Indian Meteorological Department** (IMD) has given the following criteria for Heat Waves :

- Heat Wave need not be considered till maximum temperature of a station reaches atleast 40°C for Plains and atleast 30°C for Hilly regions
- When normal maximum temperature of a station is less than or equal to 40°C Heat Wave Departure from normal is 5°C to 6°C Severe Heat Wave Departure from normal is 7°C or more
- When **normal maximum temperatur**e of a station is more than 40°C Heat Wave Departure from normal is 4°C to 5°C Severe Heat Wave Departure from normal is 6°C or more
- When actual maximum temperature remains 45°C or more irrespective of normal maximum temperature, heat waves should be declared.

Higher daily peak temperatures and longer, more intense heat waves are becomingly increasingly frequent globally due to climate change. India too is feeling the impact of climate change in terms of increased instances of heat waves which are more intense in nature with each passing year, and have a devastating impact on human health thereby increasing the number of heat wave casualties.

Urban Heat Island Effect

In large urban settlements, human activities greatly modify the environment, creating unique meteorological and climatological characteristics. The agglomeration of tall buildings, roadways, green spaces, and concrete surfaces produces intricate rain, wind, heat, and air-quality patterns. The urban heat-island effect can raise temperatures by 5oC to 10oC, exacerbating heat waves.



The main types of urban heat traps include:

Surface Heat Traps These relate to the materials and ground cover used in the urban landscape.

- Dark Surfaces: Materials like asphalt for roads and dark-colored concrete, bricks, and roofing materials absorb a large percentage of solar radiation (low albedo) during the day and release it slowly at night.
- Impermeable Surfaces: Extensive paved surfaces (parking lots, roads, sidewalks) and buildings replace natural landscapes, which means less water can evaporate or transpire from plants (evapotranspiration), a natural cooling process. The lack of moisture in the environment means more solar energy is converted to sensible heat.
- Lack of Vegetation and Water Bodies: Limited green spaces (parks, trees, green roofs) and water bodies mean less shade and reduced cooling through evapotranspiration and evaporation, turning these areas into hot zones.

Urban Geometry and Architectural Traps These traps are related to the physical design and layout of the city.

- Urban Canyons: Tall buildings and narrow streets create "urban canyons" that block natural wind flow, inhibiting ventilation and preventing heat from dissipating into the atmosphere. This design also provides multiple surfaces for the reflection and absorption of sunlight, further increasing heating efficiency.
- Building Design: Poor building insulation and certain architectural practices, such as dark roofs or lack of design features that allow for natural ventilation, can lead to significant indoor heat stress.

Anthropogenic Heat Traps These are related to heat generated directly from human activities within the concentrated urban area.

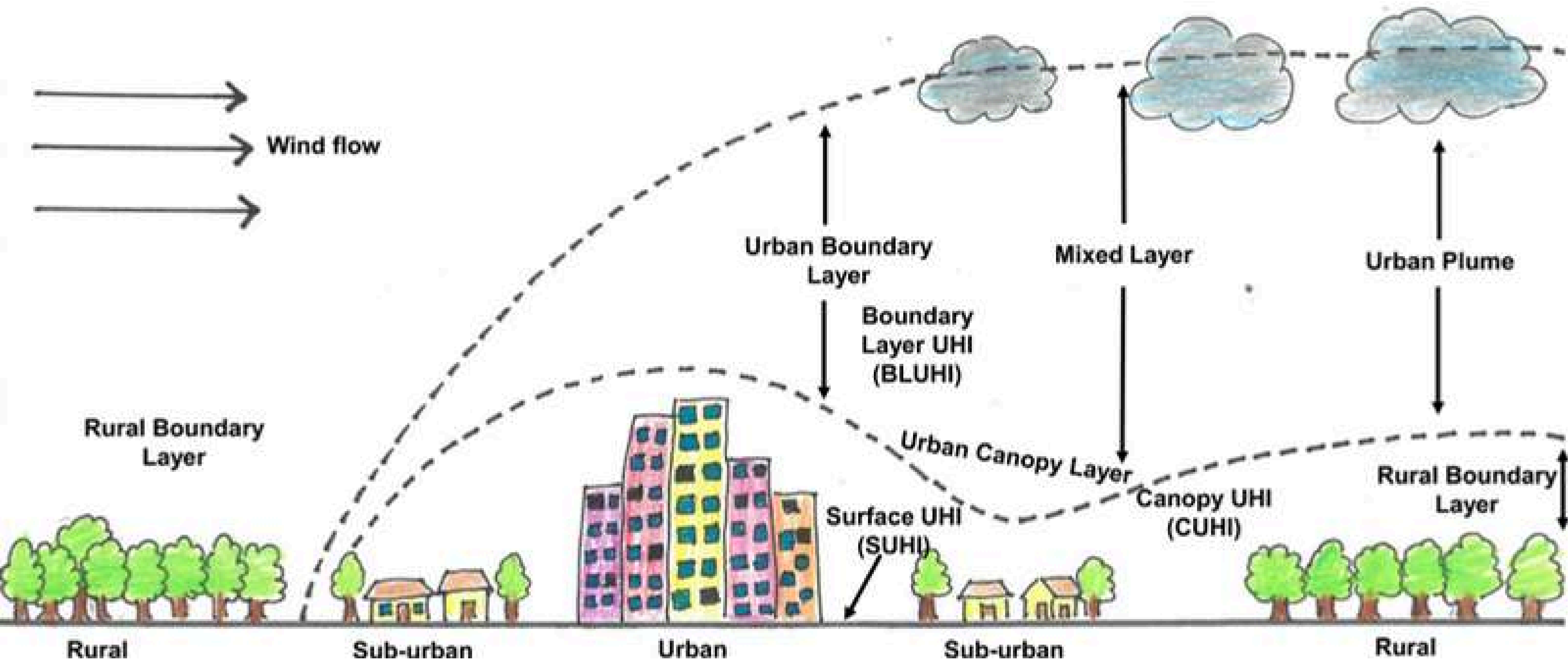
- Waste Heat: Heat is generated by everyday urban activities such as running air conditioning units, vehicles, industrial facilities, and other energy use. The concentration of these sources contributes significantly to the local temperature rise.
- Urban Haze/Pollution: High concentrations of air pollutants act as a miniature greenhouse layer, preventing outgoing thermal radiation from easily escaping the urban atmosphere.

Micro-Urban Heat Islands Within a single city, different areas experience varying degrees of heat trapping, creating localized "hot spots" often found in:

- Densely Populated Residential and Commercial Centers: Areas with high population density and intense activity tend to be major heat island zones.
- Industrial Areas: Areas with heavy industrial activity generate substantial waste heat and often have extensive paved or built-up surfaces.
- Low-Income/Marginalized Neighborhoods: Due to historical policies and socioeconomic factors, these areas often have fewer trees, less green space, older buildings with poor insulation, and limited access to cooling centers, making them disproportionately vulnerable to heat trapping.

DIRECTION

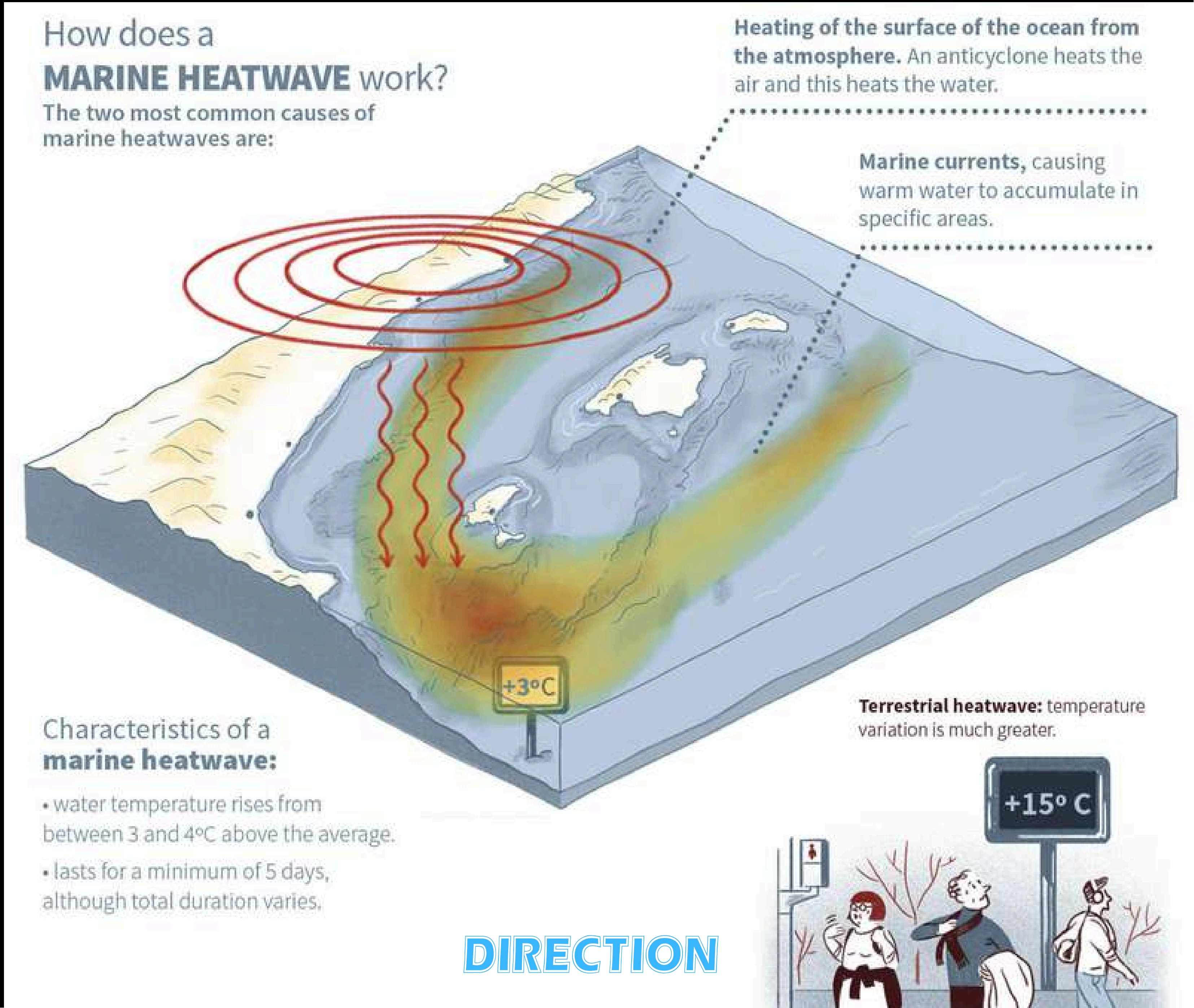
Types of UHI Effects



DIRECTION

MARINE HEATWAVES

The ocean's average temperature has increased by 1.5°C in the last century, and for the past 10 years average annual ocean temperatures have been the highest ever recorded.
In addition to this long-term, persistent warming, discrete periods of extreme regional ocean warming called marine heatwaves (MHWs) are becoming more frequent.

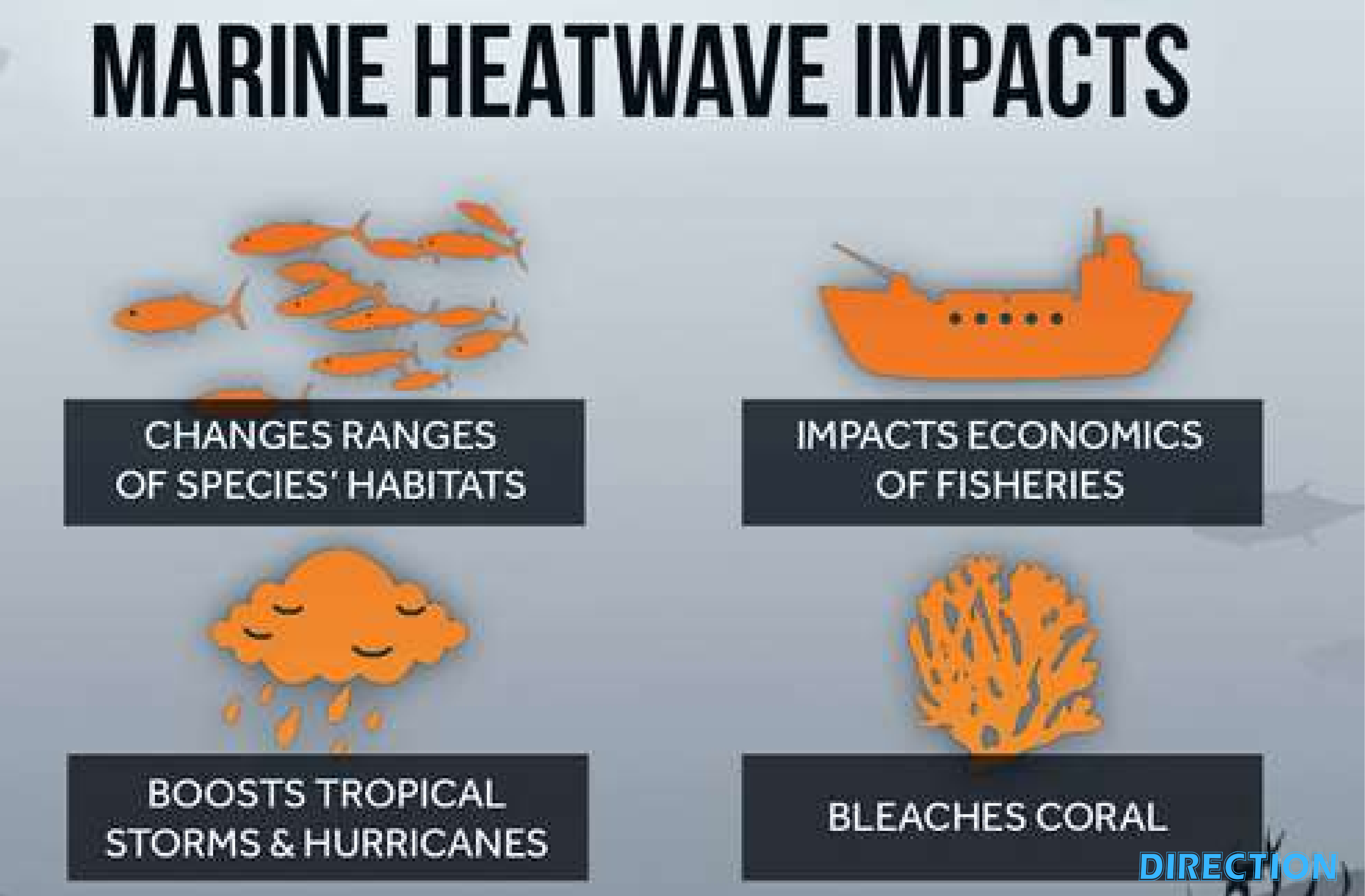


MHWs have increased by 50% over the past decade and now last longer and are more severe. MHWs can last for weeks or even years. They can affect small areas of coastline or span multiple oceans. MHWs have been recorded in surface and deep waters, across all latitudes, and in all types of marine ecosystems.

Higher water temperatures associated with MHWs can cause

- extreme weather events such as tropical storms and hurricanes, and disrupt the water cycle; making floods, droughts and wildfires on land more likely.
- MHWs have other profound socio-economic impacts for coastal communities. Aquaculture, for instance, requires water temperatures to remain suitable for farmed species, while fisheries rely on species that often relocate in response to changing environmental conditions.
- MHWs have been shown to kill or reduce the productivity of economically important species including lobster and snow crab in the northwest Atlantic and scallops off Western Australia.
- MHWs can also harm regional tourism
- MHWs have been associated with the mass mortality of marine invertebrates, and may force species to change behaviour in a way that puts wildlife at increased risk of harm. MHWs have been linked to whale entanglements in fishing gear, for example. Changing conditions can also help invasive alien species to spread, which can be devastating for marine food webs.

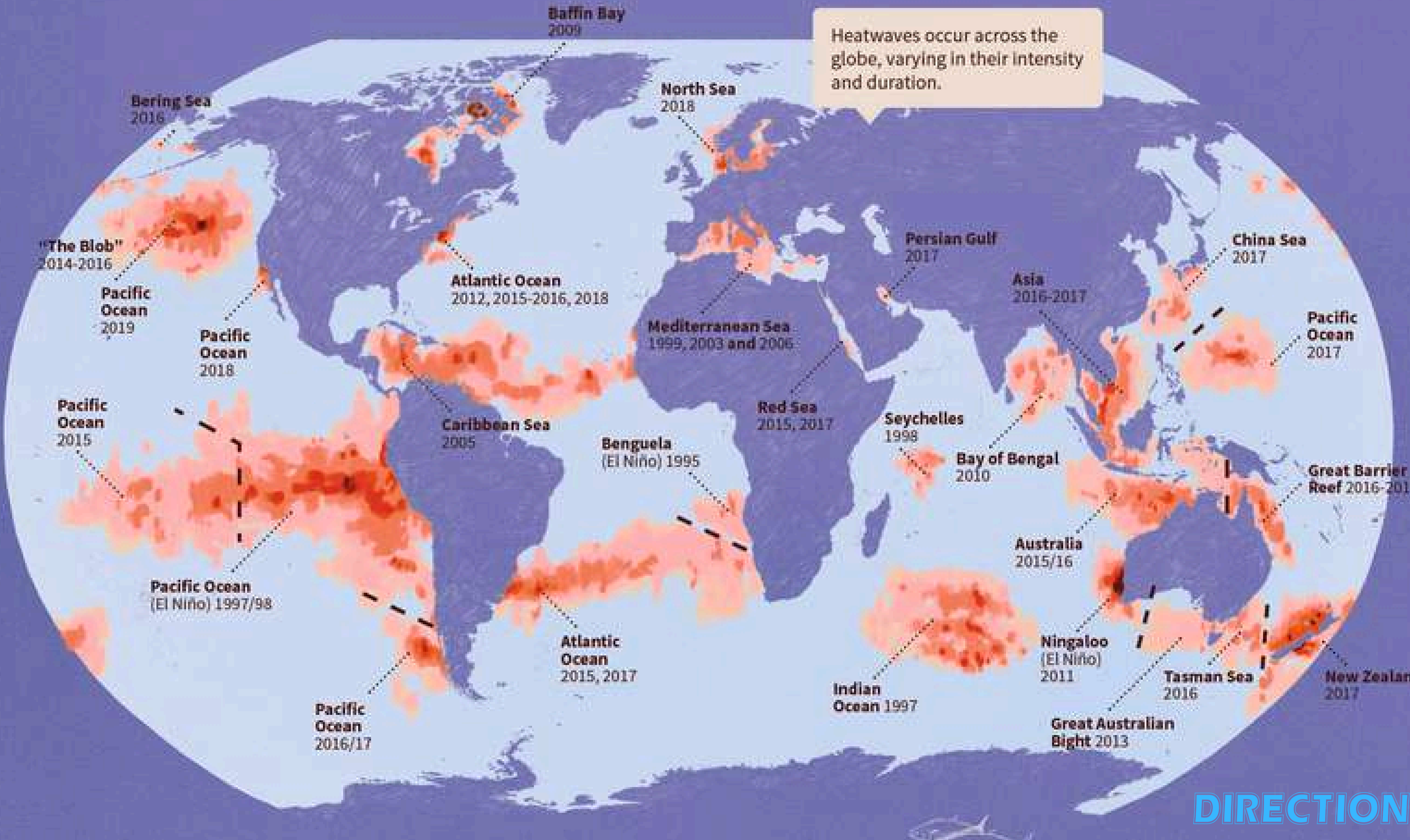
DIRECTION


MARINE HEATWAVE IMPACTS
CHANGES RANGES OF SPECIES' HABITATS
IMPACTS ECONOMICS OF FISHERIES
BOOSTS TROPICAL STORMS & HURRICANES
BLEACHES CORAL
DIRECTION

The main **Marine Heatwaves**

- Moderate
- Strong
- Severe
- Extreme

Some of the most important marine heatwaves recorded and studied.



Wildfires

Fire is a natural phenomenon that serves important ecological purposes, clearing dead and diseased plants from some forests, for example, and even helping some plants reproduce.

But a rapidly warming planet — along with a history of short-sighted forest management practices and land use decisions that push development into the wilderness — is contributing to catastrophic fires.

Wildfires are unplanned fires that burn in forests, grasslands and other ecosystems, and they can start with a natural event like a lightning strike, or by accident as the result of human activity.

- Fires emitted more than 8 billion tonnes of carbon dioxide in 2024–25, about 10 per cent above the average since 2003.
- Emissions were more than triple the global average in South American dry forests and wetlands, and double the average in Canadian boreal forests. That's a deeply concerning amount of greenhouse pollution.
- The excess emissions alone exceeded the national fossil fuel CO_2 emissions of more than 200 individual countries in 2024.

- 2018 Camp Fire (USA): The deadliest and most destructive wildfire in California history, burning 153,336 acres and destroying over 18,000 structures.
- 2019/2020 Australian Bushfires: These catastrophic fires burned 42 million acres across Australia, killing dozens of people and billions of animals.
- 1987 Black Dragon Fire (China and Russia): Also known as the Daxing'anling Wildfire, this was one of the deadliest in history, burning around 2.5 million acres.
- 2021 Siberian Wildfires (Russia): These fires burned a massive area, with nearly 40 million acres affected in Siberia, particularly in the western region and the Sakha Republic.
- 2016 Uttarakhand Forest Fires (India): One of the country's worst forest fire events, mainly affecting pine forests in the Himalayan region.
- 2024 South American Wildfires: Extreme wildfires in South America contributed significantly to the global increase in fire-related tree cover loss.

DIRECTION

TYPES OF FIRE

There are three basic types of forest fires: ground, surface, and crown.Fuel, topography, and weather drive a fire’s behavior, and changes to any of three may cause a ground fire to emerge as a surface fire or a surface fire to escalate into a crown fire, or vice versa.

Ground fires Ground fires burn mostly in decayed roots below ground and in the duff layer. The duff layer is made up of compacted dead plant materials such as leaves, bark, needles, and twigs. Ground fires are sustained by glowing combustion (without flames) and can go undetected for a long time because they produce little to no smoke and spread slowly

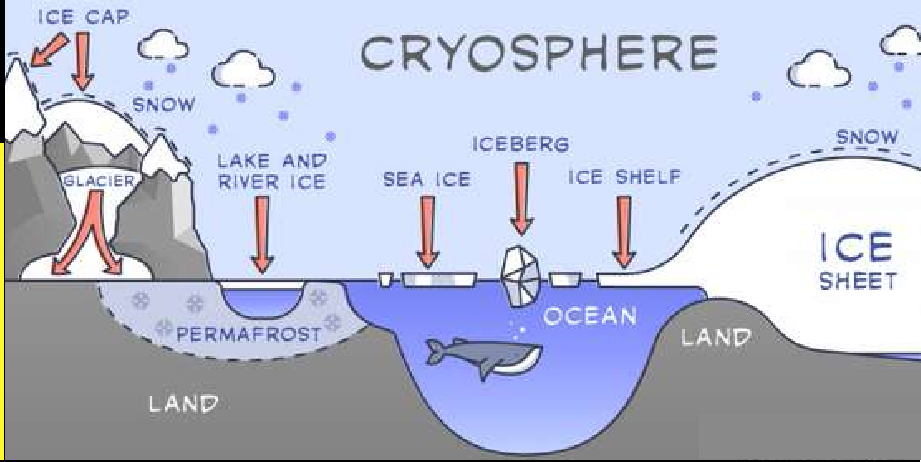
Surface fires Surface fires burn loose needles, moss, lichen, herbaceous vegetation, shrubs, small trees, and saplings that are at or near the surface of the ground, mostly by flaming combustion.
Surface fires spreading in surface fuels dictate much of a fire's expansion. They can grow in intensity to scorch or even consume the forest canopy, a characteristic that is seen in crown fires, depending on:

- the amount of surface fuel (is high),
- fuel moisture content (is low);
- slope and/or wind speed (is high),
- the resultant surface flame length (is high);
- the height to the base of tree crowns (is small);
- and the density and compactness of tree crowns (is tight).

Crown fires Crown fires burn forest canopy fuels, which include live and dead foliage/branches, lichens in trees, and tall shrubs that lie well above the surface fuels. They are usually ignited by a surface fire. Crown fires can be passive or active. Passive crown fires involve the burning of individual trees or small groups of trees (often called torching). Active crown fires, or also referred to as running crown fires, present a solid wall of flame from the surface through the canopy fuel layers as seen in the photo below. Active crown fires spread from one tree crown to the next through the canopy.

Cryosphere shrinking

Cryosphere shrinking by 87,000 square kilometers per year, Earth lost 87,000 square kilometers (33,000 square miles) of sea ice, an area about the size of Lake Superior, per year on average.

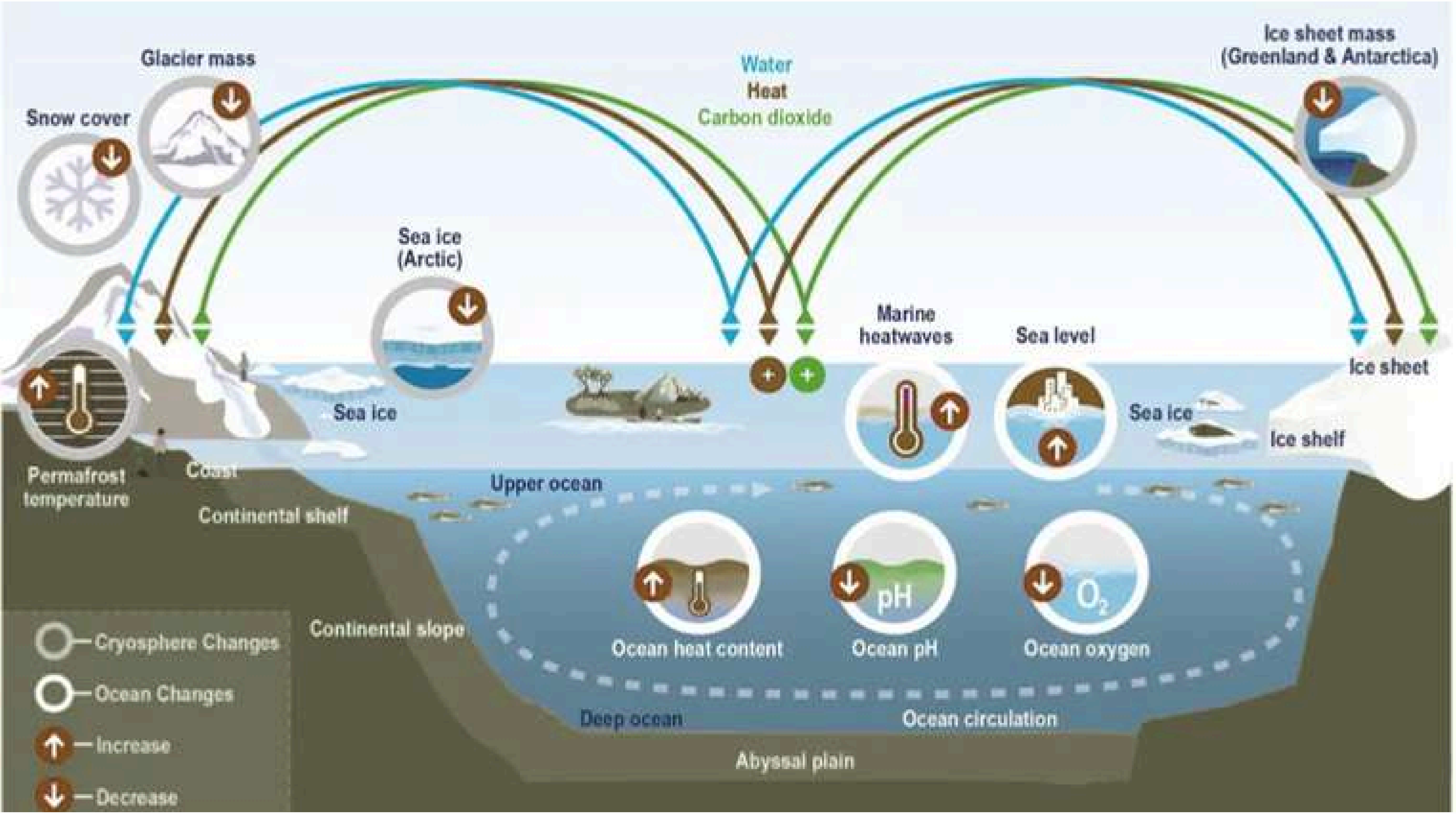


The global assessment of the extent of snow and ice cover on earth's surface—a critical factor cooling the planet through reflected sunlight—and its response to warming temperatures. Changes in the area and location of snow and ice can alter air temperatures, change sea levels, and even affect ocean currents worldwide.

Key impacts of the shrinking cryosphere

- Sea-level rise: The melting of glaciers and ice sheets, particularly from Greenland and Antarctica, is a major contributor to global sea-level rise, threatening coastal communities.
- Changes in water resources: The shrinking of glaciers and permafrost impacts river runoff and water supplies, especially in mountain regions like the Himalayas, affecting agriculture and communities that rely on meltwater.
- Increased frequency of cryospheric hazards: As the cryosphere destabilizes, there is an increased risk of hazards like glacier lake outbursts, rock and ice avalanches, and flooding.
- Disruption to the climate system: The cryosphere's bright surface reflects sunlight, and its shrinkage reduces this "albedo effect," leading to more heat absorption and further warming.

DIRECTION



Glacier mass
Snow cover
Water
Heat
Carbon dioxide
Ice sheet mass
(Greenland & Antarctica)
Sea ice
(Arctic)
Marine
heatwaves
Sea level
Ice sheet
Sea ice
Sea ice
Ice shelf
Permafrost
temperature
Coast
Continental shelf
Upper ocean
Ocean heat content
pH
Ocean pH
O_2
Ocean oxygen
Continental slope
Cryosphere Changes
Ocean Changes
Increase
Decrease
Deep ocean
Ocean circulation
Abyssal plain

DIRECTION

Polar amplification

the phenomenon where polar regions, especially the Arctic, warm at a much faster rate than the global average. This happens due to feedback loops, such as the melting of ice and snow, which exposes darker surfaces that absorb more heat, further intensifying the warming. The most significant factors include the ice-albedo feedback, atmospheric and oceanic heat transport, and clouds.

The polar amplification (PA) has become the focus of climate change. However, there are seldom comparisons of amplification among Earth's three poles of Arctic (latitude higher than 60 °N), Antarctica (Antarctic Ice Sheet) and the Third Pole (the High Mountain Asia with the elevation higher than 4000 m) under different socioeconomic scenarios.

The Impacts of Polar Amplification

The rapid warming of the polar regions is not just an isolated phenomenon - it has far-reaching consequences that affect global weather patterns, sea levels, ecosystems, and human populations. The most severe impacts include:

Rising Sea Levels

One of the most significant consequences of polar amplification is the accelerated melting of ice sheets and glaciers, particularly in the Arctic and parts of Antarctica. As the ice melts, it contributes to global sea-level rise. The Greenland ice sheet alone has been losing around 270 billion metric tons of ice per year, a pace that continues to increase. If polar ice continues to melt at current rates, scientists predict sea levels could rise by over a meter by 2100, threatening coastal communities worldwide.

Extreme Weather Patterns

Polar amplification is also linked to changes in weather patterns far beyond the polar regions. As the Arctic warms, it disrupts the jet stream - a fast-moving band of air that controls weather patterns in the Northern Hemisphere. A weakened jet stream can cause weather systems to stall, leading to prolonged periods of extreme weather, such as heatwaves, cold spells, and heavy rainfall. For example, the "polar vortex" phenomenon, where cold Arctic air moves southward, has been increasingly linked to polar warming, leading to extreme winter events in regions like North America and Europe.

DIRECTION

Ecosystem Disruptions

Polar ecosystems are incredibly vulnerable to the effects of rapid warming. In the Arctic, the loss of sea ice is threatening the habitats of iconic species like polar bears, seals, and walruses, all of which rely on ice for hunting and breeding. Similarly, warming temperatures are affecting migratory patterns, food availability, and the overall balance of the Arctic food chain. In the Antarctic, penguin populations are also at risk due to shifting ice conditions and warming waters. These ecosystem disruptions not only threaten biodiversity but also impact indigenous communities that depend on these species for their livelihoods.

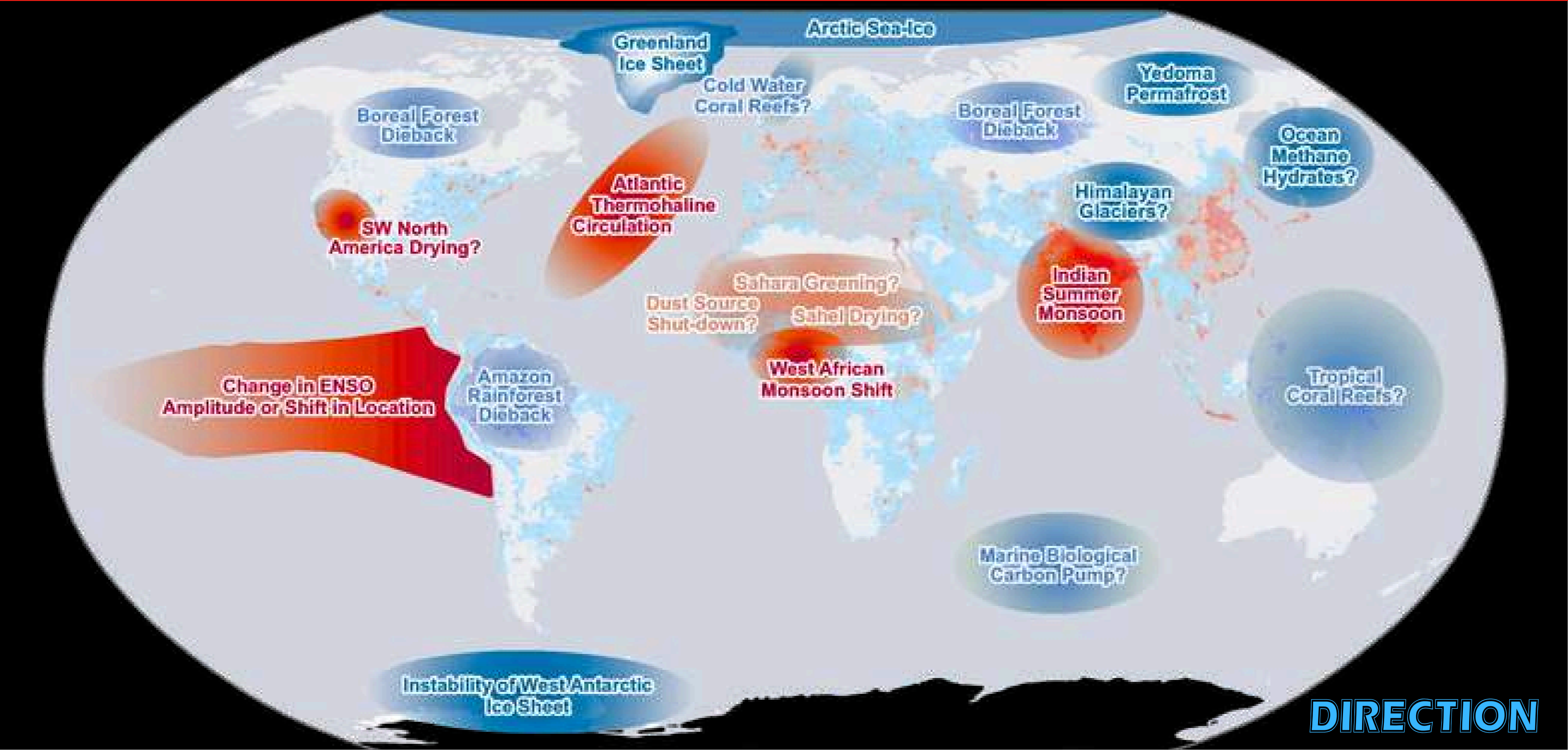
Feedback Loops and Tipping Points

The consequences of polar amplification are compounded by the existence of dangerous feedback loops and climate tipping points. As ice melts and permafrost thaws, large amounts of methane - a potent greenhouse gas - are released into the atmosphere, further accelerating global warming. Additionally, the loss of reflective ice surfaces leads to increased absorption of solar radiation, amplifying the warming effect. These feedback mechanisms could potentially push the Earth's climate system past critical thresholds, triggering irreversible changes in the global climate.

Factor	Arctic	Antarctic
Geography	Ocean surrounded by land, leading to more sea ice melt and exposure to warming water.	Landmass surrounded by ocean, which acts as a buffer against rapid temperature changes.
Ice-Albedo Feedback	Strong feedback due to rapid sea ice loss, leading to faster warming as darker ocean water absorbs more heat.	Less pronounced feedback because of the vast ice sheets covering the land, which reflect sunlight more consistently.
Ocean Circulation	More warm water flows into the Arctic from the tropics via the Gulf Stream, accelerating warming.	The surrounding Southern Ocean circulates cold water, helping to moderate temperature increases.
Atmospheric Convection	Limited convection traps heat near the surface, intensifying warming.	Higher elevation and greater convection help reduce warming near the surface.
Climate Sensitivity	Greater sensitivity to global temperature changes, leading to rapid warming.	Lower sensitivity, resulting in slower warming compared to the Arctic.

What are climate tipping points?

Climate tipping points are critical thresholds in the Earth's climate system where a minor change can result in substantial and potentially irreversible shifts. These tipping points are extremely important in the context of climate change because they represent the thresholds beyond which the natural environment may no longer return to its original state, leading to drastic alterations in climate patterns and the Earth's ecosystems.



Key climate tipping points

Several critical tipping points are particularly important due to their potential impacts on global climate patterns and ecosystems, these include:

Greenland Ice Sheet

As the Arctic warms, Greenland's ice is melting at an accelerating rate. If a certain threshold is crossed, the melting could become irreversible, contributing significantly to global sea level rise. In fact, recent satellite data from 2022 indicates that Greenland's extensive ice sheet is melting at such a swift rate that it has become the primary contributor to the rise in global sea levels. Over the last twenty years, Greenland has shed over 5,100 billion tons of ice. This massive loss is enough to submerge the entire United States under half a metre (about 1.5 feet) of water.

Permafrost thaw

Permafrost regions across Siberia, Alaska, and Canada, as well as the Tibetan plateau, hold immense reserves of organic matter that have been frozen for millennia. This layer contains the largest global carbon reserve from decomposed plant and animal matter, estimated at 1,400 billion tons (nearly double the carbon currently in the atmosphere). As global temperatures rise and this permafrost begins to thaw, it could release both carbon dioxide and methane into the atmosphere. The release of these greenhouse gases could contribute an additional 0.3°C to global warming, potentially accelerating other critical climate tipping points.

Ocean circulation changes (AMOC)

The Atlantic Meridional Overturning Circulation (AMOC) is a critical system of ocean currents that helps regulate climate and weather across Europe and North America by transporting warm water from the tropics to the north and cold water back south. However, this system is under threat as increasing amounts of freshwater from melting ice caps are diluting the ocean, weakening these currents. Recent studies indicate that the AMOC has already weakened by about 15% in the last five decades - the system's tipping point lies somewhere between 24% to 39%. If this trend continues, it could lead to significant climate shifts, including more severe weather events in Europe and changes in rainfall patterns that could affect agricultural productivity worldwide.

Coral reefs die-off

Coral reefs - crucial for biodiversity and coastal protection - are highly sensitive to water temperatures. Warming oceans and increasing acidification are causing widespread coral bleaching and die-offs. These reefs not only support diverse marine life but also protect coastlines from waves and tropical storms, contribute to nitrogen and carbon cycling, and sustain local economies through tourism and fisheries. They also help in generating the sand and debris that maintain islands and cays. However, human activities like coastal development and unregulated tourism practices, including anchoring and diving activities, are exacerbating their decline. Alarmingly, scientists warn that many reefs may have already reached their tipping points and could vanish by 2050 due to these stresses.

Amazon rainforest shift

Often referred to as the Earth's lungs, the Amazon rainforest is nearing a critical tipping point due to ongoing drought and widespread deforestation. This could drastically alter its ability to absorb carbon dioxide, potentially turning it from a carbon sink into a carbon source. This shift would mean the Amazon could start emitting more carbon dioxide than it absorbs, exacerbating global warming rather than mitigating it. The implications are severe, impacting biodiversity and global climate regulation.

Antarctic ice sheet changes

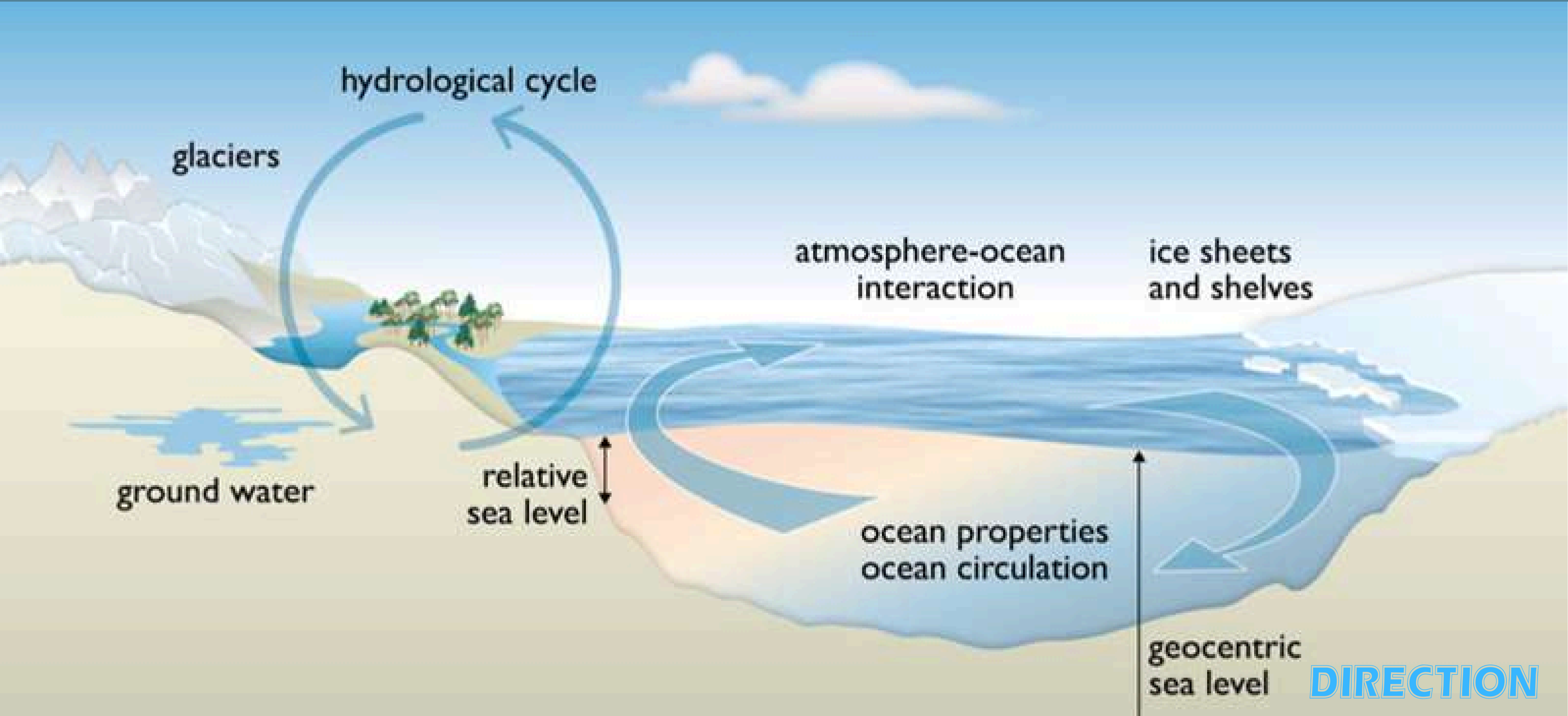
Similar to Greenland, the Antarctic ice sheet is also undergoing rapid melting, approaching critical tipping points that could significantly elevate sea levels and disrupt global ocean currents. The Antarctic region has warmed by nearly 3°C in the last 50 years, leading to an accelerated retreat of glaciers. This instability is concerning because the ice sheets hold the potential to raise global sea levels by 58 metres (over several centuries). If current trends continue, the melting of Antarctic ice could add up to one metre to sea levels by the end of this century. This not only threatens coastal areas worldwide but also endangers the rich biodiversity dependent on these icy habitats.

Monsoons

Monsoons are essential for agriculture in the tropics, from South America to West Africa and India. However, global warming is altering their patterns, jeopardising crop yields and food security. A recent study projects a decline of up to 24% in maize yields by 2030 due to these changes, with similar impacts expected for other staples like rice and wheat. This shift threatens the livelihoods of over a billion people globally, particularly in food-insecure regions.

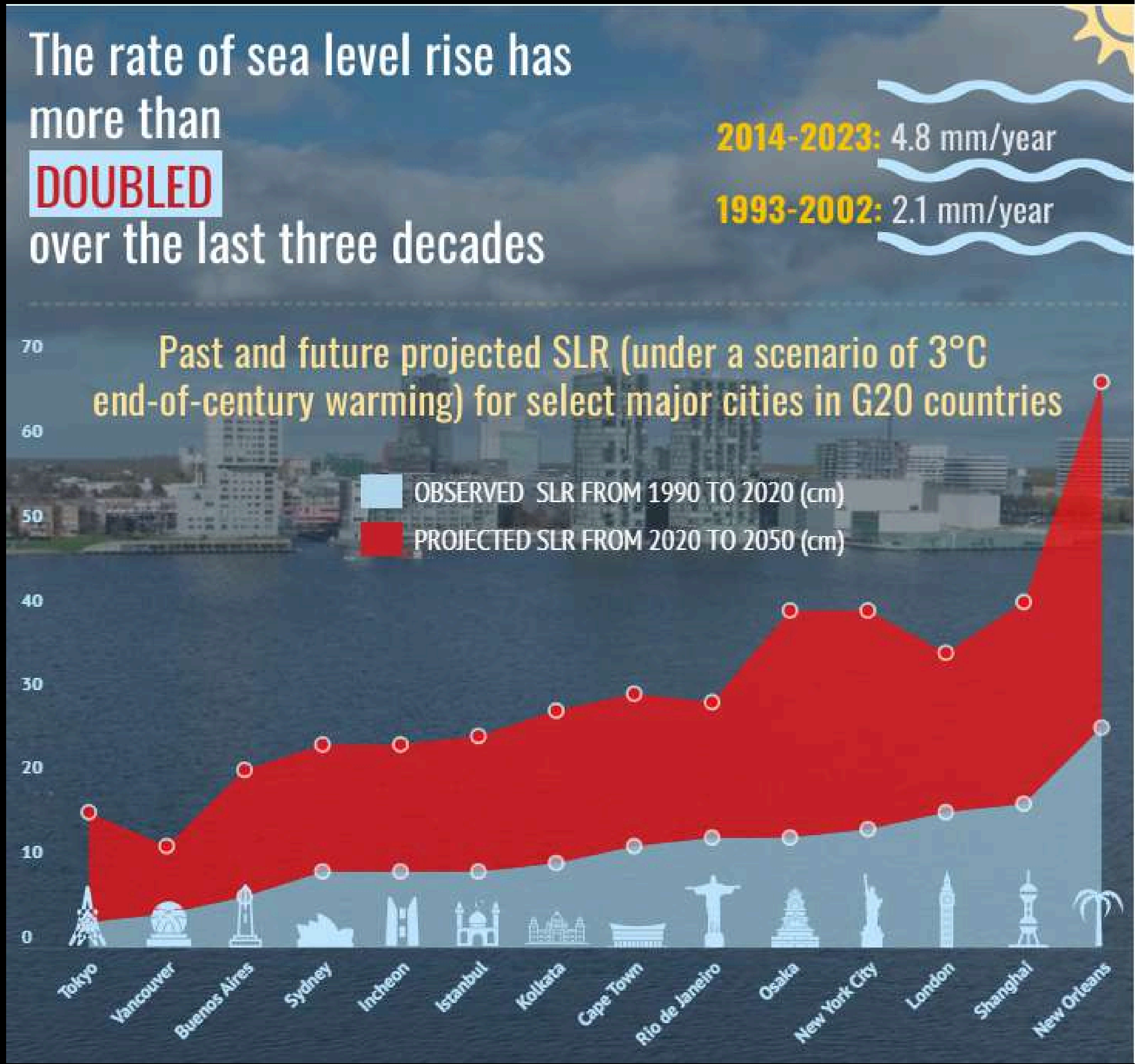
Sea Level Rise

The level of the sea globally is rising faster and higher than ever before, creating what the United Nations has described as an "urgent and escalating threat" to people around the world.



High water mark

- It is estimated that the oceans have risen by approximately 20-23 centimetres (8-9 inches) since 1880.
- In 2023, the average sea level globally reached a record high the UN's World Meteorological Organization (WMO) confirmed, according to satellite records kept since 1993.
- Worryingly, the rate of increase over the last 10 years is more than twice the rate of sea level rise in the first decade of the satellite record, from 1993 to 2002.
- Rising sea levels are the result of ocean warming and the melting of glaciers and ice sheets, phenomena which are the direct consequences of climate change.



DIRECTION

Consequences

Rising sea levels have wide-reaching implications not just on the physical environment, but also the economic, social and cultural fabric of vulnerable nations across the world.

- Saltwater flooding can damage coastal habitats, including coral reefs and fish stocks, agricultural lands as well as infrastructure, including housing, and can impact the ability of coastal communities to sustain their livelihoods.
- Flooding can contaminate fresh water supplies, promote waterborne diseases threatening people’s health and lead to stress and mental health problems.
- At the same time, tourism revenues, a key economic driver especially in many small island developing States (SIDS), can suffer as beaches, resorts and other tourist attractions like coral reefs are damaged.
- The combination of so many factors can force people to leave their homes, relocate to higher ground where available or ultimately migrate, which in turn disrupts economies, livelihoods and communities.

About Small Island Developing States

Small Island Developing States (SIDS) are a distinct group of 39 States and 18 Associate Members of United Nations regional commissions that face unique social, economic and environmental vulnerabilities.

The three geographical regions in which SIDS are located are: the Caribbean, the Pacific, and the Atlantic, Indian Ocean and South China Sea (AIS).

DIRECTION

UN Programmes of Action in Support of SIDS

Barbados Programme of Action - 1994

In 1994, the Barbados Programme of ActionPDF (BPoA) prescribed specific actions that would enable SIDS to achieve sustainable development.The Conference reaffirmed the principles and commitments to sustainable development embodied in Agenda 21 and translated these into specific policies, actions and measures to be taken at the national, regional and international levels. The Conference also adopted the Barbados Declaration, a statement of political will underpinning the commitments contained in the BPoA.

Mauritius Strategy - 2005

In 2005, the Mauritius StrategyPDF for further implementation of the BPoA was adopted to address remaining gaps in implementation.

SAMOA Pathway - 2014

In 2014, the international community gathered in Samoa for the Third International Conference on Small Island Developing States to forge a new pathway for the sustainable development of this group of countries. The SAMOA PathwayPDF recognizes the adverse impacts of climate change and sea-level rise on SIDS' efforts to achieve economic development, food security, disaster risk reduction and ocean management, among other challenges.

While many SIDS have made advances in achieving sustainable development, their inherent vulnerabilities—including small size, remoteness, climate change impacts, biodiversity loss and narrow resource base—mean that progress for many continues to be hampered, and their status as a special case for sustainable development remains.

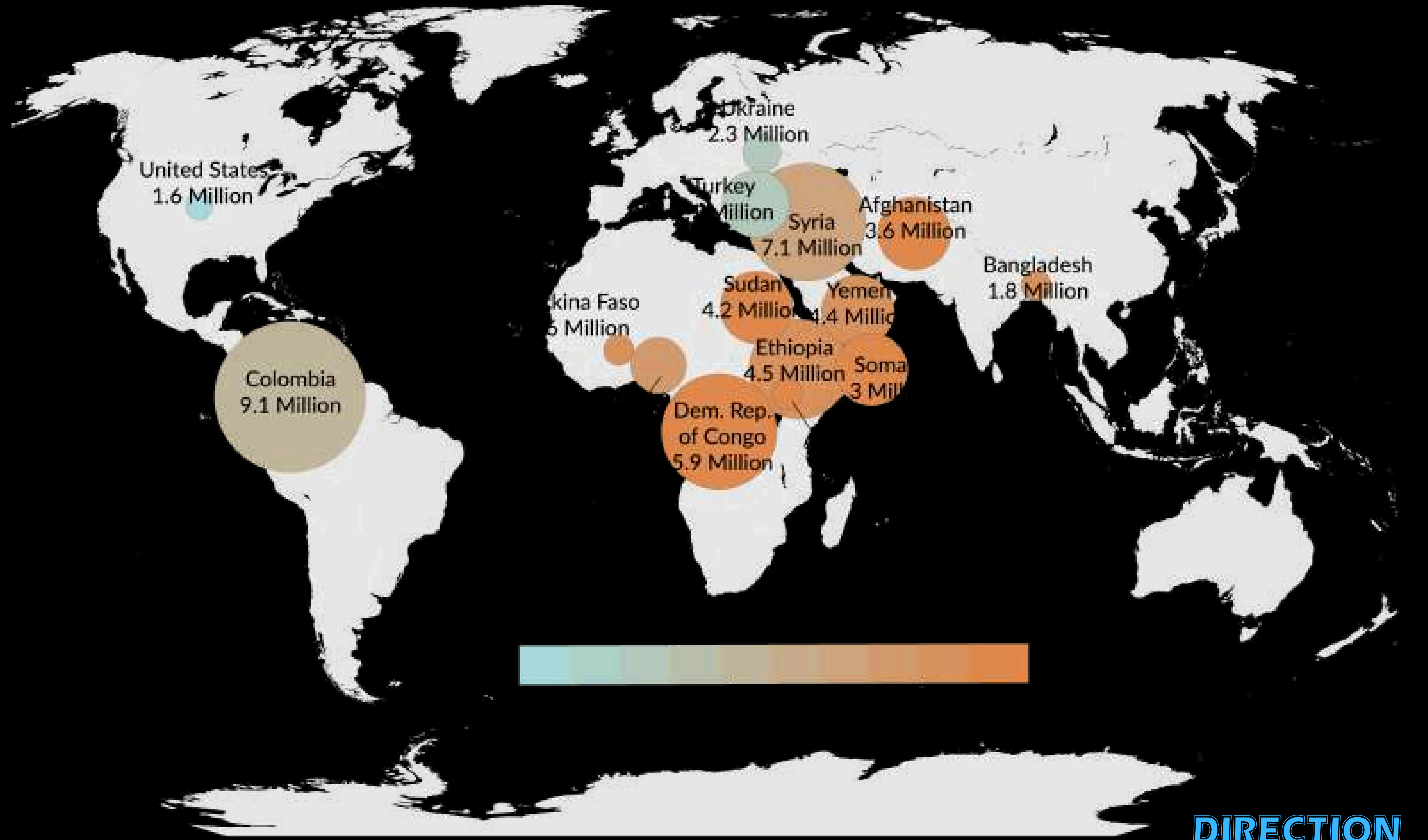
DIRECTION

Climate Refuge

The concept was first articulated in 1985 by Essam El-Hinnawi, a UN Environment Programme (UNEP) expert. He defined climate refugees – also called environmental refugees or climate or migrants – as people who have "had to leave their habitat, temporarily or permanently, because of a potential environmental hazard or disruption in their life-supporting ecosystems."

The climate crisis is amplifying displacement and making life harder for those already forced to flee.

DIRECTION


Ukraine
2.3 Million
United States
1.6 Million
Turkey
Syria
7.1 Million
Afghanistan
3.6 Million
Bangladesh
1.8 Million
Sudan
4.2 Million
Yemen
Ethiopia
4.5 Million
Colombia
9.1 Million
Dem. Rep.
of Congo
5.9 Million

Building on UNHCR's Strategic Framework for Climate Action our Strategic Plan for Climate Action 2024-2030 details a global roadmap for prioritized action in support of governments and in collaboration with a wide range of partners to realize the following ambitious goal:
That by 2030, increasing numbers of forcibly displaced and stateless people fleeing from climate-fueled crises and/or living in climate-vulnerable countries find solutions, are protected and resilient to the impacts of climate change, and have the means to live self-sufficient lives.

DIRECTION

The Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC)

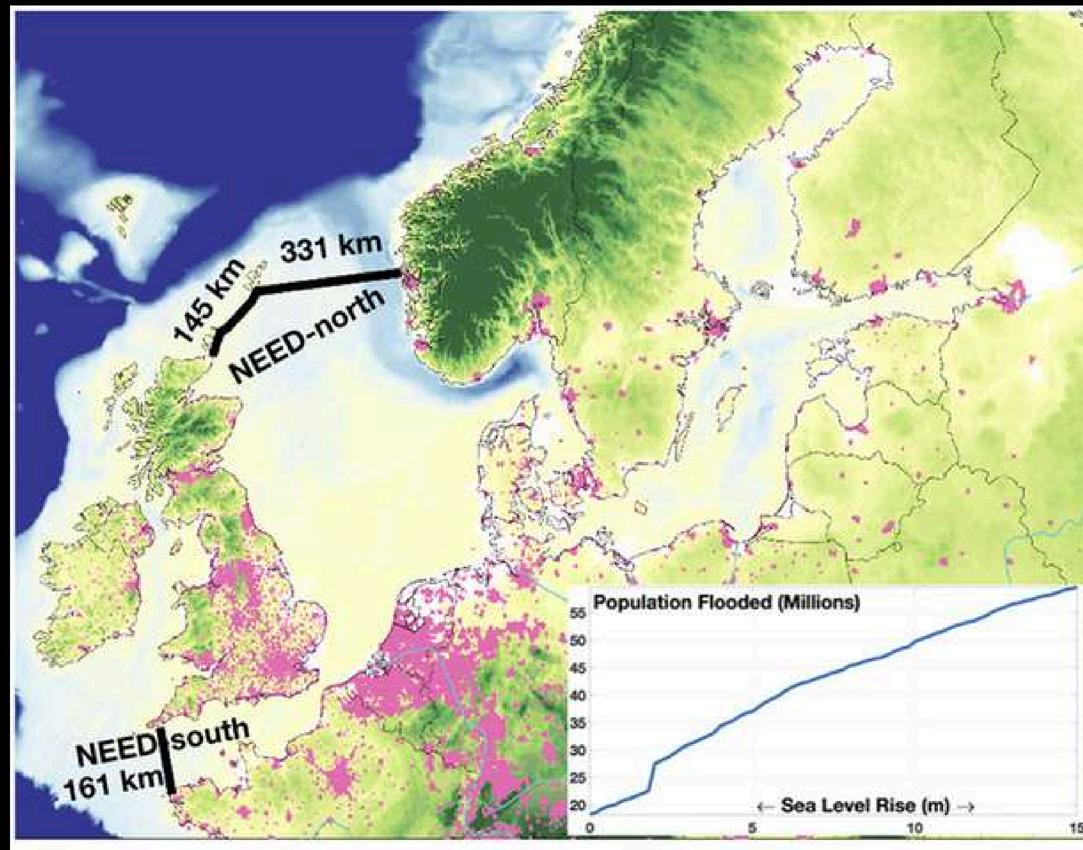
The SROCC lays out the main strategies that are available to communities and nations.

DIRECTION

The Great Garuda

To stop the advancing waters, the city, 40 percent of which is below sea level, created a masterplan that once implemented should protect Jakarta from further flooding.The Great Garuda is the name of the project, it’s a new city for 300,000 new inhabitants spread out over 17 new islands, which, due to the shape that was chosen (a great eagle with outstretched wings)

Northern European Enclosure Dam (NEED)



A massive,project called the Northern European Enclosure Dam (NEED) has been proposed to protect Northern Europe from coastal erosion and sea-level rise (SLR). It involves constructing two large dams: one 476 km long between Scotland and Norway, and a second 161 km long between France and England

Cyclone

- There are five regional bodies that coordinate tropical cyclone activities.
- ESCAP/WMO Typhoon Committee: Covers theNorthwest Pacific and South China Sea.
- WMO/ESCAP Panel on Tropical Cyclones: Covers the North Indian Ocean, including the Bay of Bengal and the Arabian Sea.
- RA I Tropical Cyclone Committee: Covers the Southwest Indian Ocean.
- RA IV Hurricane Committee: Covers the North Atlantic, Northeast Pacific, Gulf of Mexico, and Caribbean Sea.
- RA V Tropical Cyclone Committee: Covers the Southwest Pacific.
- These bodies establish pre-designated lists of names which are proposed by WMO Members' National Meteorological and Hydrological Services
- When selecting a new name, consideration is given to certain factors:
- Short in character length for ease of use in communication
- Easy to pronounce
- Appropriate significance in different languages
- Uniqueness – same names cannot be used in other regions.
-

Saffir-Simpson hurricane scale explained

Category 1
Winds 74-95 mph (119-153 km/h)
Some damage and power cuts

Category 2
Winds 96-110 mph (154-177 km/h)
Extensive damage

Category 3
Winds 111-129 mph (178-208 km/h)
Well-built homes suffer major damage

Category 4
Winds 130-156 mph (209-251 km/h)
Severe damage to well-built homes

Category 5
Winds 157+ mph (252+ km/h)
Many buildings destroyed, major roads cut off

Cyclones are classified on the basis of wind speed by the Indian Meteorological Department (IMD):

- Depression: Wind speeds of between 31–49 km/h
- Deep Depression: Between 50-61 km/h
- Cyclonic Storm: Between 62–88 km/h
- Severe Cyclonic Storm: Between 89-117 Km/h
- Very Severe Cyclonic Storm: Between 118-166 Km/h
- Extremely Severe Cyclonic Storm: Between 166-221 Km/h
- Super Cyclonic Storm: Above 222 Km/h

Melissa

This is the lowest pressure ever observed in the Atlantic in a hurricane so late in the season, and makes Melissa Earth's strongest storm of 2025, beating out the Western Pacific's Typhoon Ragasa

DIRECTION

Cloudburst

A cloudburst is an unusually intense and very short-duration rainfall event over a small area. In the Indian context, meteorologists often define it as more than 100 mm of rain in one hour over an area of roughly 30 km^2 or less.
The mechanism involves warm, moisture-laden air that is forced upward (often by steep terrain), cools rapidly, forms deep cumulonimbus clouds, and then "bursts" when it can no longer hold the condensed water — releasing an enormous downpour in a brief span. In mountainous regions this sudden deluge can trigger instant runoff, flash floods and landslides — because the steep slopes and narrow valleys accelerate water and debris flow.

- Moisture accumulation: Moist air (often from monsoon winds) travels toward a mountain or hilly region. As it meets terrain, it is forced to rise (orographic lift), cools, and condensation begins.
- Cloud build-up: The rising air forms deep towering clouds (cumulonimbus) that may reach heights of 10-15 km. The cloud may trap moisture for some time due to upward currents and terrain "trapping".
- Bursting: Eventually the cloud becomes saturated. The upward motion weakens or the cloud cannot hold the water when the droplet size becomes too large — precipitation then falls in a very concentrated downpour. In mountains the water flows off rapidly.
- Rapid impact: Because the rainfall is intense and very localised (small area), the water cannot infiltrate or disperse normally — leading quickly to runoff, flooding of gullies and rivers, landslides and debris flows.

DIRECTION

In India a few geographic and climatic factors align to make certain regions especially vulnerable:
The Himalayan and sub-Himalayan terrain: steep slopes, narrow valleys, orographic lifting of moist air. For example the states of Uttarakhand, Himachal Pradesh, Jammu & Kashmir are frequently cited.

- The monsoon systems: warm, moisture-laden air masses from the Arabian Sea or the Bay of Bengal move toward the northern mountains. When they are uplifted, condensation is enhanced.
- Slope & runoff dynamics: In flat terrain, a heavy rain spreads; in mountains, the water concentrates into narrow channels, increasing its destructive power.

Historically, cloudbursts were treated as rare, extreme events. However, recent studies indicate increasing frequency of cloudburst-type events (or "extreme precipitation spells" similar to cloudbursts) especially in the Himalayan region.

- A 2025 review of extreme precipitation events in India finds that high intensity rainfall events (which include cloudburst-like cases) have increased. Key metrics: extreme precipitation during monsoon increased by ~56 % since earlier decades; the pre-monsoon season saw doubling of extreme precipitation events.
- News reports confirm recent cloudbursts leading to major disasters – for example in 2025 a major cloudburst in the Kishtwar district of Jammu & Kashmir caused many casualties.

While precise long-term, uniformly recorded cloudburst frequency data are limited (due to the localised nature of these events), the trend of more intense, short-duration rainfall spells in likely cloudburst-prone terrains is clear.

DIRECTION

Intergovernmental Panel on Climate Change

The IPCC stands for the Intergovernmental Panel on Climate Change. It's a United Nations body established in 1988 by the World Meteorological Organization (WMO) and the UN Environment Programme (UNEP).
Its main purpose is to assess scientific information related to climate change — including its causes, potential impacts, and strategies for adaptation and mitigation. The IPCC doesn't conduct its own research; instead, it reviews and synthesizes existing scientific studies to provide comprehensive reports that guide global climate policy.

These reports are divided into three working groups:

- Working Group I – The Physical Science Basis of Climate Change
- Working Group II – Impacts, Adaptation, and Vulnerability
- Working Group III – Mitigation of Climate Change

Key Special Reports

- Special Report on Global Warming of 1.5°C (2018) – Explained the impacts of 1.5°C vs. 2°C warming and pathways to limit temperature rise.
- Special Report on Climate Change and Land (2019) – Examined land use, desertification, and food security.
- Special Report on the Ocean and Cryosphere in a Changing Climate (2019) – Focused on ocean warming, sea-level rise, and melting ice.

Major Assessment Reports

DIRECTION

First Assessment Report (FAR) – 1990

- Established that climate change is a serious global issue.
- Formed the scientific basis for the UN Framework Convention on Climate Change (UNFCCC).

Second Assessment Report (SAR) – 1995

- Strengthened evidence that human activities are influencing the climate.
- Provided key input for the Kyoto Protocol negotiations.

Third Assessment Report (TAR) – 2001

- Highlighted stronger evidence of human influence on global warming.
- Introduced the concept of climate scenarios and adaptation strategies.

Fourth Assessment Report (AR4) – 2007

- Concluded that warming of the climate system is “unequivocal.”
- Shared the Nobel Peace Prize with Al Gore for raising awareness on climate change.

Fifth Assessment Report (AR5) – 2014

- Provided the scientific foundation for the Paris Agreement (2015).
- Emphasized the need to limit global warming to below 2°C.

Sixth Assessment Report (AR6) – 2021–2023

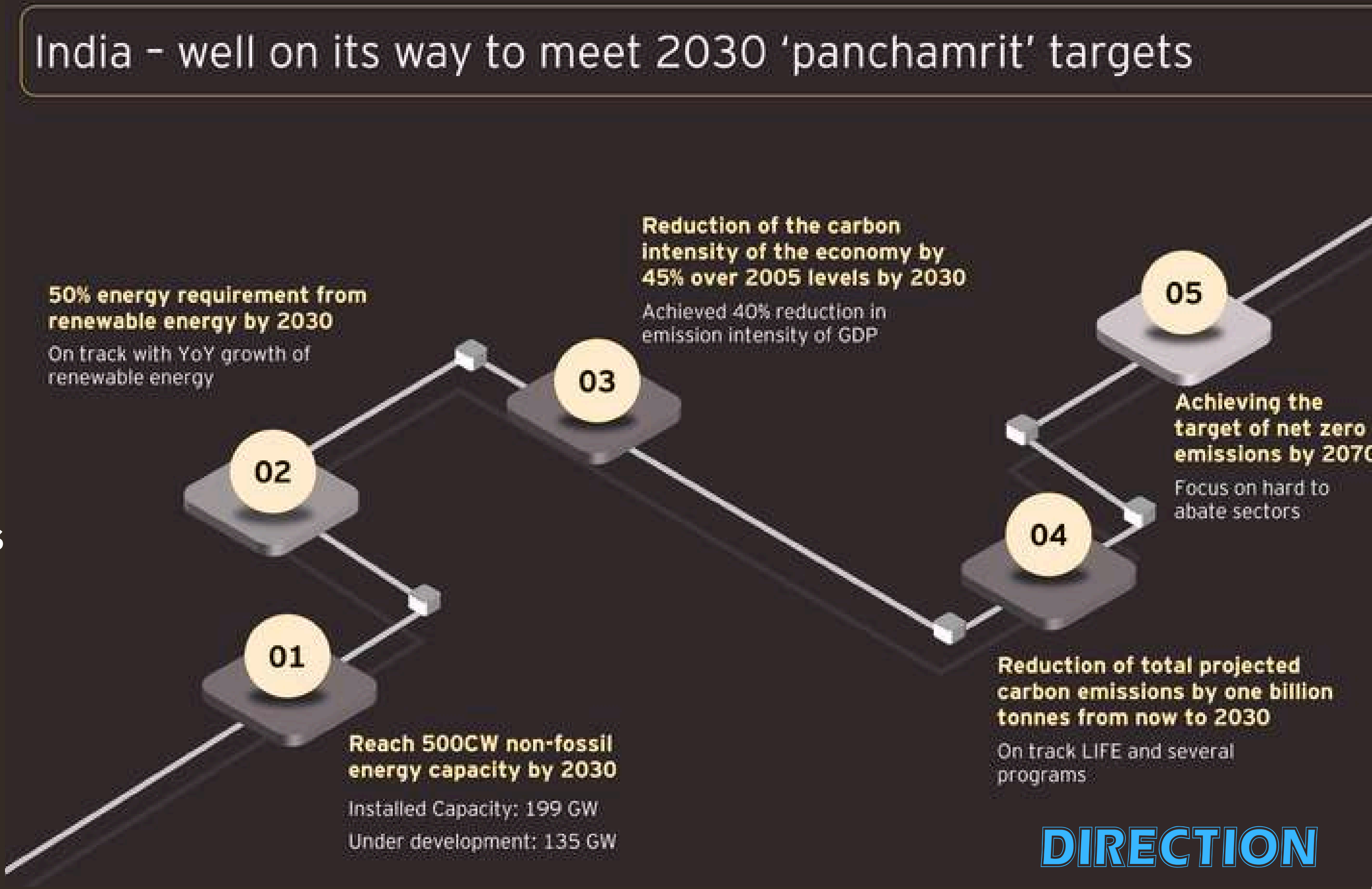
- The most comprehensive and updated assessment.
- Warned that human influence has unequivocally warmed the atmosphere, ocean, and
- land.Stressed the urgency of achieving net-zero emissions to limit warming to 1.5°C.


FAR
SAR
TAR
AR4
AR5
SR15
MR
AR6
IPCC – jointly established by WMO and UNEP
UNFCCC
Kyoto Protocol
Adaptation
2 °C limit
Paris Agreement
SROCC
SRCCL
UNFCCC Global Stocktake
Science of climate change (peer-reviewed literature)
Growing public awareness
Involvement of various actors
CLIMATE CHANGE
CLIMATE CHANGE 2001
Nobel Peace Prize
1988
1995
2007
2018
2019
2023

DIRECTION

India's Panchamrit goals are five climate commitments to reduce emissions and transition to a green economy

As a country vulnerable to climate change, India must ensure that the impact on natural habitats, agriculture and bio-resources is limited, especially considering the population's high dependence on agriculture. India is on track to meet its 2030 goals and has set ambitious targets under its ‘Panchamrit’ framework as part of its Nationally Determined Contributions under the United Nations Framework Convention on Climate Change.



DIRECTION

India's Energy transition and decarbonization are complex processes with no one-size-fits-all solution. While detailed pathways will evolve, current policies and initiatives focus on developing key building blocks. These include

- creating demand for energy transition by facilitating access to competitive green power,
- mandating renewable purchase obligations for industries and DISCOMs,
- blending biofuels, and
- introducing market-based instruments like emissions trading systems.
- Policy and fiscal support for new technologies, such as green hydrogen, offshore power, and battery storage, is also emphasized. Additionally, production-linked incentives aim to develop a domestic supply chain through financial support to ensure competitive energy supply, economic resilience, and energy independence.
- The focus on base load power, particularly through an increased share of nuclear energy capacity, remains critical.

The transport sector in India contributes 18% of the total GHG emission, with the road transportation segment alone accounting for 87% of the emissions. If the current consumption trend continues, India will need approximately 200 million tons of oil equivalent energy supply annually by 2030 to meet transportation demands. The energy transition in this sector is being pursued through measures such as blending biofuels with petroleum products, promoting electric vehicles (EVs), and electrifying Indian Railways by progressively replacing diesel traction with electric traction.

In addition to India's renewable energy, significant advancements have been made in bioethanol. The National Policy on Biofuels notified by the Government of India in 2018 mandates oil marketing companies to blend 20% ethanol, sourced from agricultural inputs, into petrol by 2030. To support this, the government determines the price at which ethanol is procured by the oil marketing companies and offers financial incentives to establish ethanol manufacturing capacity in India. Similarly, the Ministry of Power mandates 5% biomass co-firing in Thermal Power Plants (TPPs) from FY 2024-25.

Indian Railways is actively pursuing its 'Mission 100% Electrification' plan to achieve net zero carbon emissions by 2030. Key initiatives include adopting energy-efficient technologies such as three-phase electric locomotives with regenerative features, head-on generation technology, LED lighting in buildings and coaches, and using star-rated appliances. The railways also focus on afforestation to further reduce emissions.

India Renewable energy and biofuel expansion are driven by mandates and market instruments, with limited reliance on subsidies.

The government plans to launch an Emission Trading System (ETS) under the Carbon Credits Trading Scheme (CCTS), likely adopting a cap-and-trade model. This mandatory system will work alongside a voluntary carbon market, enabling non-obligated entities to trade credits. Efforts are underway to align the CCTS with global standards, fostering India's participation in international carbon markets.

Financing Net Zero Transition

US$ 10.1t

Funding required to achieve Net Zero by 2070

35-40% short fall

Conventional financing may not be sufficient

4-6% GDP

Every year required to achieve Net Zero by 2070

Global Financial Institutes

- Sovereign Green Bond
- Carbon Credits
- Technical Assistance
- Corporate Green Bond
- Public Private Partnership

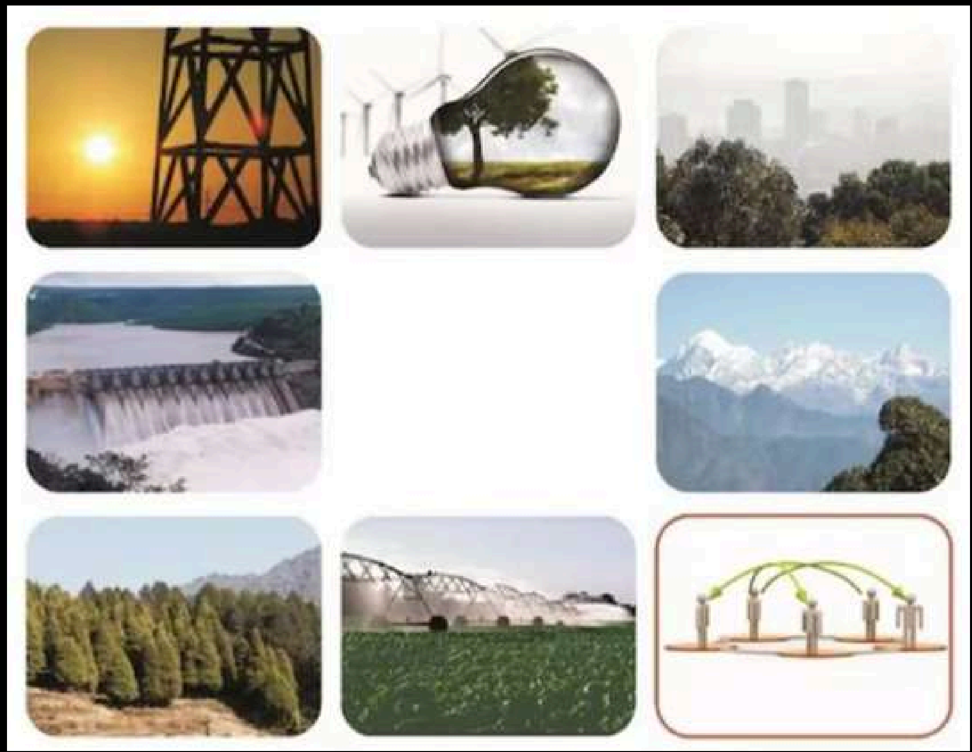
Private Finance

- Sustainability Linked Initiatives
- Startup funding
- Philanthropic investmens
- Blended Finance
- Performance based viability gap funding

Financing Energy Transitions

NAPCC refers to India's National Action Plan on Climate Change, a program launched in 2008 to address climate change through a series of national missions that promote sustainable development, energy efficiency, and adaptation. It is a framework for both national and state governments to tackle climate change challenges while advancing India's development objectives. The plan is overseen by the Prime Minister's Council on Climate Change.

- Goal: To promote sustainable development by addressing climate change, adapting to its impacts, and reducing emission intensity.
- Structure: Consists of eight "National Missions"
    - National Solar Mission
    - Enhanced Energy Efficiency
    - Sustainable Habitat
    - National Water Mission
    - National Mission for a Green India
    - Sustaining the Himalayan Eco-system
    - Sustainable Agriculture
    - Strategic Knowledge for Climate Change



- Implementation: NAPCC is a framework that guides both national and state-level actions, with states creating their own State Action Plans on Climate Change (SAPCCs).
- Funding: Financial support for the missions comes from respective National Missions.

National Solar Mission- Solar Schemes

India has several government schemes for grid-connected solar systems, including

for residential consumers.

- the PM-Surya Ghar: Muft Bijli Yojana for households and
- the Grid Connected Rooftop Solar Programme

For large-scale projects,
the government supports

- the development of solar parks

Scheme for farmers.

- initiatives under the PM-KUSUM

These programs provide subsidies and financial assistance to encourage solar adoption, with mechanisms for direct benefit transfer of subsidies.

PM-Surya Ghar: Muft Bijli Yojana: Aims to provide free electricity to one crore households through subsidies for rooftop solar panel installation.

Grid Connected Rooftop Solar Programme: The government provides Central Financial Assistance (CFA) or subsidy to residential consumers.

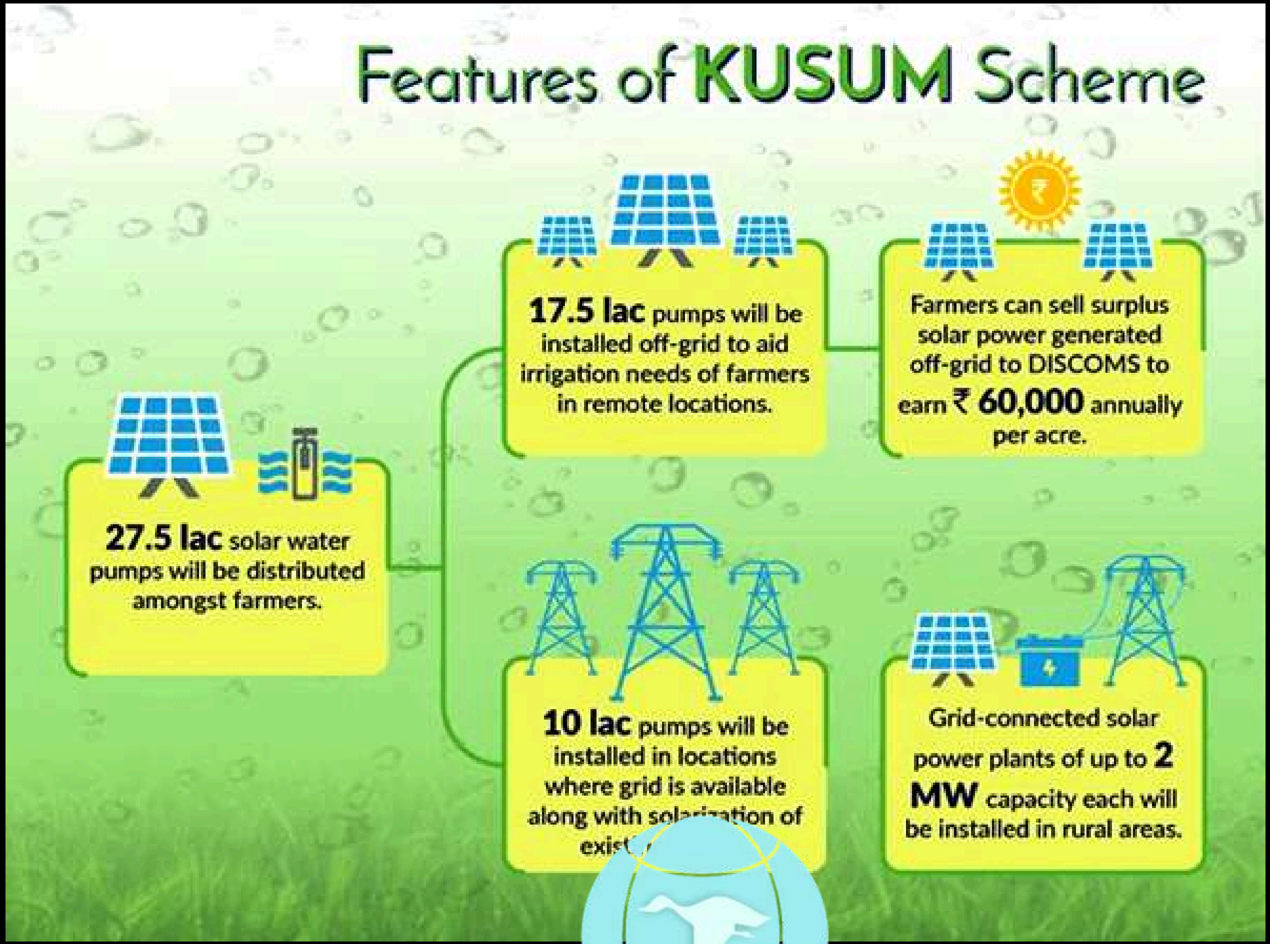
The subsidy is directly transferred to bank account after successful installation and verification by the State DISCOM.

PM-KUSUM Scheme: This scheme has multiple components:

Component-A: Setting up decentralized grid-connected solar or renewable energy power plants.

Component-B: Installing standalone solar agriculture pumps.

Component-C: Solarizing grid-connected agriculture pumps and feeders.



For large-scale projects

Solar Parks and Ultra Mega Solar Power Projects: The government supports states in setting up large solar parks with the necessary infrastructure to speed up the installation of large-scale grid-connected projects.

Central Public Sector Undertaking (CPSU) Scheme: Approves large grid-connected solar photovoltaic projects by government producers with Viability Gap Funding (VGF) support.

Key features

- **Concentrated development:** Solar parks serve as a single location for developing numerous solar projects, streamlining land acquisition and grid connection.
- **"Plug-and-play" infrastructure:** The government provides essential infrastructure, including developed land, transmission systems, road connectivity, and other clearances, which reduces the risk and complexity for individual developers.
- **Economies of scale:** Ultra-mega projects (typically 500 MW or more) are built to maximize efficiency and lower the cost of solar energy, helping to drive down tariffs.
- **Risk reduction:** By handling land acquisition, grid connection, and other necessary
- **Net Metering:** Grid-connected systems can operate on a net metering basis, where consumers are billed based on the net electricity consumed from the grid or have two meters for separate import/export readings.

Benefits: These schemes generate clean energy, reduce electricity costs, and can reduce diesel consumption for backup power.

INTERNATIONAL SOLAR ALLIANCE

The International Solar Alliance (ISA) aims at increasing solar energy deployment in member countries at an affordable rate, create solar grids and establish solar credit mechanism.

Launched at the UN Climate Change Conference (COP21) in Paris in 2015. a treaty-based intergovernmental organization **launched by India and France** to mobilize global efforts for solar energy deployment and climate change mitigation.

Its mission is to

- increase solar energy use,
- reduce costs through finance and technology, and provide energy access and security to countries,
- with a goal of mobilizing $1 trillion in investment by 2030.

The ISA is headquartered in **the National Institute of Solar Energy (NISE) Gurugram, India,** and has over 125 member and signatory countries

The International Renewable Energy Agency (IRENA)

Intergovernmental organisation that supports countries in their transition to a sustainable energy future, and serves as the principal platform for international co-operation, a centre of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy. IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy, in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity.

India is a member of the International Renewable Energy Agency (IRENA) India has a strategic partnership with IRENA to strengthen collaboration on renewable energy transitions.

- Founding member: India was the 77th founding member of IRENA when it was established.
- Strategic partnership: In 2022, India and IRENA signed a strategic partnership agreement to boost their cooperation in the field of renewable energy, supporting India's goals for green energy transitions.
- Areas of cooperation: The partnership includes joint activities on innovation, long-term energy planning, and the development of green hydrogen.
- Global role: As a member, India contributes to and benefits from IRENA's role in promoting the widespread adoption of renewable energy and serving as a platform for international cooperation

National Green Hydrogen Mission

Green Hydrogen, is produced by the process of electrolysis, where water is split into hydrogen and oxygen using electricity generated from renewable sources like solar, wind, or hydropower.
This process results in a clean and emission-free fuel that has immense potential to replace fossil fuels and reduce carbon emissions.
Another method of producing Green Hydrogen is from biomass, which involves the gasification of biomass to produce hydrogen.
Both these production methods are clean and sustainable, making Green Hydrogen an attractive option for the transition to a low-carbon future.

- To make India the Global Hub for production, usage and export of Green Hydrogen and its derivatives.
- contribute to India's aim to become Aatmanirbhar through clean energy and serve as an inspiration for the global Clean Energy Transition.
- lead to significant decarbonisation of the economy,
- reduced dependence on fossil fuel imports, and
- enable India to assume technology and market leadership in Green Hydrogen.

Strategic intervention for a green hydrogen transition primarily involves the Strategic Interventions for Green Hydrogen Transition (SIGHT) Programme, a key part of India's National Green Hydrogen Mission. This program provides financial incentives for manufacturing electrolysers and producing green hydrogen, supports pilot projects, aims to establish Green Hydrogen Hubs, and facilitates a strong policy and regulatory framework to make India a global hub for green hydrogen.

Targeted sectors

Fertilizer Production: Green hydrogen can replace fossil fuels in the production of ammonia, a key component of fertilizers.

Petroleum Refining: It can be used as a clean alternative in refining processes, helping to lower emissions in this sector.

Steel Production: Green hydrogen is a crucial part of decarbonizing the steel industry, with pilot projects specifically funded for this purpose.

Mobility: This includes using green hydrogen for fuel cell vehicles (trucks, buses, and cars) and as a cleaner alternative for shipping propulsion.

Other sectors:

Decentralized energy applications

Shipping

Production from biomass

Hydrogen storage technologies

Bio Energy

With a large surplus of biomass and other waste available in the country, energy recovery from these resources is a viable solution. Modern bioenergy is unique as it provides several social and environmental benefits apart from providing clean fuels. For example, bioenergy applications can help mitigate air, water, and land pollution. It can also create local jobs, and business opportunities, and reduce energy import bills. It can help develop decentralised and independent communities.

There are benefits to the private sector, as well, in the form of opportunities to decarbonise their industries. Other benefits include savings on fertiliser subsidies and a reduction in waste management costs. Therefore, the Ministry of New and Renewable Energy (MNRE) has notified the National Bioenergy Programme for a period 2021 to 2026 with an outlay of Rs.858 crore under Phase-I.

The National Bioenergy Programme will comprise the following sub-schemes:

- Waste to Energy Programme (Programme on Energy from Urban, Industrial and Agricultural Wastes /Residues)
- Biomass Programme (Scheme to Support Manufacturing of Briquettes & Pellets and Promotion of Biomass (non-bagasse) based cogeneration in Industries)
- Biogas Programme

National Mission for Enhanced Energy Efficiency (NMEEE)

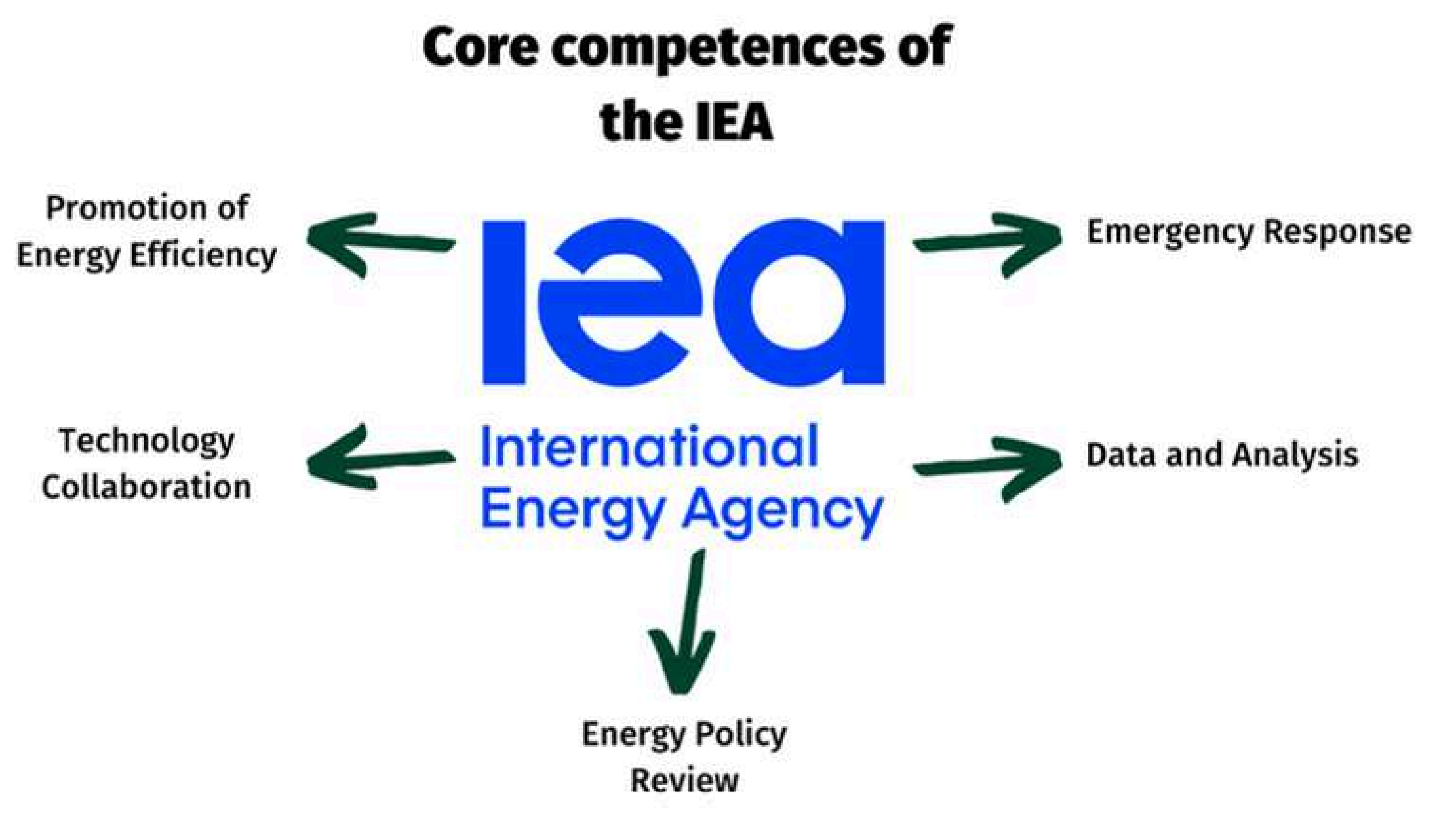
consists of four initiatives to enhance energy efficiency in energy intensive industries which are as follows:

- **Perform, Achieve and Trade (PAT)** scheme aims at reducing Specific Energy Consumption (SEC) i.e. energy use per unit of production for Designated Consumers (DCs) in energy intensive sectors, with an associated market mechanism to enhance the cost effectiveness through certification of excess energy saving which can be traded.
- **Market Transformation for Energy Efficiency (MTEE)** aims for accelerating the shift to energy efficient appliances in designated sectors through incentives and innovative business models. Under MTEE the following programmes were introduced for the promotion of energy efficient products in the market:-
- Bachat Lamp Yojna (BLY): The programme was developed for replacement of inefficient bulbs with Compact Fluorescent Lamps (CFLs).

Super-Efficient Equipment Program (SEEP): This programme was designed for market transformation of super-efficient appliances by providing financial stimulus innovatively at critical point/s of interventions.

- **Energy Efficiency Financing Platform (EEFP)** was launched to provide a platform to interact with Financial Institutions (FIs) and project developers for implementation of energy efficiency projects. Under this programme, Memorandum of Understandings (MoUs) have been signed by BEE to promote financing for energy efficiency projects. For capacity building of FIs, BEE signed MoU with Indian Banks' Association for the Training Programme on Energy Efficiency Financing.
- **Framework for Energy Efficient Economic Development (FEEED)** was designed for development of fiscal instruments to promote energy efficiency. The objective was to provide the comfort to concerned stakeholders through implementation of Energy Efficiency schemes such as Partial Risk Sharing Facility (PRSF) to provide partial credit guarantees to cover a share of the default risk that participating financial institutions face in extending loans to eligible Energy Efficiency sub-projects.

The International Energy Agency is an international energy forum comprised of 29 industrialized countries under the Organization for Economic Development and Cooperatio (OECD).



The IEA was established in 1974, in the wake of the 1973-1974 oil crisis, to help its members respond to major oil supply disruptions, a role it continues to fulfill today. IEA's mandate has expanded over time to include **tracking and analyzing global key energy trends, promoting sound energy policy, and fostering multinational energy technology cooperation.** As the global energy picture has changed, the IEA has sought to engage key non-members in its activities, including Brazil, China, India, Indonesia, South Africa, Thailand, Singapore, Morocco and accession countries Mexico and Chile. The IEA's energy analyses, international data collection, and coordinated collective emergency response capabilities are unique and highly regarded.

India is an "Associate country" and has a strategic partnership with the IEA.

Full membership eligibility:

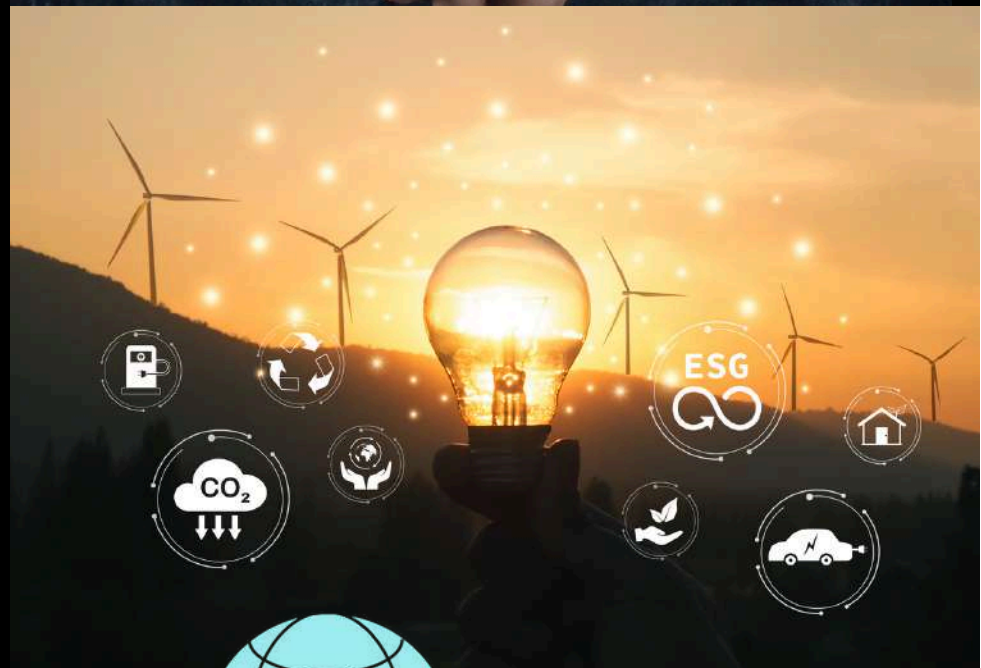
Full IEA membership is restricted to OECD member countries and requires meeting specific criteria, such as maintaining strategic oil reserves equivalent to 90 days of net imports.

India's progress:

India has been a partner of the IEA for years, and in March 2017, it officially joined as an associate member.

Path to full membership:

In October 2023, India formally requested full membership, and in February 2024, the IEA agreed to begin discussions with India on this request.



The National Mission for Sustainable Habitat (NMSH)

The National Mission for Sustainable Habitat (NMSH) is one of the nine missions under the National Action Plan on Climate Change, which seeks to promote current and future climate change mitigation and adaptation policies in the built environment, including buildings, waste management and transport.

The NMSH has been implemented through 4 flagship missions -

- Atal Mission on Rejuvenation and Urban Transformation (AMRUT),
- Swachh Bharat Mission,
- Smart Cities Mission,
- Urban Transport Programme.

Additionally, several policies and programs aimed to decarbonize existing buildings inter alia include,

- Energy Conservation Building Code,
- Building Energy Efficiency Programme,
- Star Rating System for Commercial Buildings;
- Shunya Labelling Programme,
- Econiwas Samhita for Residential Buildings;
- Standards and Labeling Programme;
- Unnat Jyoti by Affordable LEDS for All (UJALA);
- Pradhan Mantri Ujjwala Yojana.

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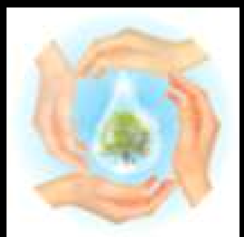
National Water Mission

he National Action Plan on Climate Change (NAPCC) describes the features of National Water Mission as under: “A National Water Mission will be mounted to ensure integrated water resource management helping to conserve water, minimize wastage and ensure more equitable distribution both across and within states.

It will seek to ensure that a considerable share of the water needs of urban areas are met through recycling of waste water, and ensuring that the water requirements of coastal cities with inadequate alternative sources of water are met through adoption of new and appropriate technologies such as low temperature desalination technologies that allow for the use of ocean water.

Goals of NWM

Goal 1: Comprehensive water data base in public domain



Goal 2: Assessment of the impact of climate change on water resources

Goal 3: Promotion of citizen and state actions for water conservation, augmentation and preservation, and Focused attention to vulnerable areas including over-exploited areas

Goals 4: Increasing water use efficiency by 20%

Goal 5: Promotion of basin level integrated water resources management

Global Water Crisis

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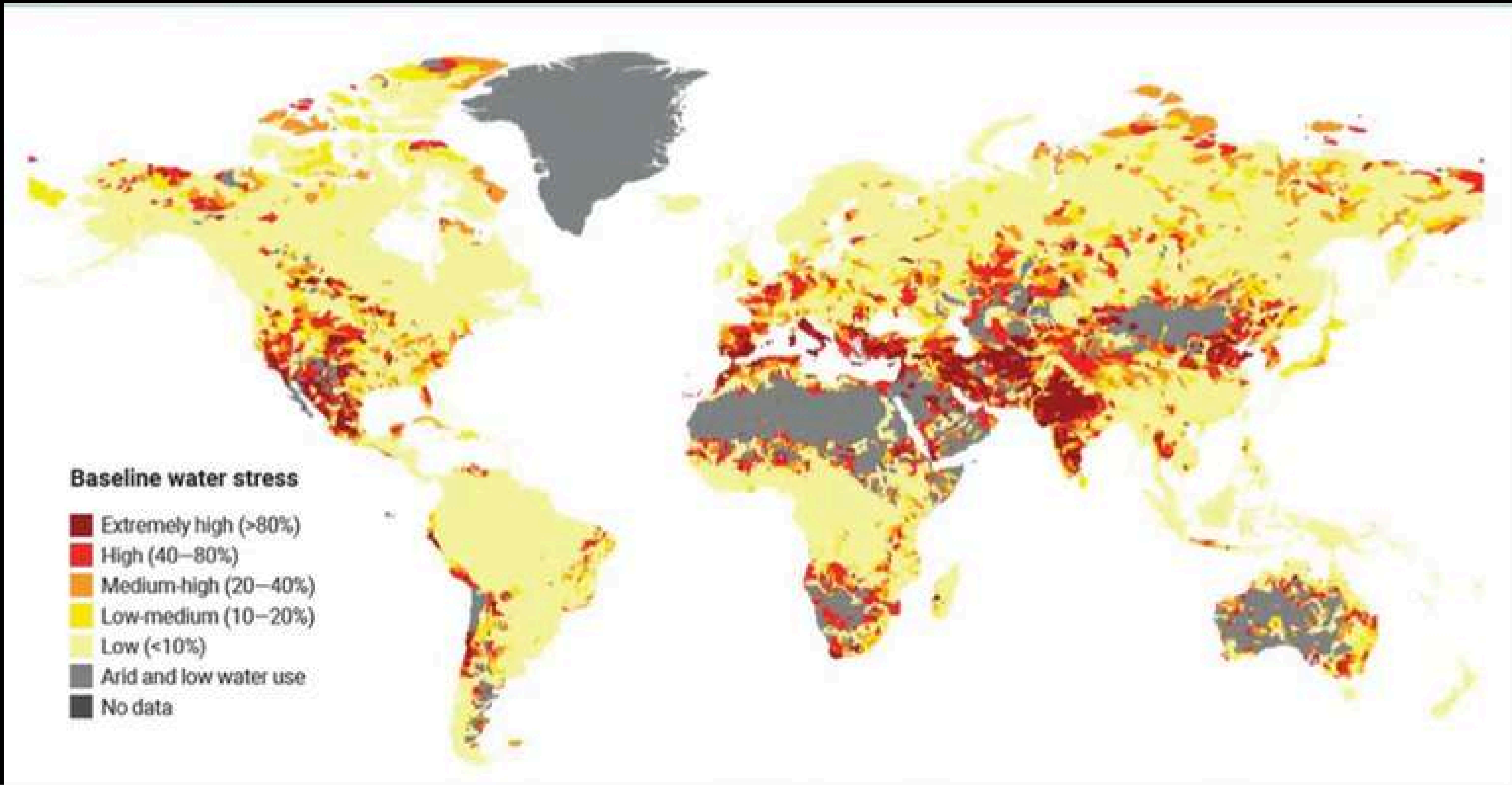
The global water crisis refers to the scarcity of usable and accessible water resources across the world. Currently, nearly 703 million people lack access to water – approximately 1 in 10 people on the planet – and over 2 billion do not have safe drinking water services. The United Nations predicts that by 2025, 1.8 billion people will be living in countries or regions with absolute water scarcity. With the existing climate change scenario, almost half the world's population will be living in areas of high water stress by 2030. In addition, water scarcity in some arid and semi-arid places will displace between 24 million and 700 million people. By 2030, water scarcity could displace over 700 million people.



Water scarcity

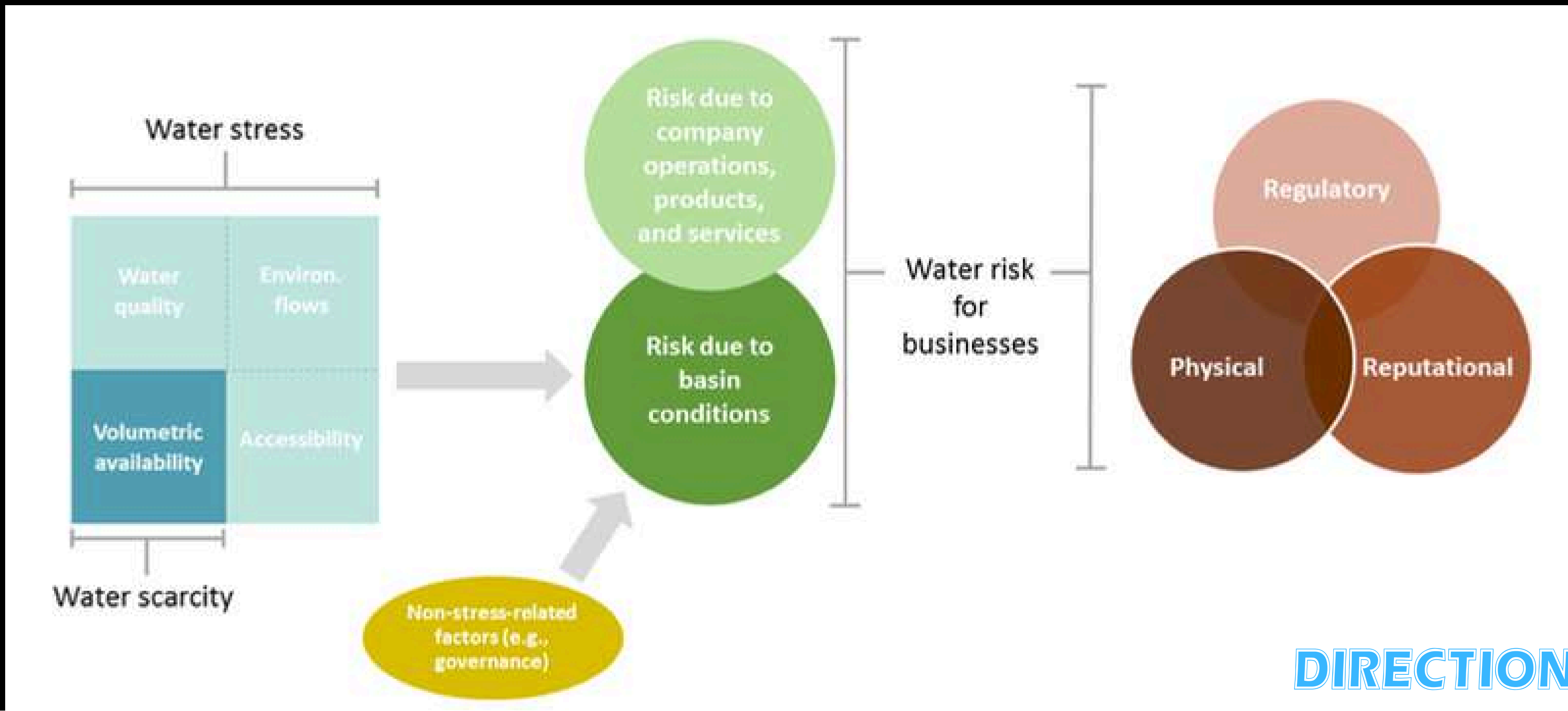
"Water scarcity" refers to the volumetric abundance, or lack thereof, of water supply. This is typically calculated as a ratio of human water consumption to available water supply in a given area. Water scarcity is a physical, objective reality that can be measured consistently across regions and over time.

Water stress

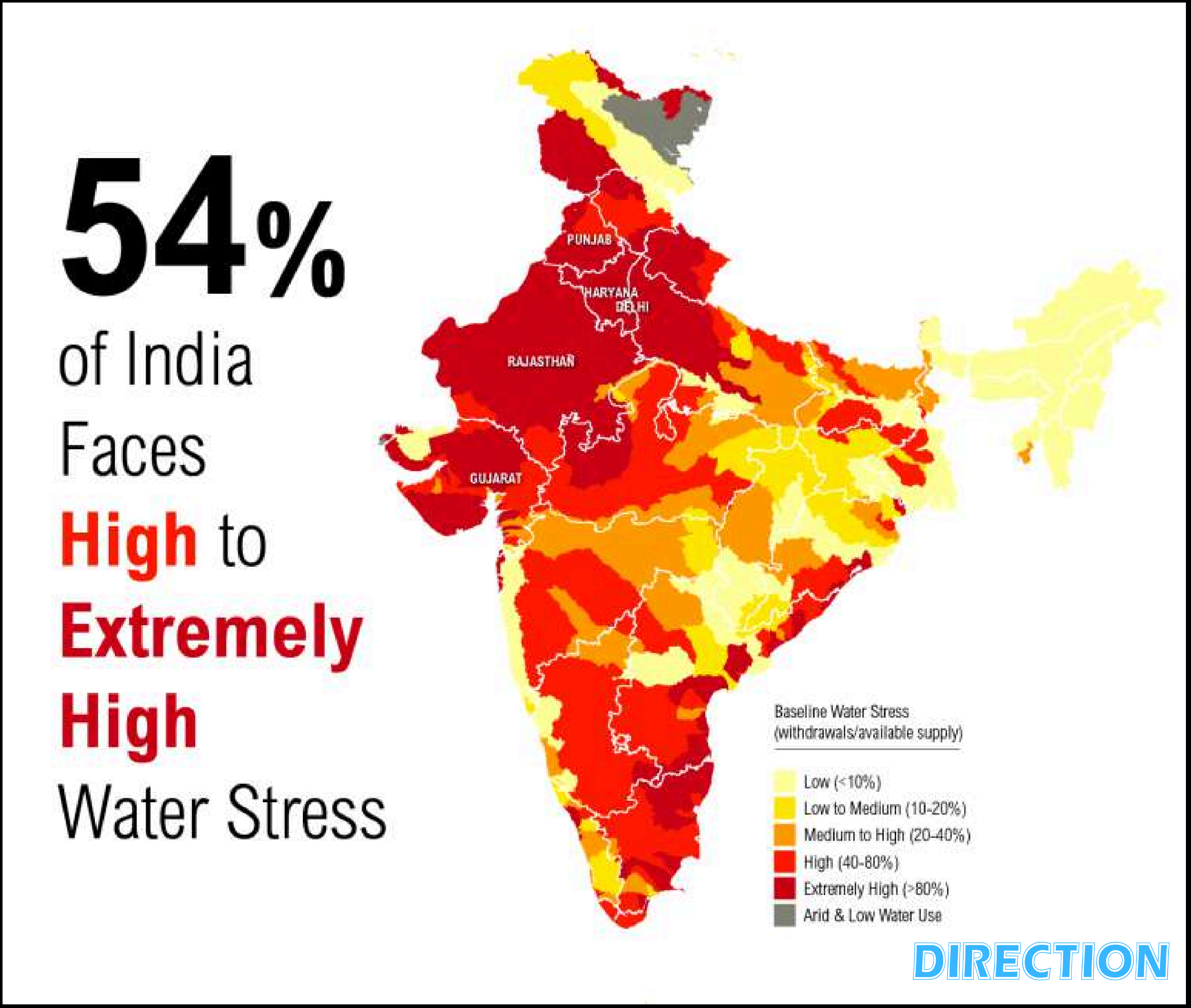
"Water stress" refers to the ability, or lack thereof, to meet human and ecological demand for water. Compared to scarcity, "water stress" is a more inclusive and broader concept. It considers several physical aspects related to water resources, including water scarcity, but also water quality, environmental flows, and the accessibility of water.

Water risk

"Water risk" refers to the probability of an entity experiencing a deleterious water-related event. Water risk is felt differently by every sector of society and the organizations within them and thus is defined and interpreted differently (even when they experience the same degree of water scarcity or water stress). That notwithstanding, many water-related conditions, such as water scarcity, pollution, poor governance, inadequate infrastructure, climate change, and others, create risk for many different sectors and organizations simultaneously.



India is already struggling to provide all its citizens with sustainable and equitable access to water resources. In fact, even though 18% of the world's population resides in India, the country only has enough water resources to sustain 4% of its people. This reality makes India the most water-stressed country despite its vast rivers and underground aquifers.



Top Reasons for Water Scarcity in India

There are various reasons why water scarcity in India is so prevalent. From interstate water disputes to poor water infrastructure, many factors feed into the country's water resource challenges. However, three specific issues have the biggest impact on India's water availability and capacity to meet current and future demands.

1. Contamination and Pollution

India continues to urbanize and grow. While that's great, the country's water bodies are becoming increasingly toxic. Research suggests that around 70% of India's surface water sources are unfit for consumption. It's also estimated that nearly 40 million liters of wastewater flow into India's rivers, tributaries, lakes, and other water sources, but only a small fraction is effectively treated.

With contaminated and polluted water bodies, India has few clean water resources to sustain its economy, ecosystem, and civil society. The impact of this reality is significant. According to an article by the World Economic Forum, environmental degradation is costing India the equivalent of around $80 billion US dollars annually. The health costs stemming from water pollution is up to the equivalent of $8.7 billion US dollars per year—and the number of lives lost annually in India because of water scarcity, hygiene, and sanitation is around 400,000 people.

2. Depleting Groundwater

For most people in India, groundwater is the only source of water, enabling citizens to meet some of their domestic and agricultural needs. However, because India has such a large population, the widespread extraction of water has resulted in a noticeable decline of these resources and an increases of salinity in such resources.

According to the World Bank, almost 63% of India's districts are experiencing decreasing groundwater levels. Poverty rates where districts' groundwater tables have fallen below eight meters (8 M) are also high, coming in at 9% to 10%, making small farmers incredibly vulnerable to these effects. If water availability does not improve in India, at least 25% of the country's agriculture will be at risk.

3. The Climate Crisis

Monsoons have long been a water source for India, but climate change is leading to unpredictable floods and droughts, both of which are exacerbating water scarcity conditions. For example, while India is experiencing more days with heavy rainfall, the country is seeing longer dry spells in between these monsoon storms. One area that is particularly impacted is India's central belt, which encompasses western Maharashtra State and the Bay of Bengal. Over the last 70 years, extreme rainfall events have increased threefold—but total annual rainfall has decreased.

Remediate, Desalinate, Reuse

Improving water availability in India will be challenging for industries, municipal water corporations, and consulting engineers who assist these clients with these challenges. This is especially apparent since the country is already experiencing severe water scarcity due to complex factors.

However, taking a step in the right direction is possible if the main players continue to implement three strategies:

- Remediate surface water sources,
- Desalinate water sources,
- Treat & Reuse wastewater sources.

Each of the suggested steps is crucial. The first two play a role in decontaminating water bodies so that they are clean and safe enough to utilize—and the third helps improve India's water supply so that the country can meet its current and future water demands. By utilizing these strategies, industries, municipal water corporations, and consulting engineers who work with these organizations can tackle the three biggest factors contributing to India's water scarcity.

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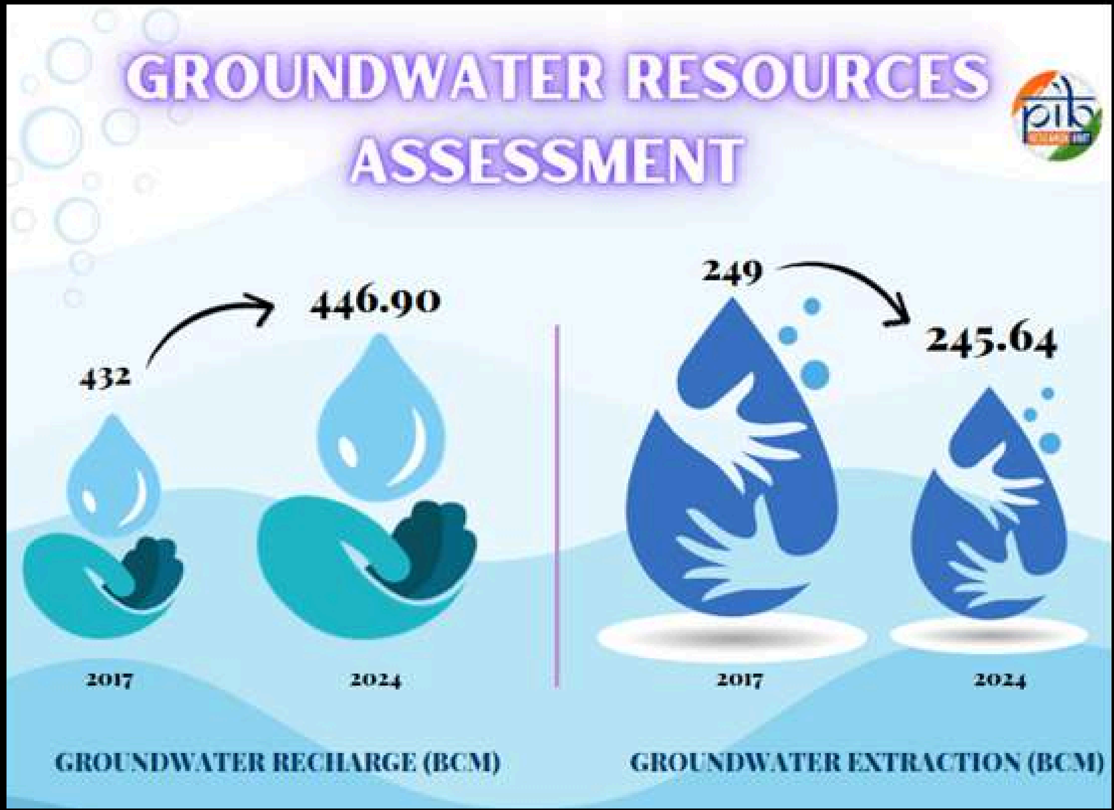
In 2024, total annual groundwater recharge experienced a significant increase of 15 BCM (Billion Cubic Meters), while extraction decreased by 3 BCM compared to the 2017 assessment. This progress underscores the importance of understanding groundwater's availability, usage, and the challenges ahead.

India's Groundwater Revival



The year 2024 has seen positive advancements in several key areas, with notable highlights including:

- Total Annual GW Recharge has increased (15 BCM) substantially and Extraction has declined (3 BCM) in 2024 from 2017 assessment.
- Recharge from Tanks, Ponds and WCS (Water Control System) has shown a consistent increase in the last five assessments. In the year 2024, it has increased by 0.39 BCM w.r.t. 2023.
- With respect to the year 2017, there is an increase of 11.36 BCM in recharge from Tanks, Ponds & WCS (from 13.98 BCM in 2017 to 25.34 BCM in 2024).
- The percentage of Assessment Units under Safe Category have increased from 62.6% in 2017 to 73.4 % in 2024. The percentage of Over Exploited Assessment units have declined from 17.24 % in 2017 to 11.13 % in 2024.

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Clean Groundwater: Essential for Future Generations

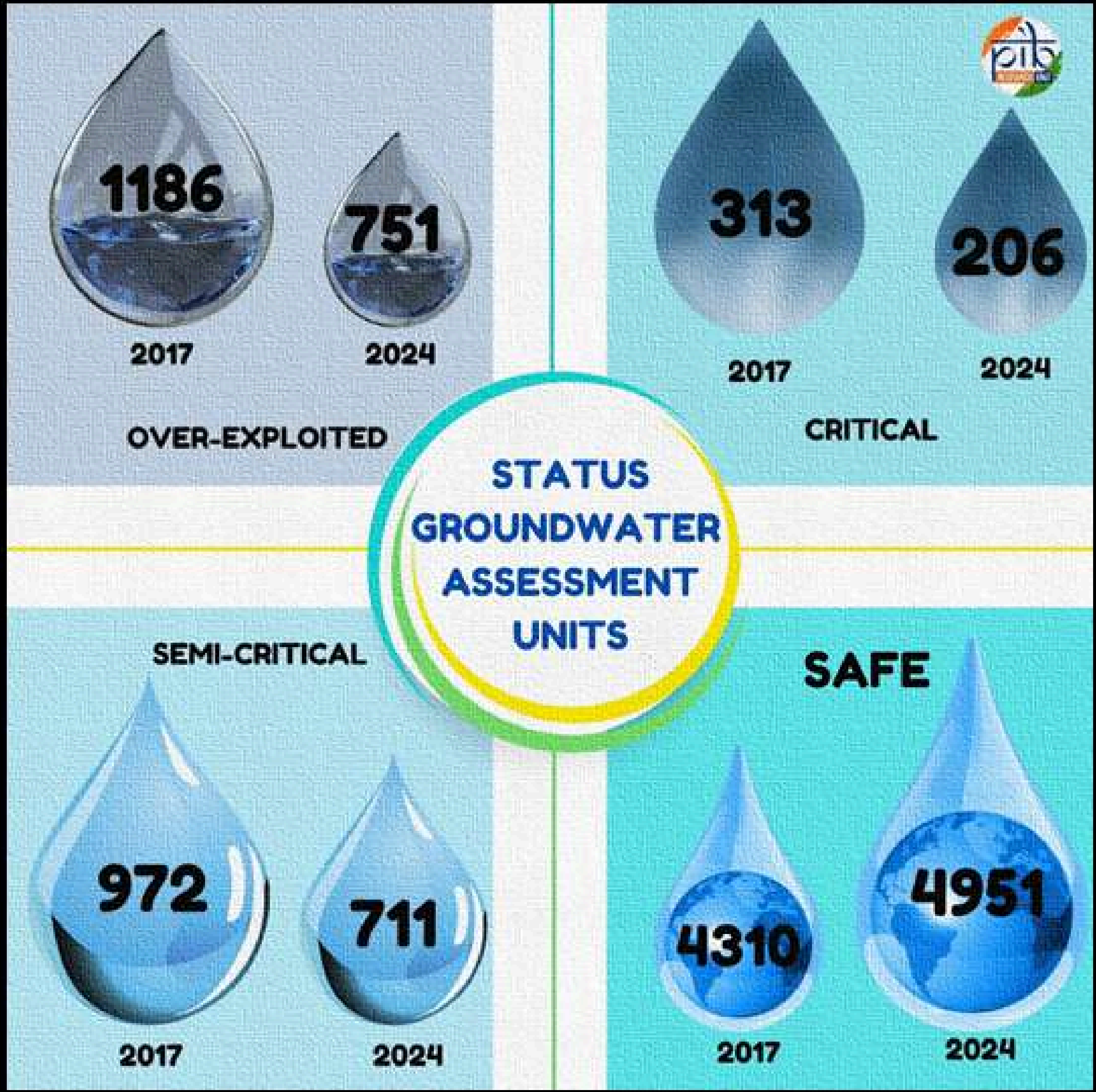
Maintaining groundwater quality is just as crucial as its recharge for sustainable water management.

Key pollutants such as Arsenic, Fluoride, Chloride, Uranium, and Nitrate pose serious health risks, either through direct toxicity or long-term exposure.

Additionally, Elevated Electrical Conductivity (EC) can indicate contamination from agricultural runoff, industrial discharge, or saline intrusion, while Iron contamination may lead to gastrointestinal issues, highlighting the importance of careful water quality monitoring.

To assess the critical areas impacted by contamination, the Annual Groundwater Quality Report for 2024 offers a comprehensive analysis of groundwater quality across India, drawing insights from data collected at over 15,200 monitoring locations and 4,982 trend stations. The report emphasizes the importance of not only preserving groundwater but also ensuring its quality for effective, long-term water management.

The report further reveals that 81% of groundwater samples are suitable for irrigation, with 100% of groundwater samples from the North-Eastern states being rated "excellent" for irrigation, underscoring the favorable conditions for agriculture in the region.



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Regional Variations:

- Stage of Groundwater Extraction > 100%: Punjab, Rajasthan, Dadra and Nagar Haveli and Daman and Diu, Haryana, and Delhi.
- Stage of Groundwater Extraction > 90% to 100%: Nil
- Stage of Groundwater Extraction > 70% to 90%: Tamil Nadu, Uttar Pradesh, Puducherry and Chandigarh.
- Stage of Groundwater Extraction < 70%: Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Chhattisgarh, Goa, Gujarat, Himachal Pradesh, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Mizoram, Nagaland, Odisha, Sikkim, Telangana, Tripura, Uttarakhand, West Bengal, Andaman and Nicobar, Jammu and Kashmir, Ladakh, Lakshadweep.

Groundwater Trends (2017-2024):

- Groundwater recharge increased by 15 BCM since 2017.
- Groundwater extraction reduced by 3 BCM compared to 2017.
- Recharge from tanks, ponds, and conservation structures increased by 11.36 BCM (from 13.98 BCM in 2017 to 25.34 BCM in 2024).

Contributions to Recharge:

Rainfall: Accounts for 61% of the total groundwater recharge, making it the primary contributor.
Water Bodies, Tanks, and Ponds: Significant contributors to recharge, with recharge from these sources increasing by 11.36 BCM from 2017 to 2024 (from 13.98 BCM to 25.34 BCM).

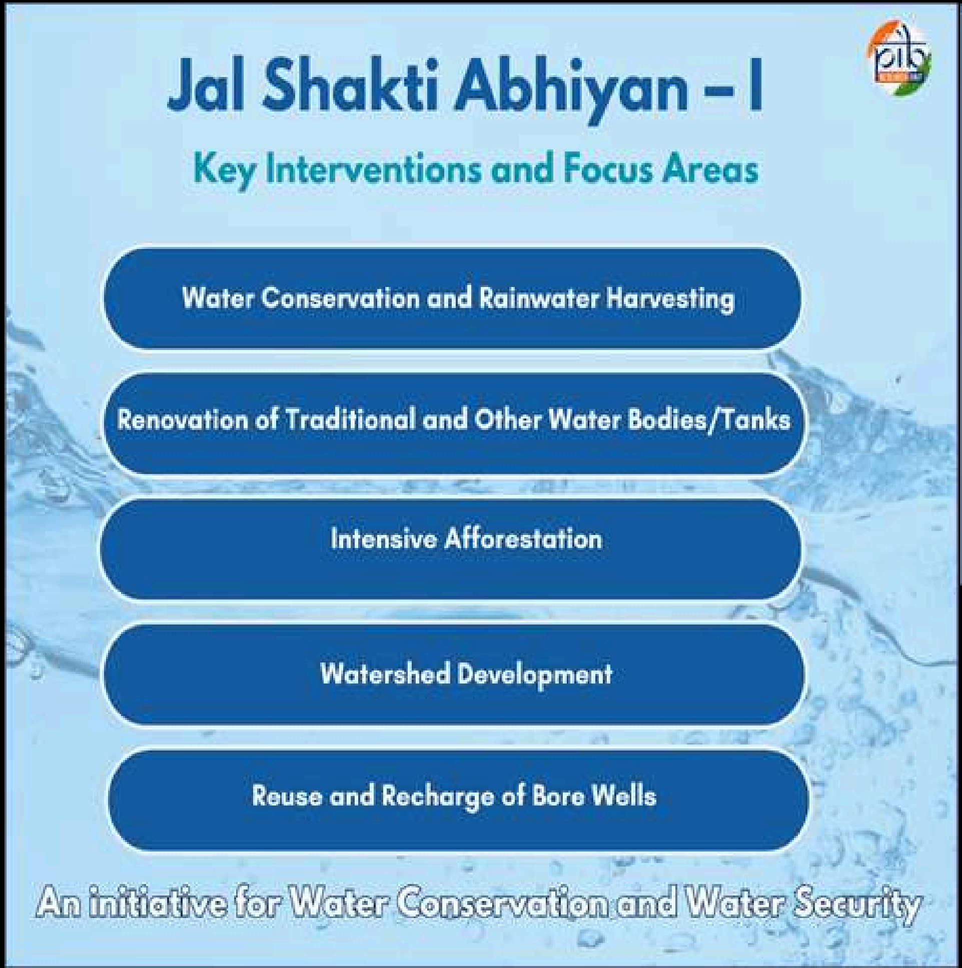
Water Quality Concerns:

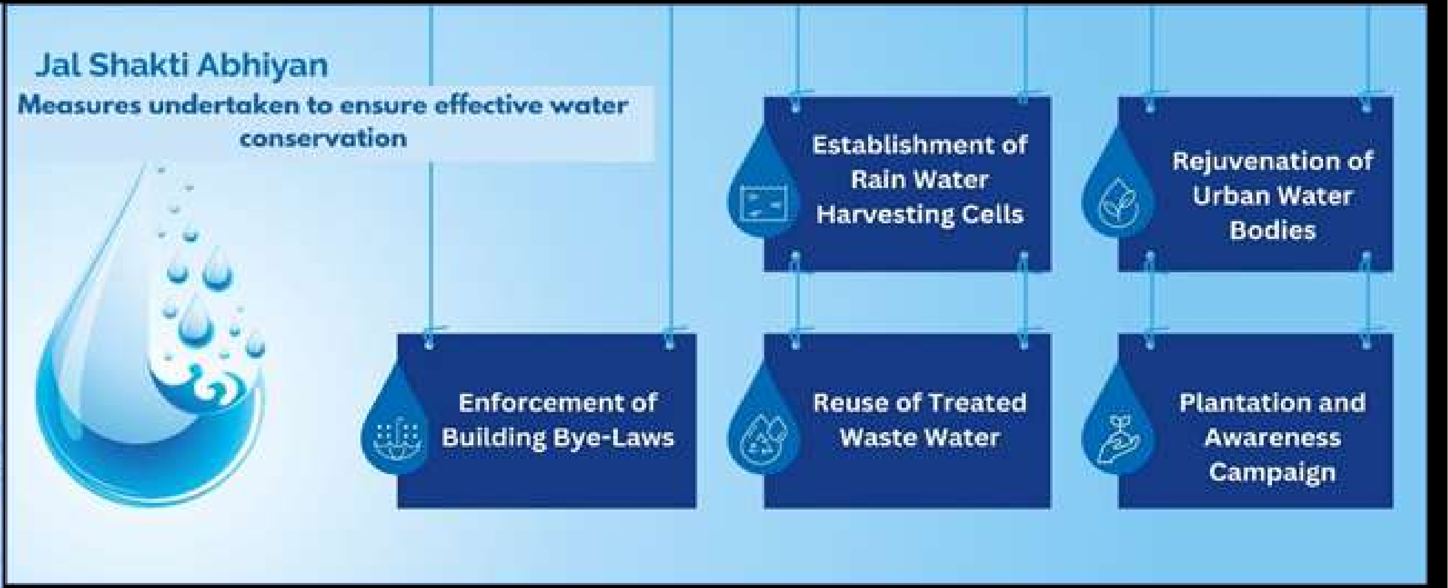
- Contaminants in Groundwater: Presence of pollutants such as Arsenic, Fluoride, Nitrate, and Uranium affecting groundwater quality in various regions.
- Saline Groundwater: 127 assessment units (1.8%) categorized as saline, primarily due to brackish or saline groundwater in phreatic aquifers.
- Irrigation Suitability: 81% of groundwater samples are deemed suitable for irrigation.
- North-East states have 100% of groundwater categorized as “excellent” for irrigation.
- Regional Contamination: Areas with high Electrical Conductivity (EC) and specific contaminants are identified as hotspots for pollution, stemming from agricultural runoff and industrial discharges.

Ground Water Assessment and Management Initiatives

These positive outcomes are the result of collaborative efforts between state and central governments. The Government of India has launched various initiatives to preserve water and ensure its availability for future generations. Key schemes include

- Jal Shakti Abhiyan (JSA): Launched in 2019, now in its 5th phase , focusing on rainwater harvesting and water conservation across rural and urban districts through convergence of various schemes.



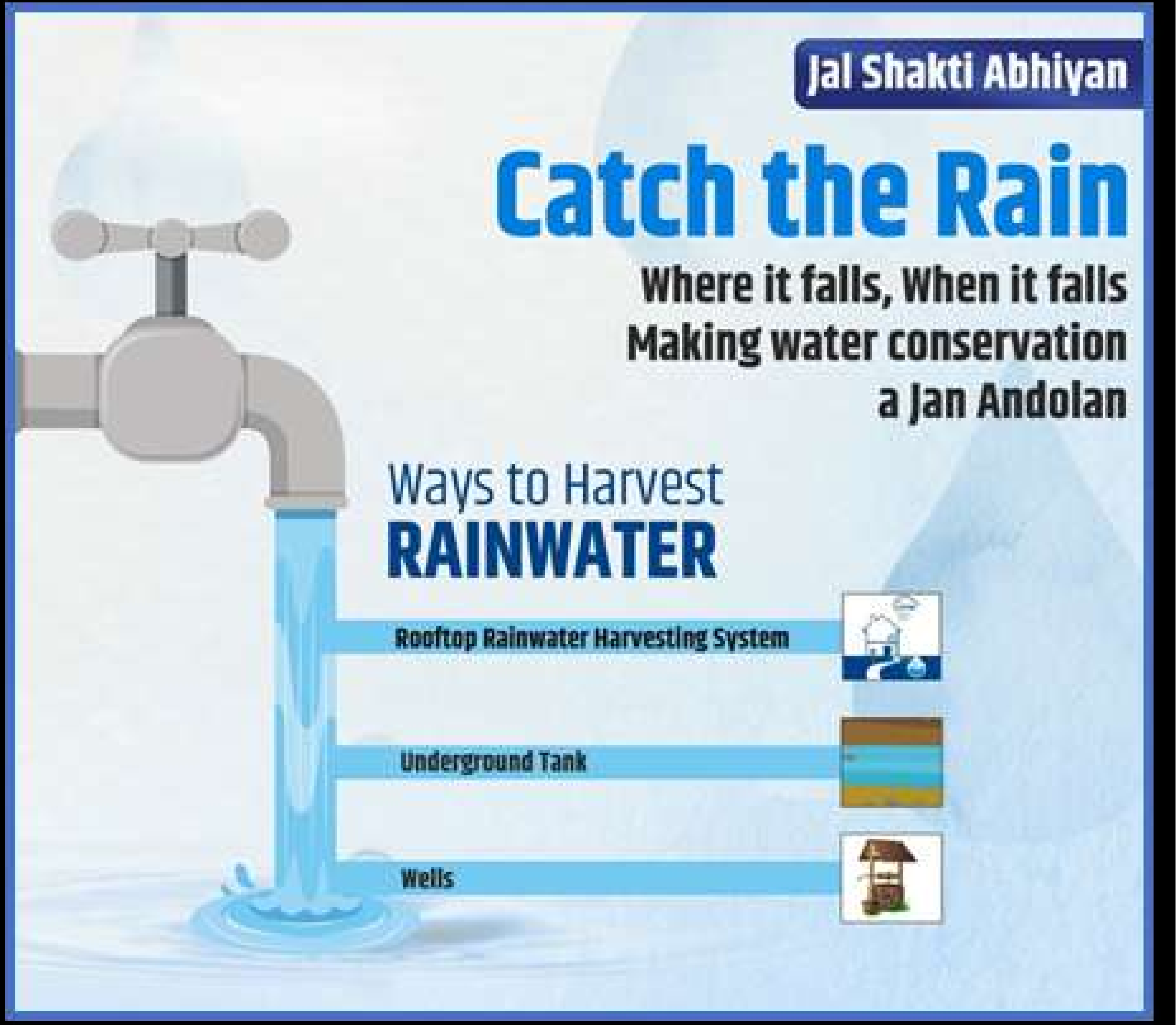


DIRECTION

Jal Shakti Abhiyan: Catch the Rain – 2024

In 2021, "Jal Shakti Abhiyan: Catch the Rain" (JSA: CTR) was launched with the theme "Catch the Rain – Where it Falls When it Falls." This initiative subsumed the earlier Catch the Rain campaign, extending its coverage to all blocks in both rural and urban areas across the country. Since its inception, JSA: CTR has become an annual campaign.

At present Jal Shakti Abhiyan: Catch the Rain – 2024, themed **"Nari Shakti se Jal Shakti,"** , highlighting the crucial role of women in water conservation.



Atal Bhujal Yojana (2020): Targets water-stressed Gram Panchayats in 80 districts across 7 states, focusing on groundwater management.
Gujarat, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan and Uttar Pradesh. The purpose of this plan is to augment the central and state government programs for the community-based sustainable groundwater management, which will be accomplished by combining various prominent schemes. The Atal Jal scheme aims at water conservation and efficiency and is an initiative undertaken by the Ministry of Water Resources, River Development and Ganga Rejuvenation and now the Jal Shakti Ministry.

National Mission for a Green India

The National Mission for a Green India or the commonly called Green India Mission (GIM), is one of the eight Missions under the National Action Plan on Climate Change (NAPCC). It was launched in February, 2014 with the objective to safeguard the biological resources of our nation and associated livelihoods against the peril of adverse climate change and to recognise the vital impact of forestry on ecological sustainability, biodiversity conservation and food-, water- and livelihood-security. It aims at

- protecting, restoring and enhancing India's diminishing forest cover and responding to climate change through adaptation and mitigation measures.
- It envisages a holistic view of greening that extends beyond tree planting.
- GIM focusses on multiple ecosystem services such as biodiversity, water, biomass, preserving mangroves, wetlands, critical habitats etc. along with carbon sequestration.

The revised Green India Mission (GIM) plan is for the 2021–2030 period, with the goal of increasing forest and tree cover by 24 million hectares to create an additional carbon sink of 2.5 to 3 billion tonnes of CO_2 equivalent by 2030.

Key objectives include improving ecosystem services and increasing forest-based livelihood incomes. The plan outlines three sub-missions:

- improving forest quality,
- increasing forest cover through ecosystem restoration, and
- enhancing the incomes of forest-dependent communities.

Implementation is based on a bottom-up model with Joint Forest Management Committees (JFMCs) playing a key role.

National Mission for Sustaining the Himalayan Ecosystem (NMSHE)

The National Mission for Sustaining the Himalayan Ecosystem (NMSHE) is a cross-sectoral initiative under India's National Action Plan on Climate Change (NAPCC) that aims to understand, protect, and sustainably manage the fragile Himalayan ecosystem.

Its key objectives include

- building institutional and human capacity,
- developing long-term scientific monitoring, and
- framing evidence-based policies and action programs for sustainable development in the Indian Himalayan Region.
- Glacier research: Study glaciers, snow, and ice to understand their behavior and their linkage with the social sector.
- Water resource management: Conduct hydrological investigations of lakes and springs and develop flood frequency relationships.

This involves scientific assessments of the ecosystem's vulnerability, developing new methods for health assessment, and creating a knowledge network to address issues like climate change impacts and sustainable resource management.

The mission covers the Himalayan states and Union Territories, including Himachal Pradesh, Uttarakhand, Sikkim, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura, Meghalaya, Assam, West Bengal, Jammu and Kashmir, and Ladakh.

The Department of Science and Technology (DST) is implementing the mission.

National Mission for Sustainable Agriculture (NMSA)

The National Mission for Sustainable Agriculture (NMSA) is an Indian government initiative to promote sustainable, productive, and climate-resilient agriculture by integrating location-specific farming systems, improving soil health, and enhancing water-use efficiency. **Objectives**

- Promote location-specific Integrated/Composite Farming Systems to enhance livelihood and food security.
- Conserve natural resources through appropriate soil and moisture conservation measures.
- Promote comprehensive soil health management practices, including soil testing and balanced use of fertilizers.
- Optimize water use through efficient on-farm water management, like drip and sprinkler technologies.
- Encourage climate-resilient agriculture and adaptation measures to cope with climate variability and extreme events.

Key components and related schemes

- Soil Health Management (SHM): Focuses on soil health card schemes and promotes balanced fertilizer use.
- On Farm Water Management (OFWM): Implemented under the mission to enhance water use efficiency through technologies like drip and sprinkler irrigation.
- Paramparagat Krishi Vikas Yojana (PKVY): Promotes organic farming practices by providing financial assistance for organic inputs and infrastructure.
- Mission Organic Value Chain Development for North Eastern Region (MOVCDNER): A scheme under NMSA focused on building organic value chains in Northeast India.
- National Mission on Natural Farming (NMNF): Promotes chemical-free natural farming rooted in traditional knowledge.

National Mission on Strategic Knowledge for Climate Change (NMSKCC),

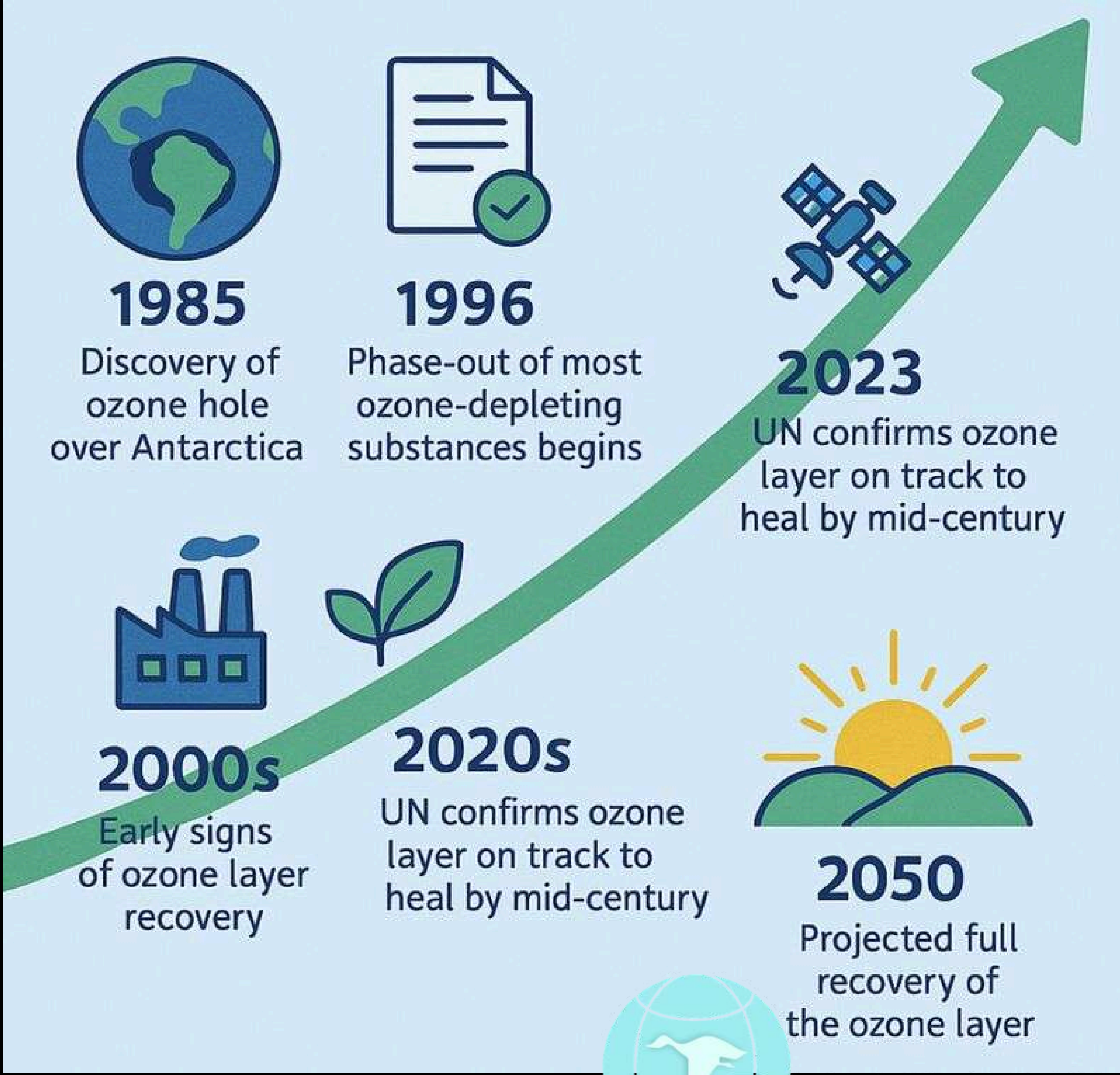
The National Mission on Strategic Knowledge for Climate Change (NMSKCC), implemented by the Department of Science and Technology, under the NAPCC promotes research, knowledge generation and capacity building relating to climate science.The mission has been revised to align its objectives and priorities with the commitments of the country.

Goals and objectives

- Knowledge generation: Foster research in climate science, impacts, and adaptation strategies to support evidence-based decision-making.
- Knowledge networking: Create networks among existing institutions to facilitate data sharing and collaborative research on climate change.
- Capacity building: Develop both human and institutional capacities through training, public awareness programs, and establishing State Climate Change Cells to connect state action plans with national priorities.
- Modeling and impact assessment: Build national capability to model the regional impacts of climate change on different sectors and ecological zones.
- International collaboration: Forge alliances and partnerships for research and technology development with other countries.

Montreal Protocol

The Montreal Protocol is a global treaty signed in 1987 to protect the Earth's ozone layer by phasing out the production and consumption of ozone-depleting substances (ODS). Considered one of the most successful environmental agreements, it regulates nearly 100 chemicals used in products like refrigerators and aerosol cans that were discovered to be causing a "hole" in the ozone layer, allowing harmful UV radiation to reach the surface. The protocol is flexible, allowing developing countries a grace period to comply and has been adapted over time to address new scientific information.



The Kigali Amendment to the Montreal Protocol

MONTREAL

The Montreal Protocol is considered to be one of the most successful environmental agreements of all time and can serve as an inspirational example of what international cooperation can achieve.

Up to 0.4°C of global temperature increase could be avoided by the successful implementation of the Kigali Amendment.

National implementation
Achieving the commitment to Kigali Amendment is the mandate of the National Ozone Unit in national governments and is supported by other related entities.

Continues the Montreal Protocol's historic legacy by **phasing down the use of hydrofluorocarbons.**

2019 Signed in 2016 and entered into force in 2019.

2021 The Parties to the Montreal Protocol have **phased out 98% of ODS** globally compared to 1990 levels.

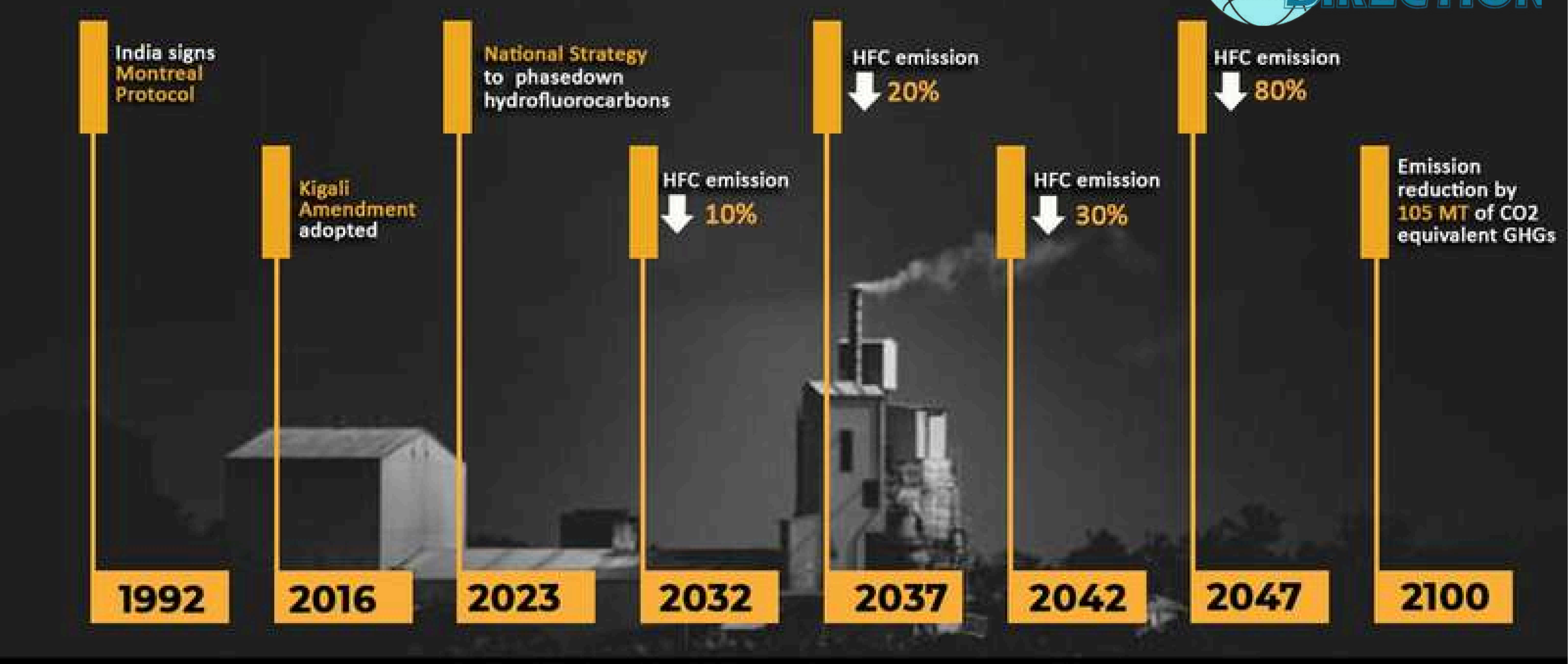
2033 Ban on HFC trade with non-Parties. The trade of HFCs with Parties that have not ratified the Amendment will be banned from 1 January 2033.

2047 HFC phase-down complete as Parties are required to **reduce HFC consumption by up to 85% by 2047** compared to baseline levels.

2060 Full recovery of the ozone layer expected.

Ratification status of the Kigali Amendment

India ratified the Kigali Amendment in 2021, committing to a phasedown of hydrofluorocarbon (HFC) production and consumption. This involves a four-step reduction, with a goal of 85% phase-down by 2047, and is being guided by India's India Cooling Action Plan (ICAP) (launched in 2019) and National Strategy for HFCs. These efforts aim to reduce the impact of HFCs, which are potent greenhouse gases, while also promoting energy efficiency and sustainable cooling. Phasedown schedule: India will complete its HFC phase-down in four steps:



India is the first Country in the World to develop a comprehensive cooling action plan. The **India Cooling Action Plan (ICAP)** is a comprehensive policy by the Indian government that provides a 20-year integrated vision for cooling across various sectors to reduce cooling demand, transition to sustainable refrigerants, improve energy efficiency, and promote better technology.

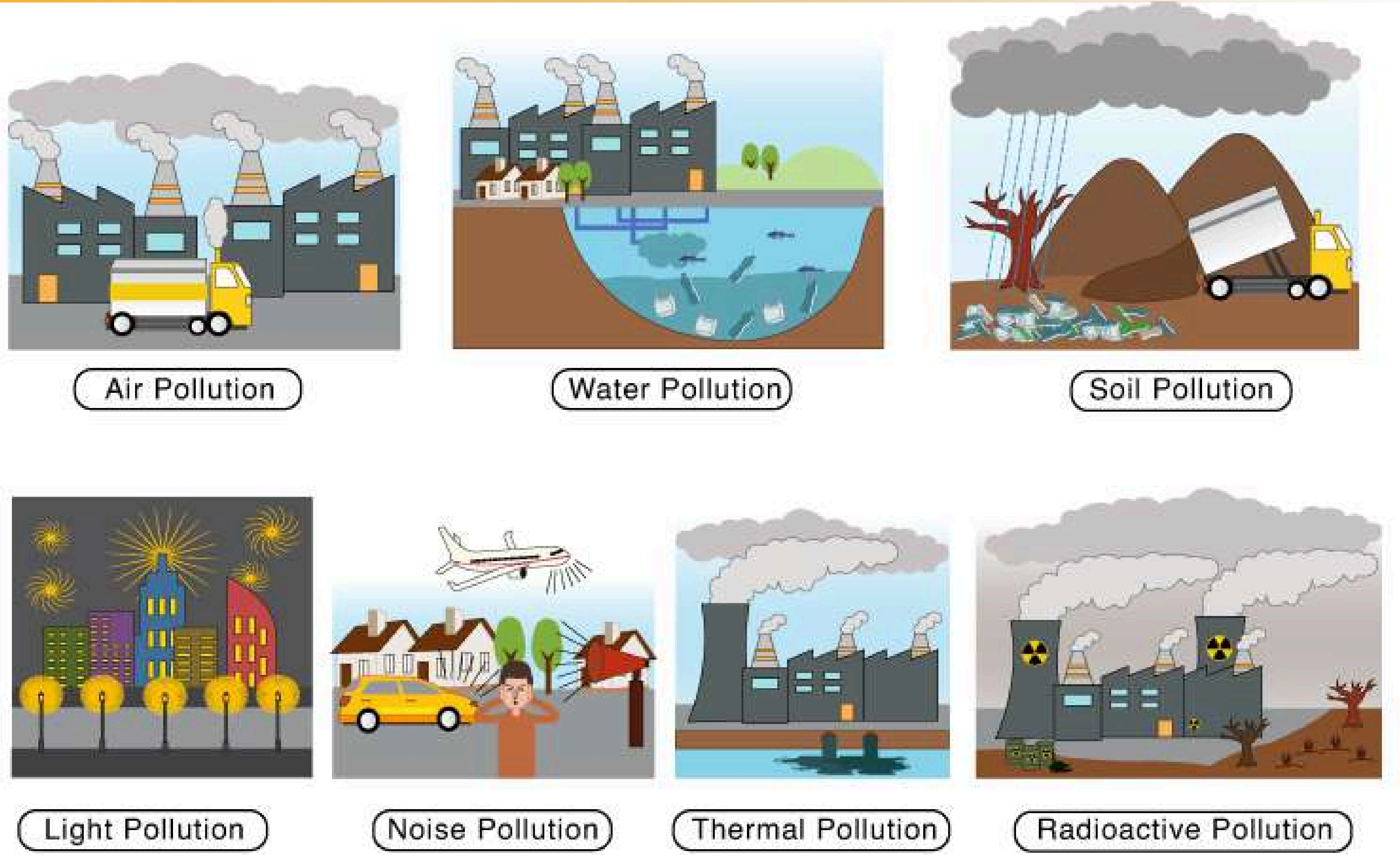
It aims to address both mitigation and adaptation by providing sustainable cooling solutions that avoid further warming.

- India Cooling Action Plan was launched in March, 2019
  - long-term integrated vision to address the cooling requirement with a 20 years' time horizon.
  - Reduction of cooling demands
  - Reduction in Refrigerant demand
  - Enhancing energy efficiency
  - Better technology options

- Integrated actions with respect to cooling across sectors will have a higher impact during the implementation of Kigali Amendment than actions taken in isolation.
- Maximising economic and social co-benefits, besides environmental gains.

Pollution

Pollution is defined as introducing harmful substances (solid, liquid, or gas) or any form of energy (light, heat, sound, or radioactivity) into the environment. The harmful elements that damage air, water, and land quality and cause pollution are called pollutants.

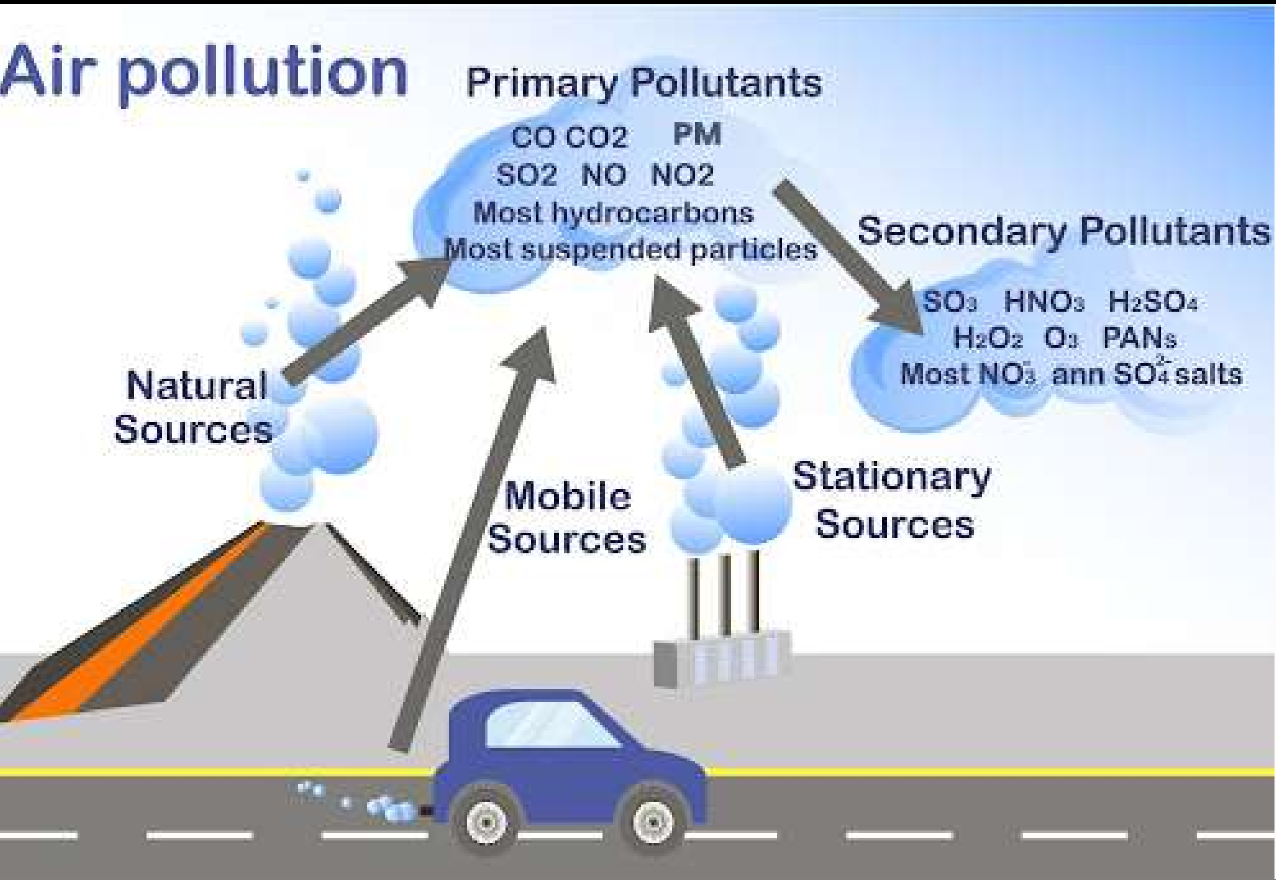


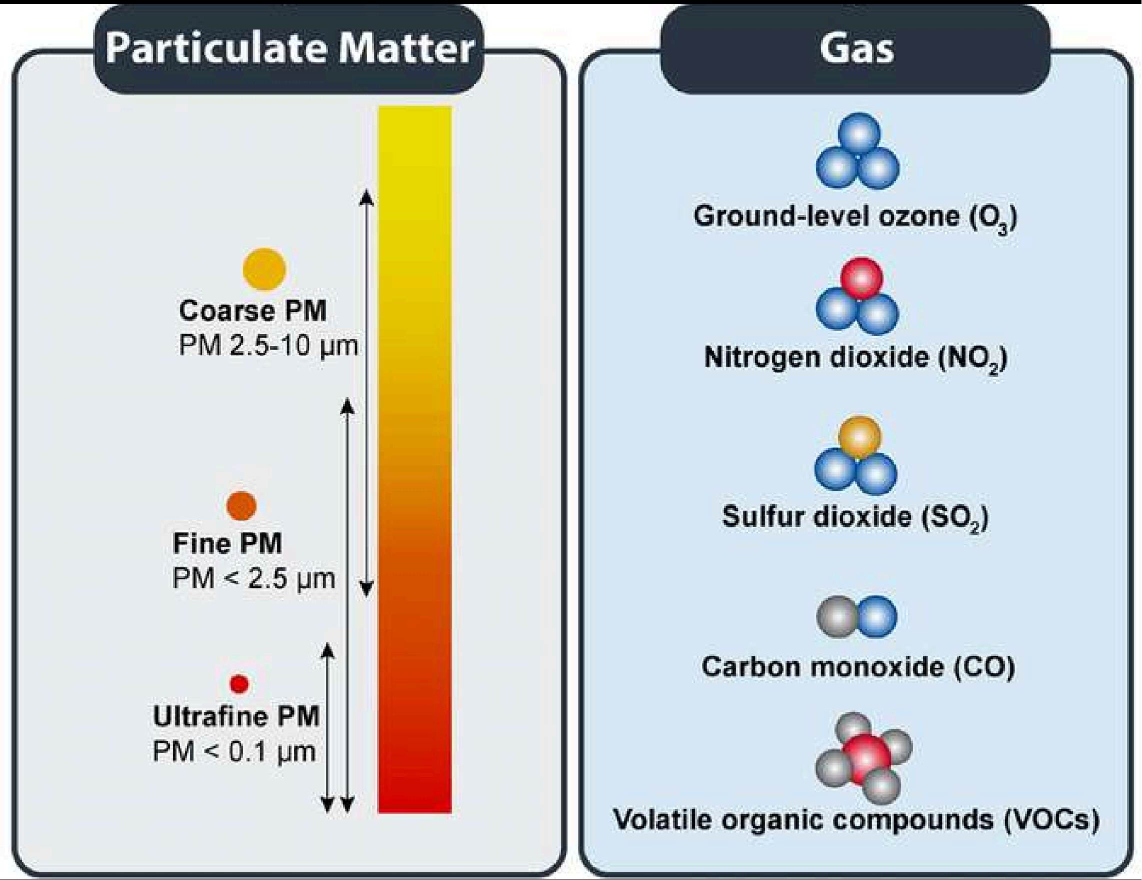
Air Pollution

DIRECTION IAS

The air in our atmosphere has a roughly stable chemical composition consisting of nitrogen, oxygen, argon, carbon dioxide, and trace amounts of other gases. Any change in the air composition due to the addition of unwanted gases such as sulfur dioxide, carbon monoxide, and nitrogen oxides, chemicals, particulate matter, and biological molecules is called air pollution.

Primary air pollutants are emitted directly into the atmosphere from sources, while **secondary air pollutants** form in the atmosphere through chemical reactions between primary pollutants and other substances. Examples of primary pollutants include carbon monoxide, sulfur dioxide, and particulate matter, while secondary pollutants include ozone, acid rain, and photochemical smog.





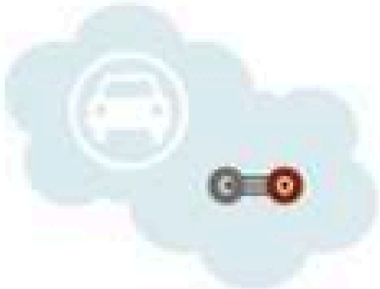
Air pollution can happen from both human-made (anthropogenic) and natural sources.

Some of the significant sources of air pollution are given below:

- **Burning of fossil fuels** such as coal, oil, and natural gas
- Exhaust from automobiles and industries
- Indiscriminate cutting of trees (**deforestation**)
- **Wildfires** resulting from burning stubble and farm residues
- Release of methane from microbial decay
- Excessive discharge of greenhouse gases like carbon dioxide and nitrous oxide
- **Chlorofluorocarbons** (CFCs) released from aerosols sprays, refrigerants, and air conditioners
- Release volcanic ash and gases

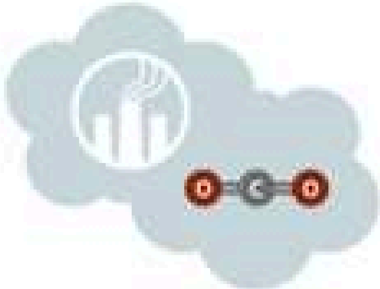
A BRIEF GUIDE TO ATMOSPHERIC POLLUTANTS

A number of different chemical entities, from a range of sources, can contribute towards atmospheric pollution, the consequences of which can include global warming and smog. This graphic looks at a selection of major groups of atmospheric pollutants, their major sources, and their effects.



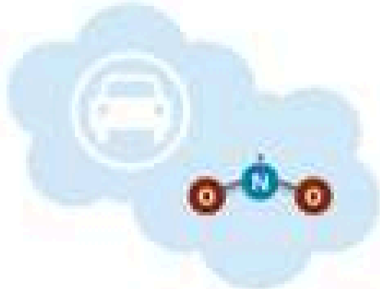
CARBON MONOXIDE

A gas generated by the incomplete combustion of fuels – primarily from road transport. Affects human health, as it reduces oxygen-carrying capacity of the blood. It also reacts with other atmospheric gases to produce ozone.



CARBON DIOXIDE

A gas generated by the burning of fossil fuels in the production of electricity. Also emitted by natural processes. Human emissions are linked with rising atmospheric CO_2 levels and anthropogenic global warming.



NITROGEN OXIDES

Primarily created by combustion in road transport. Nitrous oxide is an important global warming contributor, whilst nitrogen dioxide is involved in ground-level ozone forming reactions, and is also a component of smog.

SULFUR DIOXIDE

The primary source of sulfur dioxide is the burning of fossil fuels to generate electricity. It can contribute to smog, reacts with water to produce acid rain, and can also cause wheezing and breathing problems for asthmatics.

AMMONIA

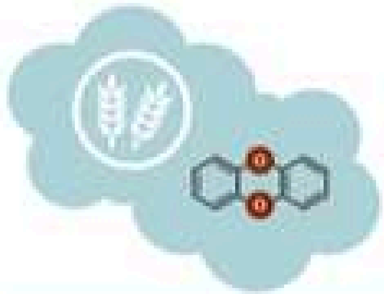
Ammonia's primary atmospheric source is from its use in agriculture, such as manure & fertilisers. It can react with other pollutants to produce particulate matter. It also has the ability to over-enrich ecosystems with nitrogen.

VOCs

VOCs (volatile organic compounds) are emitted naturally by vegetation. Amongst significant human sources is road transport, as well as solvents. They can contribute to formation of ground-level ozone and smog.

OZONE

The ozone layer shields us from UV radiation, but ground-level ozone is a major pollutant. It's formed from other pollutants in the presence of sunlight. Ozone is a major component of smog, and can also cause health effects.



POPs

POPs (persistent organic pollutants) are volatile chemicals released into the atmosphere, often from agricultural or industrial uses. They persist in the environment and can have health effects on both wildlife & humans.

PARTICULATE MATTER

Particulate matter is composed of a huge number of different components. Some are directly emitted, while others are generated by reactions in the atmosphere. They cause haze and can also cause lung problems if inhaled.

HEAVY METALS

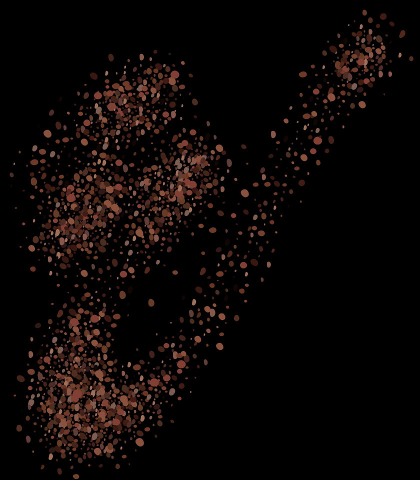
Heavy metals are released into the atmosphere from a range of sources, including burning of fossil fuels and road transport emissions. Some, such as mercury and lead, have toxic health effects in humans.

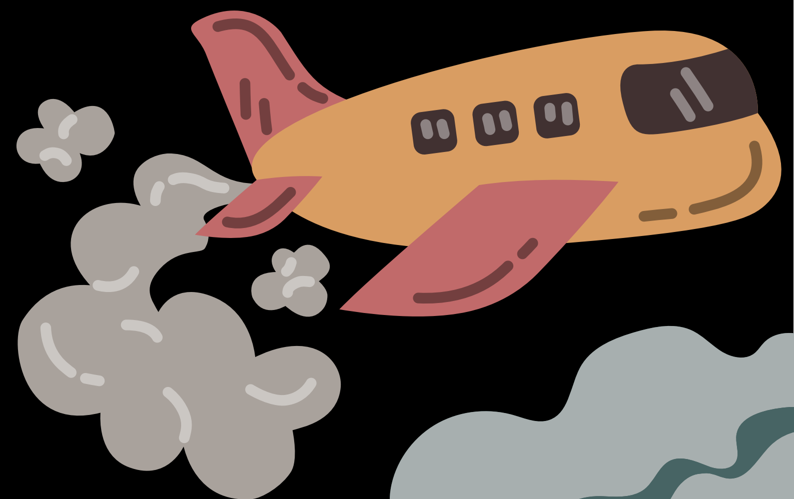
Primary air pollutants

These are emitted directly from identifiable sources, such as vehicles, power plants, and industrial facilities.

Examples:

- Carbon monoxide
- Sulfur dioxide
- Nitrogen oxides
- Hydrocarbons
- Particulate matter (dust, ash, soot)





Carbon monoxide (CO) pollution, primarily from the incomplete combustion of fuels like those from vehicle exhaust, furnaces, and stoves, causes health problems by binding to hemoglobin in the blood and blocking oxygen transport to the body's organs. The effects range from headaches, dizziness, and confusion at low levels to cardiovascular damage, brain damage, and death at high levels.

Causes of carbon monoxide pollution

- Vehicular emissions: The largest source of outdoor CO pollution comes from the exhaust of cars, trucks, and buses.
- Residential heating: Malfunctioning or unvented gas space heaters, furnaces, and gas stoves can release CO into a home.
- Fuel-burning appliances: Other sources include generators, fireplaces, and ovens that burn fossil fuels.
- Incomplete combustion: CO is a byproduct of incomplete combustion, which occurs when there isn't enough oxygen to fully burn fuels like gasoline, natural gas, coal, or wood.

Health effects

- Reduced oxygen transport: CO has a much higher affinity for hemoglobin than oxygen, forming carboxyhemoglobin and preventing the blood from carrying oxygen to organs and tissues.
- Mild to moderate symptoms: Low to moderate exposure can cause headaches, fatigue, dizziness, nausea, and confusion.
- Cardiovascular effects: For people with existing heart conditions, this can lead to chest pain (angina) because the heart muscle doesn't get enough oxygen, especially under stress or during exercise.
- Severe and fatal effects: At very high concentrations, CO can cause loss of consciousness, brain damage, and death within a short period. It is particularly dangerous for people who are sleeping.
- Fetal development: High exposure for pregnant women can lead to adverse developmental effects in the unborn baby.

Sulfur dioxide pollution causes adverse health effects like respiratory issues and contributes to environmental problems such as acid rain.

Its causes are primarily from

- burning sulfur-containing fossil fuels in power plants and
- industrial processes like oil refining, metal smelting, and cement manufacturing.

Other sources include

- shipping,
- volcanic activity, and
- geothermal fields.

Health effects Respiratory irritation:

- irritates the nose, throat, and airways, leading to coughing, wheezing, and shortness of breath.
- Aggravated pre-existing conditions: It can worsen conditions like asthma, bronchitis, and emphysema, particularly during physical activity.
- Vulnerable populations: Children, the elderly, and people with chronic lung and heart conditions are at higher risk.
- Long-term effects: Long-term exposure to high levels can reduce lung function and increase the risk of hospital admissions.

DIRECTION IAS

Environmental effects

- Acid rain When is released into the atmosphere, it reacts with water vapor to form sulfuric acid.This acid is the main component of acid rain, which can acidify lakes and soils, harming aquatic life and vegetation.Acid rain can also accelerate the deterioration of buildings and cultural monuments.
- Particulate matter and smog contributes to the formation of fine particulate matter when it reacts with other compounds like ammonia.This particulate matter is a major component of smog, which reduces air quality.
- PM 2.5is linked to negative impacts on human health, particularly respiratory and cardiovascular issues.
- Damage to ecosystems: Acid rain harms aquatic life, damages forests, and leaches nutrients from the soil.Plant damage: It directly damages plants by disrupting photosynthesis and causing excessive water loss through stomata.

Nitrogen oxides are a group of gases that have significant adverse effects on human health and the environment. These effects are primarily caused by the combustion of fossil fuels and biomass at high temperatures.

Causes of Emissions The primary sources of nitrogen oxides are both natural and human-made:

- Fossil Fuel Combustion: The main human-generated source, primarily from motor vehicle exhaust and fuel burning in power plants, industrial facilities, commercial, and residential heating.
- Agriculture: Excessive use of nitrogen-based fertilizers in agriculture contributes significantly to atmospheric through microbial activity in soils.
- Indoor Sources: Unvented gas stoves, kerosene heaters, wood-burning fireplaces, and tobacco smoke can cause high indoor levels.
- Natural Processes: Natural sources include lightning strikes, microbial activity in soils, and forest fires.

Effects of On Human Health

- Respiratory Issues: irritates the eyes, nose, throat, and lungs. Exposure can lead to coughing, wheezing, shortness of breath, increased airway inflammation, and increased susceptibility to respiratory infections.
- Asthma: Long-term exposure is linked to an increased risk of developing asthma in children and can trigger more severe asthma attacks in people with the condition.
- Severe Exposure: Breathing high levels of can cause rapid burning and swelling of throat tissues, a build-up of fluid in the lungs (pulmonary edema), reduced oxygenation of tissues, and potentially death.
- Particulate Matter Formation: reacts with other compounds in the atmosphere to form fine particulate matter, which can penetrate deep into the lungs and cause or worsen respiratory and heart diseases.

On the Environment

- Acid Rain: reacts with water, oxygen, and other chemicals in the atmosphere to form nitric acid, a main component of acid rain. Acid rain damages trees, crops, buildings, and acidifies aquatic and terrestrial ecosystems, harming fish and plant populations.
- Smog and Ground-level Ozone: is a primary ingredient in the formation of photochemical smog and ground-level ozone when it reacts with volatile organic compounds (VOCs) in the presence of sunlight. Ground-level ozone damages vegetation and can harm human health.
- Eutrophication: Increased nitrogen inputs from NO_{x} emissions can overload water bodies with nutrients, leading to excessive algal growth, which depletes oxygen and creates "dead zones" harmful to aquatic life.
- Climate Change: Nitrous oxide , another nitrogen oxide compound, is a potent greenhouse gas (much more potent per pound than carbon dioxide) that contributes to global warming.
- Visibility Impairment: Nitrate particles formed from contribute to fine atmospheric particles that reduce visibility and create a reddish-brown haze over cities.

DIRECTION IAS

Hydrocarbon pollution

Causes of hydrocarbon pollution

- Incomplete combustion: Primarily from vehicles, this process releases harmful hydrocarbons into the air.
- Oil spills: Accidental spills during the extraction, transport, or dumping of crude oil and petroleum products are major sources of both marine and land pollution.
- Industrial and agricultural waste: Wastewater from industrial facilities and the use of pesticides contribute significantly to hydrocarbon contamination of water and soil.
- Natural sources: While human activities are the primary cause, natural sources also exist.
- Leaking infrastructure: Spills from oil production lines and leaks from underground storage tanks also contribute to pollution.

Effects of hydrocarbon pollution

Human health:

- Respiratory issues: Hydrocarbons can cause respiratory complications and asthma-like symptoms.
- Cancer: Many hydrocarbons are carcinogenic, increasing the risk of cancer, particularly with long-term exposure.
- Neurological effects: Acute exposure can lead to headaches, dizziness, and disorientation, while chronic exposure may result in neurological damage.
- Other health problems: Exposure can also lead to damage to the liver, kidneys, immune system, and cardiovascular system.

Environmental effects:

- Air pollution: Hydrocarbons contribute to smog and other forms of air pollution.
- Water contamination: Spilled oil and other hydrocarbons can contaminate both freshwater sources and oceans. In marine environments, a film can form on the surface, blocking oxygen transfer and harming aquatic life.
- Soil degradation: Pollution can contaminate soil, making it unsuitable for plant growth.
- Plant damage: Hydrocarbons can accelerate plant aging, cause tissue breakdown, and lead to the shedding of leaves, flowers, and twigs.

Particulate matter pollution

Causes of particulate matter pollution

- Combustion: Burning fossil fuels in vehicles, power plants, and residential heating systems is a major source, releasing soot and other particles.
- Industrial processes: Manufacturing and other industrial activities also release significant amounts of particulate matter.
- Natural sources: Wildfires and volcanic eruptions release ash and gases laden with particulate matter.
- Construction and agriculture: Dust from construction sites, unpaved roads, and agricultural fields contributes to air pollution.
- Secondary formation: Airborne chemicals like nitrogen oxides and volatile organic compounds (VOCs) can react in the atmosphere to form new particulate matter.

Health effects:

- Respiratory problems: Worsening of asthma, bronchitis, and COPD, as well as increased respiratory infections.
- Cardiovascular problems: Increased risk of heart attacks, strokes, and arrhythmias.
- Long-term risks: Can lead to lung cancer and contribute to premature death.
- Developmental issues: Linked to adverse pregnancy outcomes like pre-term birth and low birth weight.

Environmental effects:

- Climate change: Soot particles can absorb and trap heat, contributing to global warming.
- Reduced visibility: Particulate matter creates smog and haze, obscuring views.
- Ecosystem damage: Particles can settle on plants, disrupting their function, and contribute to acid rain, which damages forests and waterways.
- Water pollution: Deposition into water bodies can change nutrient balances and affect aquatic life.

The Asian Tropopause Aerosol Layer (ATAL) weakens the South Asian monsoon by creating a layer of aerosols in the upper troposphere that disrupts atmospheric circulation and radiative balance. This can lead to reduced rainfall and more severe droughts, especially during events like El Niño, when ATAL is intensified.

How ATAL affects the monsoon

- Weakens the South Asian High (SAH): ATAL causes an increase in diabatic heating in the upper troposphere over the SAH region, which leads to an anomalous upward flow. This upward flow decreases adiabatic heating, causing cooling anomalies in the upper troposphere and ultimately weakening the SAH.
- Increases atmospheric stability: A doubled increase in ATAL intensity can cause a temperature inversion in the upper troposphere, which stabilizes the atmosphere and prevents moisture from rising further.
- Reduces moisture transport and latent heat release: The enhanced atmospheric stability caused by ATAL limits the upward movement of moisture. This reduces the amount of latent heat released during condensation, which further weakens the monsoon.
- Disrupts atmospheric circulation: The combination of a weakened SAH and increased stability disrupts the normal Hadley circulation, leading to anomalous subsidence over land.
- Amplifies droughts: The resulting large-scale subsidence can amplify the severity of monsoon droughts.

How aerosols get into ATAL

- Upward transport during monsoon: Strong deep convection during the monsoon season lifts aerosols from the lower atmosphere into the upper troposphere and lower stratosphere.
- Long-range transport: Aerosols like dust and black carbon from sources like East China and North India are transported to the ATAL region.
- El Niño influence: During El Niño years, atmospheric circulation can lift more aerosols from East Asia to the ATAL, increasing its intensity and impact.

Secondary air pollutants

Ground-level ozone pollution is caused by the chemical reaction of nitrogen oxides (NOx) and volatile organic compounds (VOCs) in the presence of sunlight. These precursor pollutants are released from sources like vehicle emissions, power plants, and industrial processes. The effects are negative and include respiratory problems like asthma and lung damage, as well as damage to sensitive plants and ecosystems.

Causes

- Formation Process: Ground-level ozone is a "secondary pollutant" because it is not directly emitted but forms from a chemical reaction in the atmosphere.
- Sunlight: The reaction requires sunlight, which is why ozone levels are often highest on hot, sunny days.
- Precursor Pollutants: The key ingredients are NOx and VOCs:
  - Nitrogen Oxides (NOx): Sources include vehicle exhaust, power plants, and industrial boilers.
  - Volatile Organic Compounds (VOCs): Sources include gasoline vapors, industrial processes, and solvents.
- Sources of Pollutants: Both human and natural activities release NOx and VOCs:
  - Human: Burning fossil fuels in cars and power plants, industrial processes.
  - Natural: Wildfires and vegetation (VOCs), volcanoes, and lightning strikes (NOx).

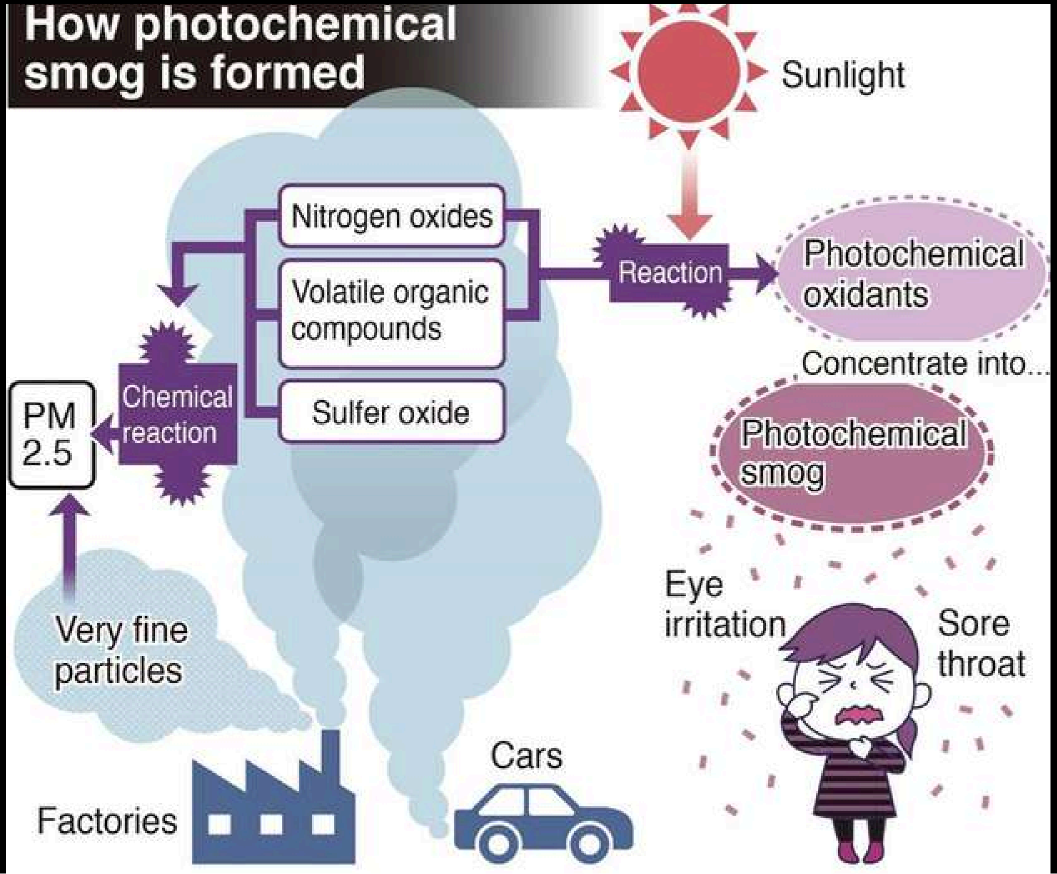
DIRECTION IAS

Effects | Health Effects:

- Irritates the lungs and airways, causing inflammation and chest pain.
- Aggravates respiratory diseases like asthma and COPD.
- Can lead to reduced lung function and permanent lung scarring with long-term exposure.

Environmental Effects:

- Damages sensitive vegetation, affecting forests, crops, and ecosystems.
- Contributes to reduced crop yields.
- Other effects:
- Acts as a greenhouse gas, contributing to climate change.



Photochemical smog: A complex mixture of pollutants, including ozone and nitrogen dioxide, that forms from the reaction of nitrogen oxides and hydrocarbons under sunlight.

Acid rain is caused by air pollution from pollutants like sulfur dioxide and nitrogen oxides

Causes of acid rain

- Human activities:Fossil fuel combustion: Burning coal, oil, and gas in power plants, factories, and vehicles releases large amounts of sulfur dioxide and nitrogen oxides .
- Industrial processes: Manufacturing and other industrial activities are significant sources of these pollutants.
- Agriculture: Livestock farming contributes to acid rain through ammonia emissions.
- Natural sources:Volcanic eruptions: Natural eruptions release sulfur dioxide into the atmosphere.Lightning: This can produce nitrogen oxides.
- Forest fires: These also contribute to the emission of these gases.

Effects of acid rain

- Damage to ecosystems:Aquatic ecosystems: Acid rain can acidify lakes and rivers, making them uninhabitable for fish and other aquatic life. It can also release toxic aluminum from the soil into the water.
- Forests: It can damage trees by stripping nutrients from the soil and making it harder for them to absorb water and nutrients.
- Soil: It can leach essential nutrients from the soil and release toxic substances.Damage to buildings and materials:Acid rain corrodes stone, marble, and metal, causing structures like buildings, monuments, and statues to deteriorate.
- Human health impacts:The sulfate and nitrate particles that form from acid rain in the atmosphere can be inhaled, leading to respiratory problems like asthma, dry cough, and throat irritation.

Peroxyacetyl nitrate (PAN) is a harmful air pollutant formed by photochemical reactions between nitrogen oxides and volatile organic compounds in smog.

Causes of PAN formation

- Photochemical reactions: PAN is a secondary pollutant, meaning it is formed in the atmosphere through chemical reactions rather than being emitted directly.
- Precursors: The key precursors are nitrogen oxides and volatile organic compounds (VOCs).
- Source of precursors: These precursors primarily come from human activities like the combustion of fossil fuels in vehicles, power plants, and other industrial processes.
- Formation process: The formation pathway involves the reaction of a peroxyacetyl radical with nitrogen dioxide . The process is driven by sunlight (photochemical), which is why PAN is a major component of photochemical smog.

Effects of PAN pollution

- Human health: PAN is a strong lachrymator, causing eye irritation at very low concentrations. It is also considered a potential mutagen and contributor to skin cancer.
- Vegetation damage: PAN is highly phytotoxic and can cause visible damage to plants, such as glazing or bronzing of leaves.
- Atmospheric transport: Due to its temperature-dependent stability, PAN can be transported long distances in cooler parts of the atmosphere. It acts as a reservoir for nitrogen oxides (NOx) and decomposes to release them in warmer environments, which can facilitate ozone formation regionally and globally.

Central Pollution Control Board is executing a nation-wide programme of ambient air quality monitoring known as National Air Quality Monitoring Programme (NAMP). The network consists of 966 operating stations in 419 cities/towns in 28 states and 7 Union Territories of the country

The objectives of the N.A.M.P. are to

- determine status and trends of ambient air quality;
- to ascertain whether the prescribed ambient air quality standards are violated;
- to Identify Non-attainment Cities; to obtain the knowledge and
- understanding necessary for developing preventive and corrective measures and to understand the natural cleansing process undergoing in the environment through pollution dilution, dispersion, wind based movement, dry deposition, precipitation and chemical transformation of pollutants generated.

Under N.A.M.P., four air pollutants viz .,

- Sulphur Dioxide (SO2),
- Oxides of Nitrogen as NO2,
- Respirable Suspended Particulate Matter (RSPM / PM10) and
- Fine Particulate Matter (PM2.5)

have been identified for regular monitoring at all the locations.

- The monitoring of meteorological parameters such as wind speed and wind direction, relative humidity (RH) and temperature were also integrated with the monitoring of air quality.
- The monitoring of pollutants is carried out for 24 hours (4-hourly sampling for gaseous pollutants, 8-hourly sampling for particulate matter and 24-hourly sampling for PM2.5) with a frequency of twice a week, to have one hundred and four (104) observations in a year.

The monitoring is being carried out with the help of

- Central Pollution Control Board;
- State Pollution Control Boards;
- Pollution Control Committees and other agencies.

CPCB co-ordinates with these agencies to ensure the uniformity, consistency of air quality data and provides technical and financial support to them for operating the monitoring stations. N.A.M.P. is being operated through various monitoring agencies. Large number of personnel and equipment are involved in the sampling, chemical analyses, data reporting etc. It increases the probability of variation and personnel biases reflecting in the data, hence it is pertinent to mention that these data be treated as indicative rather than absolute.

India's National Ambient Air Quality Standards (NAAQS),
established by the Central Pollution Control Board (CPCB), define the maximum permissible levels for 12 pollutants, including PM10, PM2.5, SO2, and NO2, to protect public health and the environment.

The 12 pollutants regulated under India's NAAQS:

- Particulate Matter: PM10 and PM2.5
- Gases: Sulfur Dioxide , Nitrogen Dioxide, Carbon Monoxide (CO), and Ammonia Ozone
- Heavy Metals: Lead (Pb), Arsenic, and Nickel
- Organic Compounds: Benzene and Benzo-Pyrene

These standards, notified in 2009, include different limits for different areas (e.g., industrial, residential, and ecologically sensitive) and specify annual averages and 24-hour averages for various pollutants.

Key aspects of India's NAAQS Regulated pollutants: The standards regulate 12 pollutants, a significant increase from previous norms, which now includes dangerous pollutants like PM2.5, ozone, lead, and benzene.

Area-specific standards: The permissible limits for pollutants are different depending on the land use of the area.Industrial areas: Have higher permissible limits compared to residential areas.Residential, rural, and other areas: Have lower permissible limits, reflecting a focus on public health.

Ecologically sensitive areas: Have the strictest standards for some pollutants, like SO2 and NO2, to protect vulnerable ecosystems.Monitoring and compliance:Annual average:

These are based on a minimum of 104 measurements per year, taken twice a week.24-hour average: These standards must be met 98% of the time annually, with a 2% tolerance for exceedance but not on two consecutive days.

Pollutant	Time Weighted Average	Concentration in Ambient Air	
		Industrial, Residential, Rural, and Other Areas	Ecologically Sensitive Area (notified by Central Government)
Sulphur dioxide (SO_2), µg/m^3	Annual 24 hours	50 80	20 80
Nitrogen dioxide (NO_2), µg/m^3	Annual 24 hours	40 80	30 80
Particulate matter (< 10 µm) or PM_{10}, µg/m^3	Annual 24 hours	60 100	60 100
Particulate matter (< 2.5 µm) or $PM_{2.5}$, µg/m^3	Annual 24 hours	40 60	40 60
Ozone (O_3), µg/m^3	8 hours 1 hour	100 180	100 180
Lead (Pb), µg/m^3	Annual 24 hours	0.50 1.0	0.50 1.0
Carbon monoxide (CO), mg/m^3	8 hours 1 hour	02 04	02 04
Ammonia (NH_3), µg/m^3	Annual 24 hours	100 400	100 400
Benzene (C_6H_6), µg/m^3	Annual	05	05
Benzo(α)Pyrene (BaP) – particulate phase only, ng/m^3	Annual	01	01
Arsenic (As), ng/m^3	Annual	06	06
Nickel (Ni), ng/m^3	Annual	20	20

AIR QUALITY INDEX

Eight pollutants namely particulate matter (PM) 10, PM2.5, Ozone (O_3), Sulphur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), lead (Pb) and ammonia (NH_3) act as major parameters in deriving the AQI of an area.

AQI is the air quality index; it gives you the index value that what is the current pollution status in the city, how polluted the air currently is. different levels of AQI symbolises different things like on prolonged exposure to ‘poor’ AQI, individuals might witness breathing problem.

SAFAR is India's System of Air Quality and Weather Forecasting and Research, a national initiative to provide real-time and forecasted air quality data for metropolitan cities. It measures various pollutants and weather parameters, presents them using a color-coded Air Quality Index (AQI), and offers health advisories for the public to help them understand and take action on air pollution.

As per **CPCB's (Central Pollution Control Board) air quality standards, AQI is categorised into six parts.** As the AQI value increases, health impacts become serious. For instance, while under satisfactory AQI, sensitive people might witness minor breathing discomfort, severe AQI may cause respiratory impact even on healthy people, and serious health issue in people with existing respiratory issues.

AIR QUALITY INDEX (AON)	CATEGORY
0-50	Good
51-100	Satisfactory
101-200	Moderate
201-300	Poor
301-400	Very Poor
401-500	Severe

DIRECTION

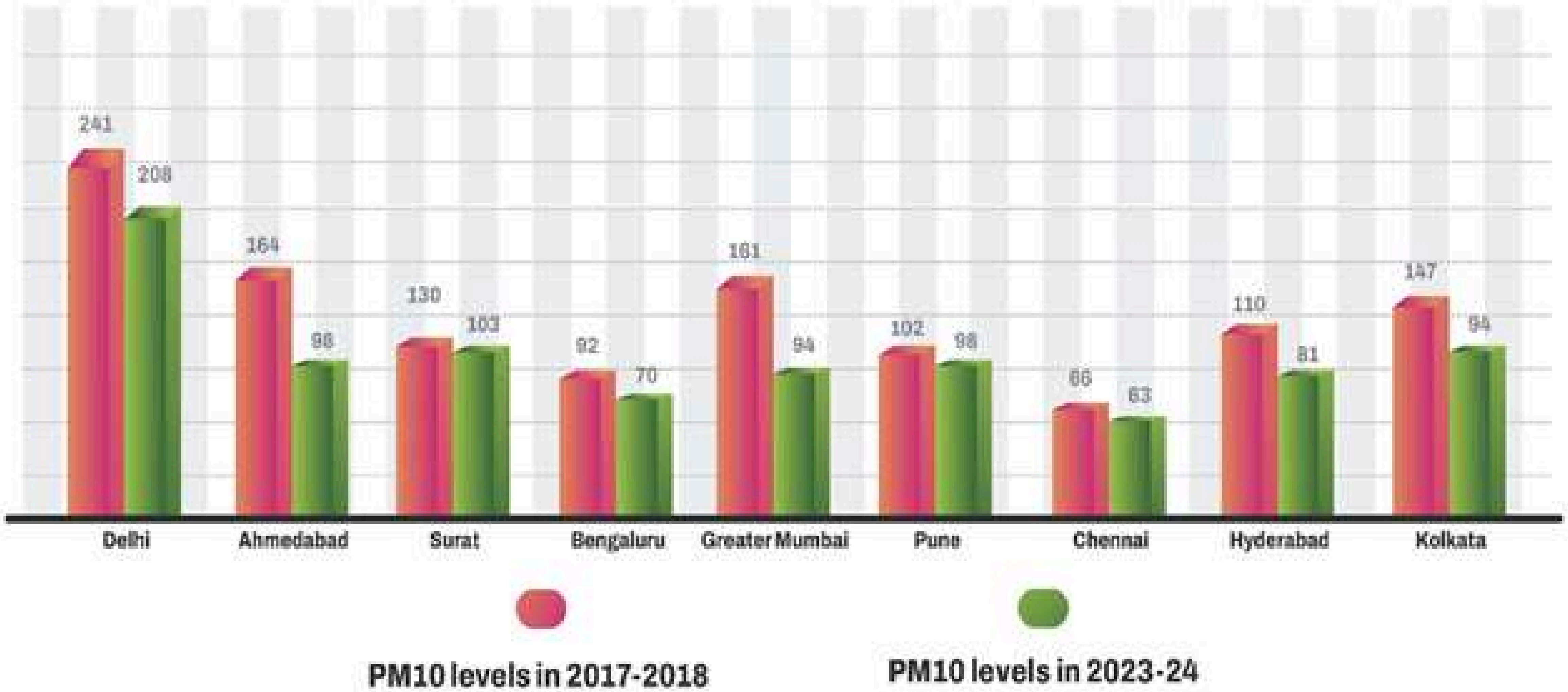
Swachh Vayu Diwas: India’s Commitment to Clean Air

- September 7 is celebrated as International Day of Clean Air for Blue Skies In line with this global movement, India celebrates Swachh Vayu Divas on the same day, reinforcing its dedication to addressing the critical issue of air pollution. <u>National Clean Air Programme (NCAP)</u>: A national strategy to improve air quality, with targets to reduce particulate matter (PM) by 20-30% by 2024, later extended to 40% by 2026.

The themes for <u>International Day of Clean Air for Blue Skies</u> have been

- 2020: "Clean Air for All"
- 2021: "Healthy Air, Healthy Planet"
- 2023: "#TogetherForCleanAir"
- 2024: No specific theme stated, but focused on the health impacts of air pollution.
- 2025: "Racing for Air. Every Breath Matters."

Air Quality in terms of PM10 levels in Metro cities



Swachh Vayu Sarvekshan is structured as a rigorous, multi-tiered evaluation mechanism, founded on comprehensive due diligence under the National Clean Air Programme. Swachh Vayu Sarvekshan is conducted for 130 cities under NCAP annually to promote healthy competition among cities to take expeditious actions to improve air quality.

The following cities were conferred awards by the Minister, EF&CC:

In Category-1 (population of over 10 lakh population):

Indore secured 1st rank with score of 200 out of 200. Indore has planted over 16 lakh trees in last year, earning a Guinness World Record, and has public transport run through 120 electric buses and 150 CNG buses.

Jabalpur secured 2nd rank with score of 199 out of 200. Jabalpur has set up 11 MW waste to energy plant and developed greenery.

Agra and Surat secured 3rd rank with a score of 196 out of 200. Agra has remediated legacy waste dump site and carried out Miyawaki plantation. Surat has brought EV policy to provide incentives and tax benefits to EVs and maintains 38% green cover.

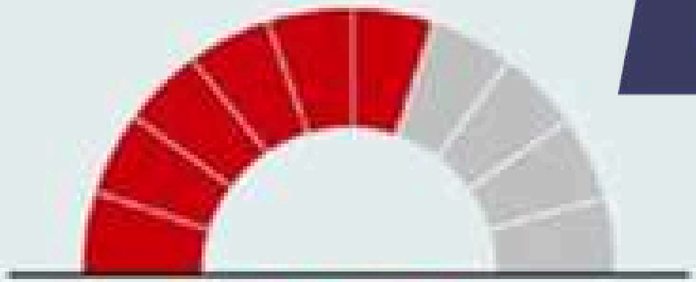
In Category – 2 (population between 3 and 10 lakh):
Amravati secured 1st rank with score of 200 out of 200. Amravati improved road infrastructure including 340 km end-to-end pavement and carried out extensive greening in 53 gardens, and converted 19 acres of barren land into dense forest.
Jhansi and Moradabad secured 2nd rank with score of 198.5 out of 200. Jhansi developed urban greening and miyawaki forests. Moradabad has worked on road infrastructure and construction and demolition waste management.
Alwar secured 3rd rank with a score of 197.6 out of 200. Alwar has remediated the legacy waste dump.
In Category- 3 (population under 3 lakh):
Dewas secured 1st rank with score of 193 out of 200. Dewas shifted industries to cleaner fuels
Parwanoo secured 2nd rank with score of 191.5 out of 200. Parwanoo worked on end-to-end pavement of roads
Angul secured 3rd rank with score of 191 out of 200. Angul also worked on road infrastructure and conducted public outreach activities.

Key government initiatives and policies

- National Clean Air Programme (NCAP): A national strategy to improve air quality, with targets to reduce particulate matter (PM) by 20-30% by 2024, later extended to 40% by 2026.
- Graded Response Action Plan (GRAP): A plan for Delhi-NCR that mandates specific actions based on air quality levels, ranging from restricting construction to vehicle bans.
- National Air Quality Index (AQI): Provides real-time information on air quality to the public.
- Commission for Air Quality Management (CAQM): A body for managing air quality in the National Capital Region and surrounding areas.

DIRECTION

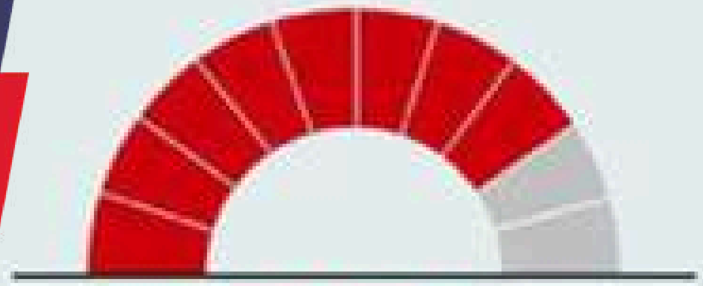
LATEST NEWS



STAGE 1
(AQI 'POOR' - 201 TO 300)

Stopping all construction and demolition activities with plot size of 500 sqm or more which have not been registered on dust mitigation monitoring portals

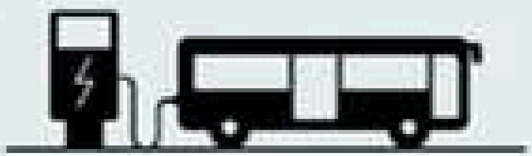
- Mechanised sweeping, water sprinkling on roads
- Enforcing guidelines on use of anti-smog guns at construction site
- Enforcing ban on open burning of waste and PUC for vehicles
- Discoms to minimise power supply interruptions in NCR
- Encourage offices to start unified commute for employees to reduce traffic



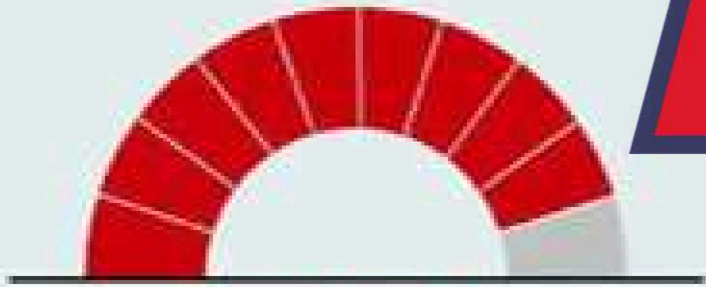
STAGE 2
(AQI 'VERY POOR' - 301 TO 400)

Stopping use of diesel generator sets except for essential and emergency services (hospitals, railways, metro, airports, water pumping stations, 'projects of national importance')

- Not allowing coal/firewood in tandoors at hotels
- Enhance parking fees to discourage private transport
- Augment CNG/ electric bus and metro services by procuring additional fleet and increasing the frequency of service



UPDATE

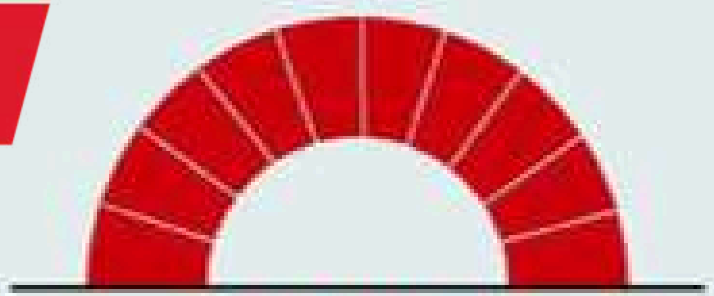


STAGE 3

(AQI 'SEVERE' - 401 TO 450)

Ban on construction and demolition activities except railway, metro, hospitals, sanitation projects etc, linear public projects like highways, roads, flyovers

- Closure of industries that have PNG supply and are not running on approved fuels. In industrial areas that don't have PNG supply, industries not running on approved fuels will operate only for five days a week
- State governments in NCR may impose restrictions on BS III petrol and BS IV diesel four-wheelers



STAGE 4

(AQI 'SEVERE +' - MORE THAN 450)

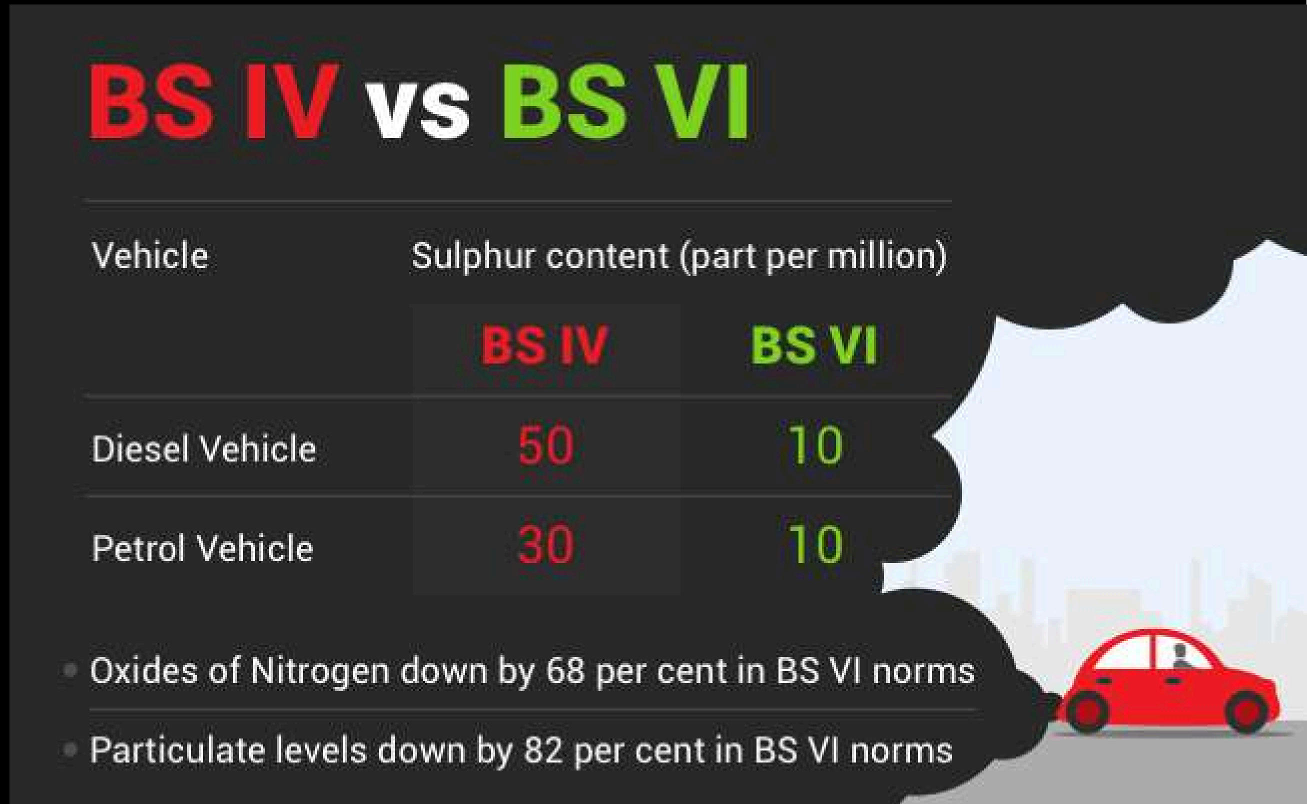
State govts can consider closing schools; odd-even vehicle system; decide on letting public, pvt offices to work on 50% strength, rest to work from home

- Stop entry of truck traffic (except essentials, CNG, e-trucks). Ban on plying of Delhi-registered diesel medium- and heavy-goods vehicles, except essentials
- Ban on plying of four-wheeler diesel vehicles, except BS-VI and vehicles for essential services
- Ban C&D activities in linear public projects such as highways, roads, flyovers

(Actions under Stages II, III and IV will be invoked three days in advance of AQI reaching the projected level)

Transportation and fuel measures

- Stricter Vehicle Emission Standards: Leapfrogging from BS-IV to BS-VI norms nationwide since April 2020.
- Promotion of Electric and Alternative Vehicles: Incentivizing electric vehicles through the FAME scheme (Faster Adoption and Manufacturing of Electric Vehicles) and expanding public transport like Metro rail and high-capacity buses.
- Cleaner Fuels: Promotion of cleaner fuels like Compressed Natural Gas (CNG) and LPG, along with ethanol blending in petrol.
- Scrappage Policy: Encouraging the scrapping of old, polluting vehicles.
- Mandatory PUC Certification: Ensuring vehicles have a valid Pollution Under Control certificate.



BS IV vs BS VI

Vehicle	Sulphur content (part per million)	
	BS IV	BS VI
Diesel Vehicle	50	10
Petrol Vehicle	30	10

- Oxides of Nitrogen down by 68 per cent in BS VI norms
- Particulate levels down by 82 per cent in BS VI norms

DIRECTION

Industrial Emission Norms: Revision of industrial emission standards and installation of online continuous monitoring devices in major industries.

- Construction and Demolition Waste Management Rules: Introduced rules for managing construction and demolition waste, including dust mitigation measures like water sprinkling and mechanical sweeping.
- Brick Kilns: Mandating the shift of brick kilns to "zig-zag" technology.
- Waste Management: Implementation of rules for solid waste management to control open burning of waste.

Other initiatives

- Energy Efficiency: Promoting energy-efficient appliances and energy conservation practices.
- Greening: Developing green corridors and urban green belts to absorb pollutants.
- Public Awareness: Running public awareness programs and using platforms like the SAFAR (System of Air Quality and Weather Forecasting and Research) portal.
- Household Energy: Pradhan Mantri Ujjwala Yojana promotes the use of clean cooking fuel (LPG) instead of firewood.

Zig-zag technology arranges bricks to create a zigzag path for hot air and combustion gases, which improves heat transfer and combustion efficiency. This leads to reduced fuel consumption and lower emissions of particulate matter and other pollutants.

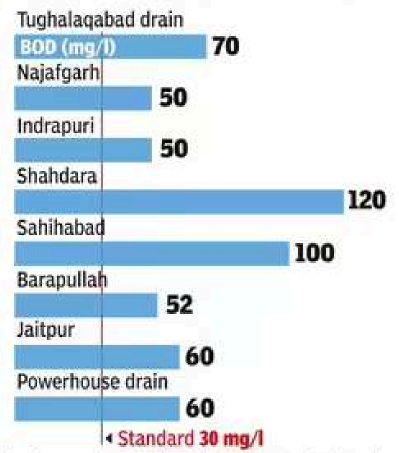
Water pollution

Water pollution is caused by industrial discharge, agricultural runoff, and untreated sewage, which introduce contaminants like chemicals, fertilizers, and pathogens into water bodies. Other major causes include oil spills, plastic and solid waste, and mining activities. Natural events like volcanic eruptions and animal waste can also contribute, but human activities are the primary source.

RIVER CLEANEST AT THE POINT IT ENTERS DELHI: REPORT

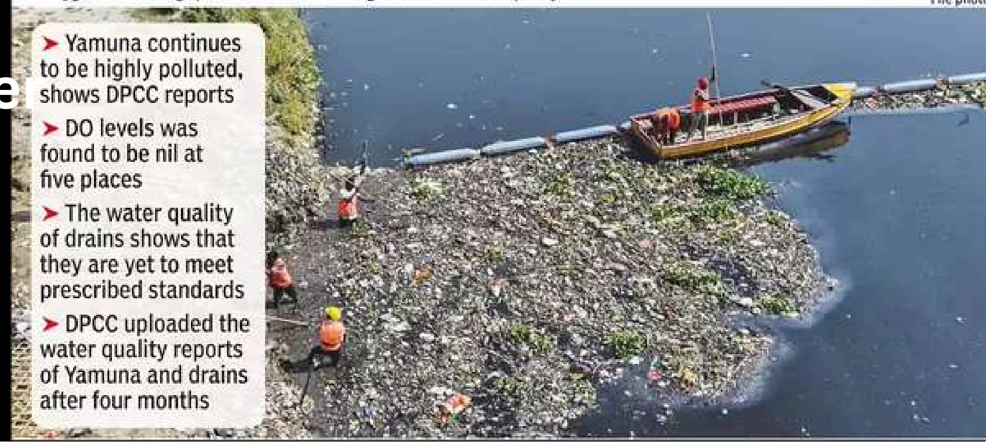
Locations	BOD (mg/l)	DO (Mg/l)
Water quality criteria (C class)	3 mg/l or less	5 mg/l or more
Palla	2	8.6
Wazirabad	7	7.2
ISBT bridge	47	NIL
ITO bridge	30	2.8
Nizamuddin bridge	40	NIL
Okhla	50	NIL
Agra canal at Okhla Barrage	44	NIL
Yamuna at Asgarpur (after confluence of Shahdara and Tughlaqabad drains)	85	NIL

Water quality status of major drains

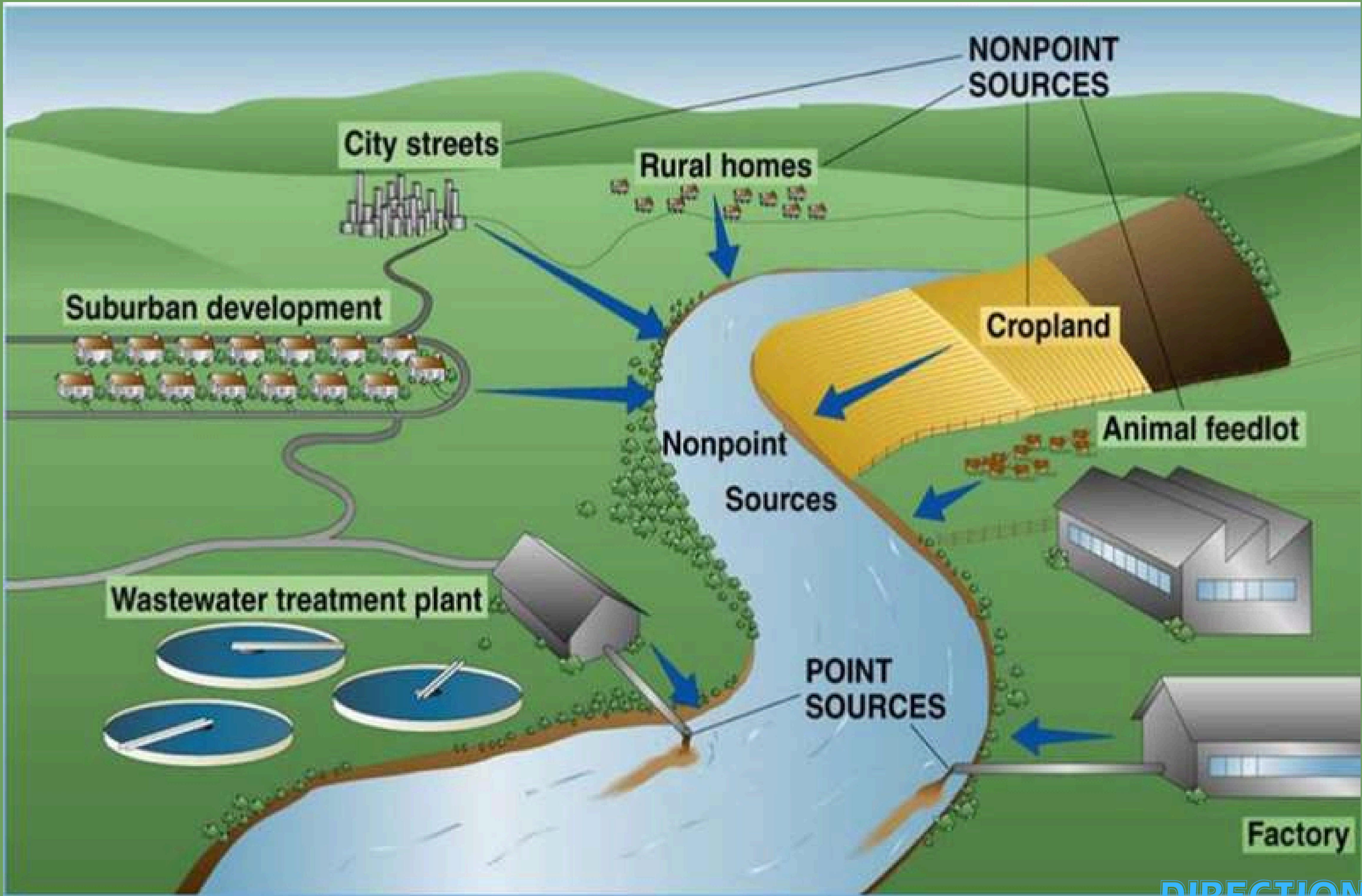


Note | Dissolved oxygen (DO) is the amount of oxygen present in water. If dissolved oxygen in water drops below the standard mark, it can be harmful for aquatic life; biochemical oxygen demand (BOD). Higher BOD indicates more oxygen is required, which is less for oxygen-demanding species to feed on and signifies lower water quality

File phot

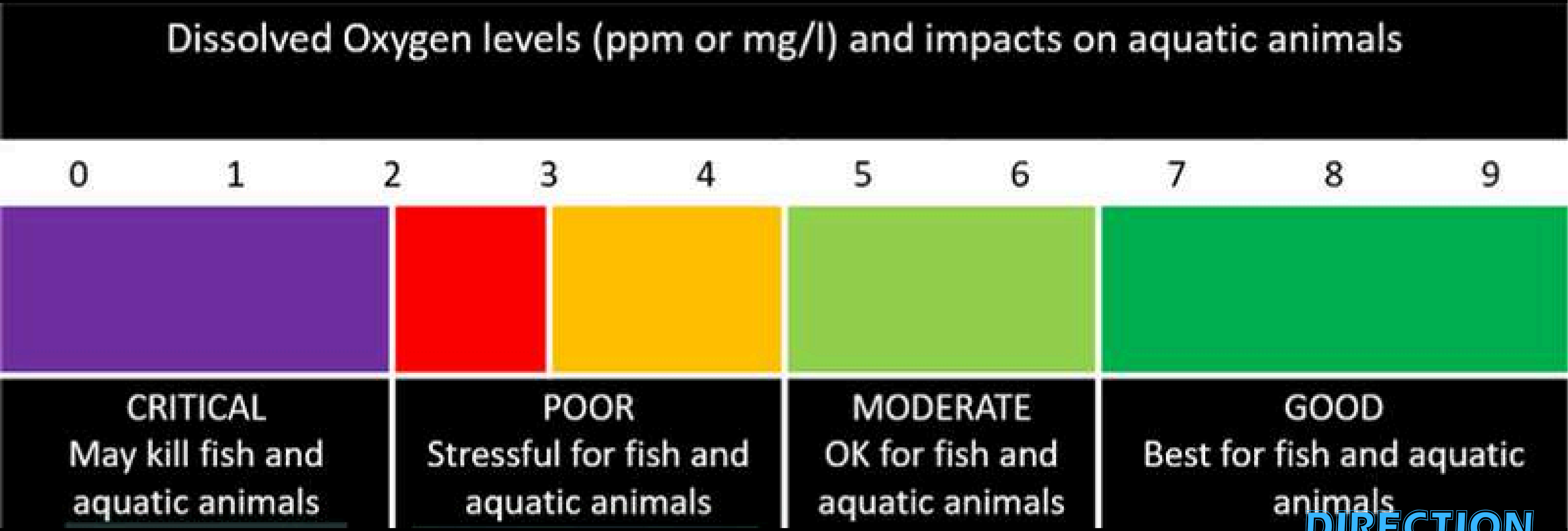


Point source water pollution comes from a single, identifiable source like a factory pipe or sewage treatment plant, while **nonpoint source pollution** comes from diffuse, widespread areas, such as agricultural or urban runoff. Point sources are easie to control because the pollution is collected at a single point, whereas nonpoint sources are more difficult to manage as they come from many locations


NONPOINT
SOURCES
City streets
Rural homes
Suburban development
Cropland
Animal feedlot
Nonpoint
Sources
Wastewater treatment plant
POINT
SOURCES
Factory

Measure of Pollution Load in Water

Dissolved oxygen (DO) is the amount of oxygen gas O2 present in water, which is essential for aquatic life like fish and invertebrates. It enters water through direct absorption from the atmosphere, enhanced by turbulence, and as a byproduct of photosynthesis by aquatic plants. **Low DO levels, often caused by pollution,** can harm or kill aquatic organisms, and are influenced by factors like water temperature, salinity, and decomposition.

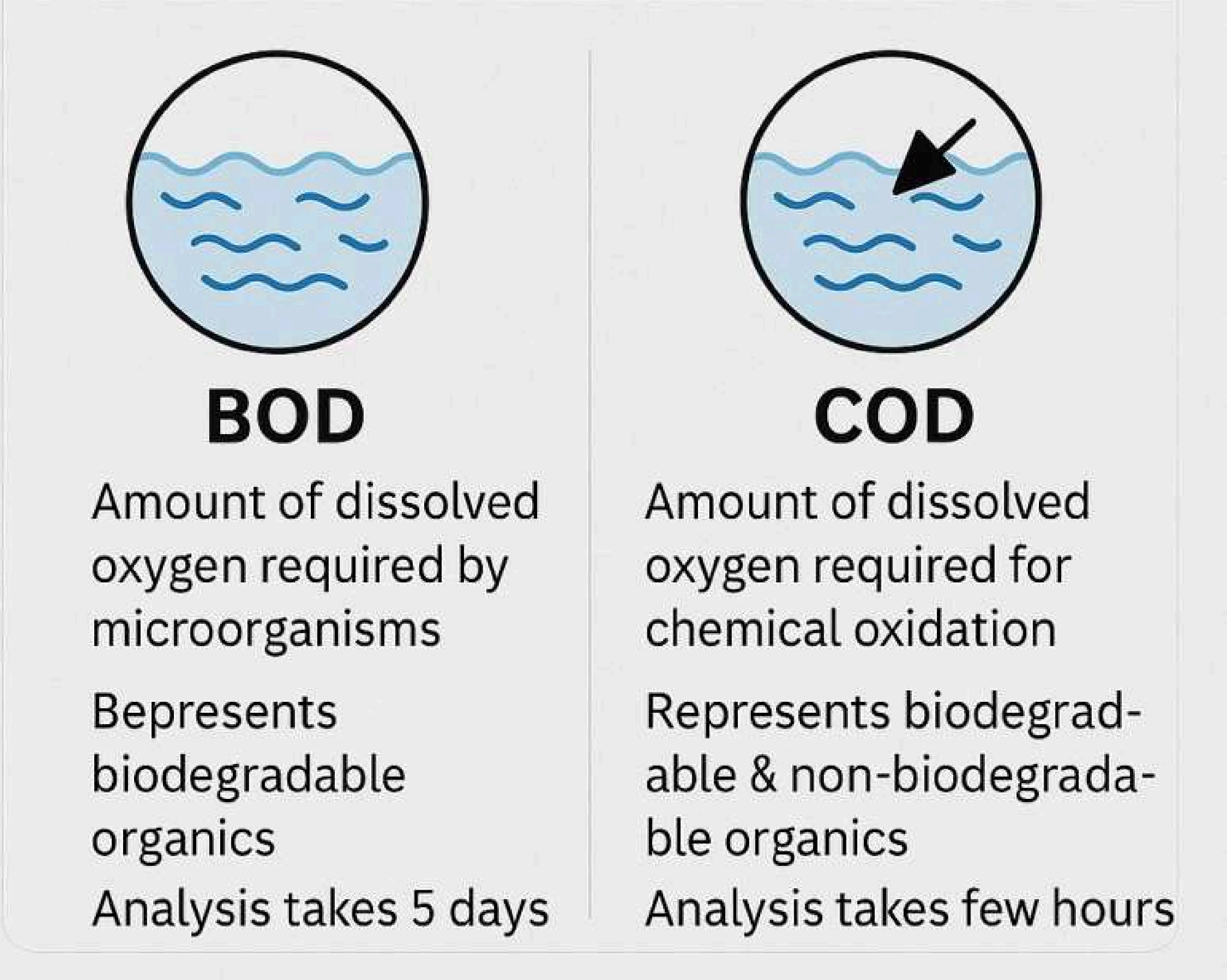


Biological Oxygen Demand (BOD) is the amount of dissolved oxygen microorganisms use to break down organic material in water, and a high BOD indicates significant organic pollution. It is a key indicator of water quality, where a higher BOD value means more oxygen is consumed, which can be detrimental to aquatic life due to oxygen depletion. BOD is commonly measured as the milligrams of oxygen per liter of water over a 5-day incubation period at 20°C20 degrees cap C 20°C

BOD Level in mg/liter	Water Quality
1 - 2	**Very Good:** There will not be much organic matter present in the water supply.
3 - 5	**Fair:** Moderately Clean
6 - 9	**Poor:** Somewhat Polluted - Usually indicates that organic matter present and microorganisms are decomposing that waste.
100 or more	**Very Poor:** Very Polluted - Contains organic matter.

DIRECTION

Chemical Oxygen Demand (COD) is a measure of the total amount of oxygen required to chemically oxidize organic and inorganic pollutants in a water sample. It is expressed in milligrams of oxygen per liter (mg/L) and is used to gauge water quality and monitor the effectiveness of wastewater treatment processes. High COD levels indicate a large amount of oxidizable pollutants, which can deplete the dissolved oxygen in aquatic systems, harming aquatic life



DIRECTION

Water pollution is caused

Industrial activities

- Industrial waste: Many industries release harmful chemicals, heavy metals (like lead and mercury), and toxic substances directly into water without proper treatment.
- Thermal pollution: Industries use water for cooling, and the heated water they discharge into rivers or lakes can reduce oxygen levels and harm aquatic life.

Agriculture

- Pesticides and fertilizers: Runoff from farms carries synthetic fertilizers and pesticides into waterways, leading to nutrient enrichment and contamination.
- Livestock waste: Animal waste and other pollutants from livestock farming can also contaminate water sources.

Sewage and wastewater

- Untreated sewage: A large percentage of the world's sewage is discharged into rivers and oceans without being treated, introducing disease-causing microorganisms and organic waste.
- Domestic waste: Household waste, including detergents and chemicals from personal hygiene products, contributes to water pollution.

DIRECTION

Other sources

- Oil spills: Accidental leaks and spills from oil tankers, pipelines, and other vessels can cause severe and lasting damage to aquatic ecosystems.
- Marine dumping: The dumping of trash, especially plastic, into the oceans pollutes marine environments and harms wildlife.
- Urban runoff: Stormwater in cities picks up pollutants from streets, parking lots, and rooftops, carrying them into nearby water bodies.
- Mining: Mining operations release dust and chemical contaminants into water systems, contaminating both surface and groundwater.
- Deforestation: The removal of trees increases soil erosion, which can lead to higher levels of sediment and bacteria in rivers and lakes.

THREAT TO ENVIRONMENT

- Pollutants continuously enter open ocean through maritime routes, harbours, and other areas
- Various types of ships, such as ferries, cargo containers, tankers, and submarines contribute to ocean pollution
- Presence of multiple types of ships has made oceans more congested
- Oil tanker tracking data shows ships moving across the oceans of Europe and South Asia
- Oil pollution is worsening, creating a hostile environment for marine organisms, biodiversity, and the microbiome
- Oil spills in the ...an spread over time, ...owing marine water currents
- Intensified recreational activities and industrialisation contribute to loss of natural vegetation and marine species

TOI

DIRECTION

Heavy metals are dense metallic elements that pollute water through sources like industrial and agricultural runoff, mining, and improper waste disposal. Common examples include lead, mercury, cadmium, arsenic, chromium, copper, and zinc. These metals are a problem because they do not break down easily and can build up in organisms, potentially causing serious health problems and harming aquatic ecosystems.

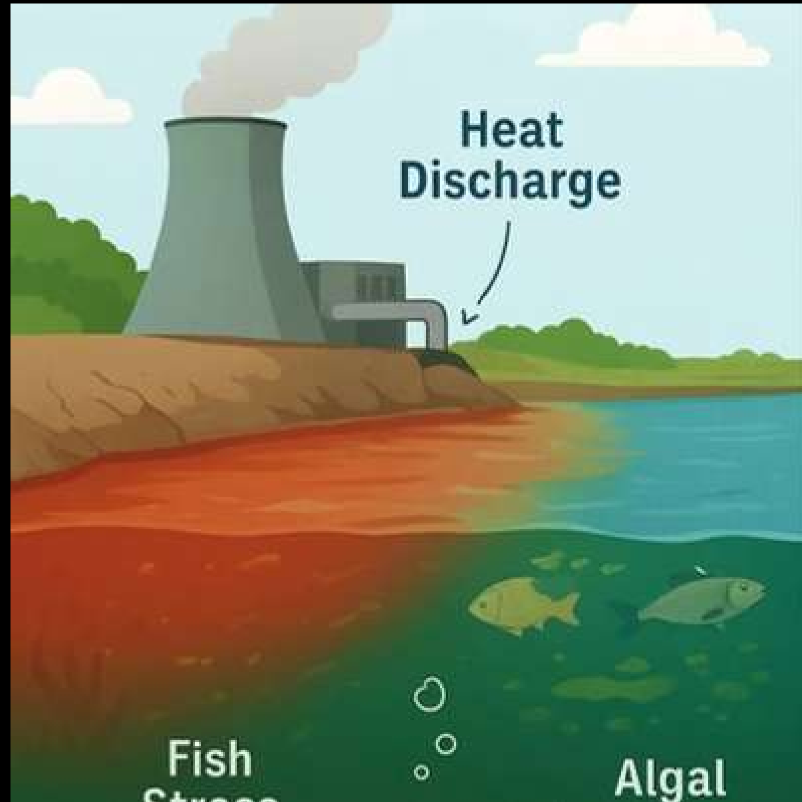
Sources of heavy metal pollution

- Industrial activities: Discharge from industries like manufacturing, metal processing, and electroplating.
- Mining: Leaching from mine tailings and ore processing.
- Agriculture: Runoff from farms, use of pesticides and fertilizers, and animal manure from livestock that are fed growth-promoting additives with heavy metals.
- Waste disposal: Leaching from landfills, incineration of waste, and sewage sludge.
- Transportation: Emissions from vehicles, including leaded gasoline and brake pad wear.
- Infrastructure: Corrosion of pipes and plumbing materials.
- Natural sources: Some heavy metals occur naturally, but human activities increase their concentration in water.

Impacts of heavy metals

- Bioaccumulation: They build up in living organisms over time.
- Health effects: They can cause a range of health issues in humans, including cardiovascular and neurological disorders, and are often carcinogenic.
- Ecological damage: They are toxic to aquatic life, disrupting ecosystems.

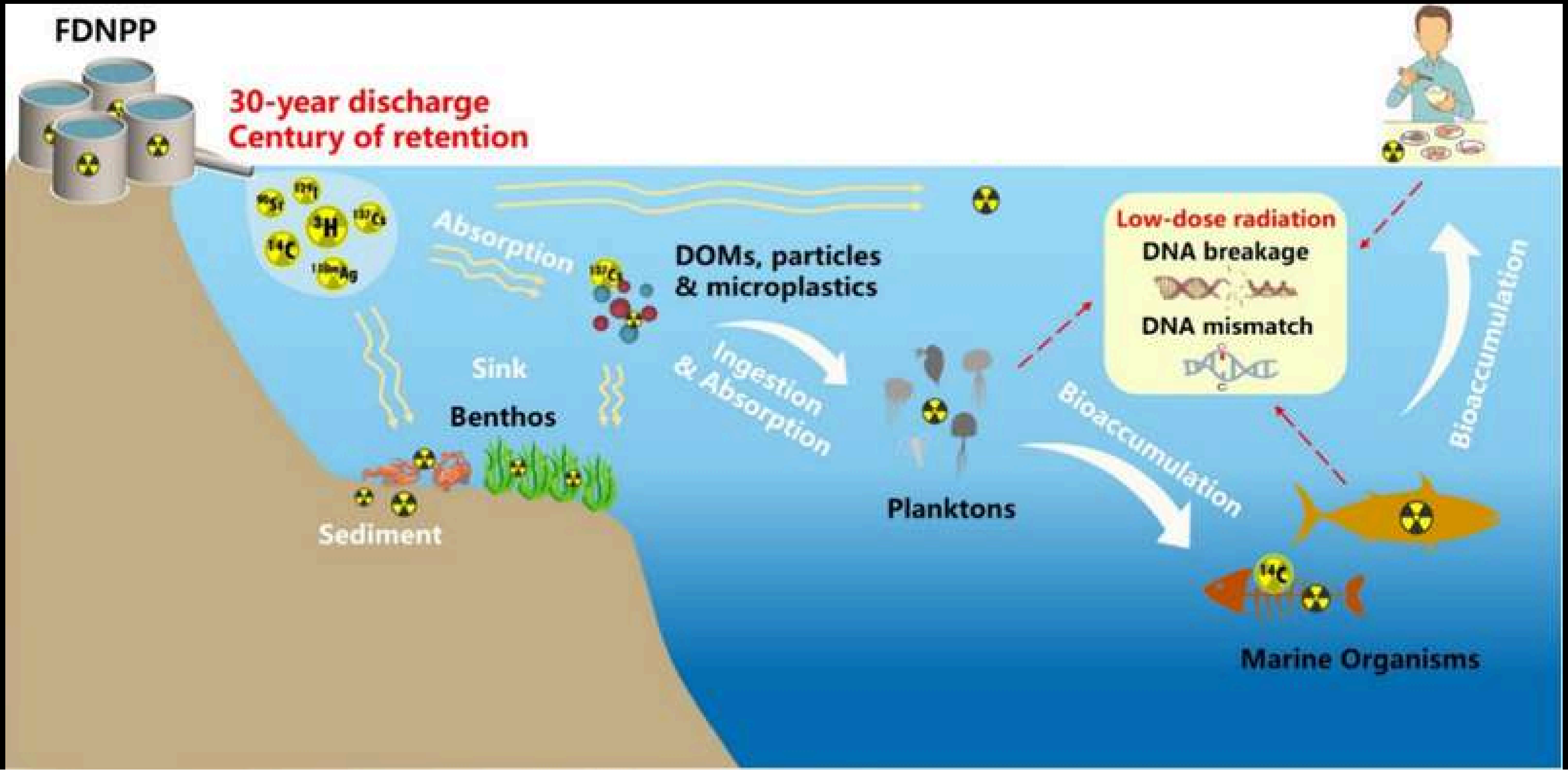
Thermal pollution is the degradation of water quality caused by human activities that change the water's temperature, typically by releasing hot water from power plants and industries.



- Primary cause: Industries and power plants using water for cooling and then releasing it back into the water source at a higher temperature.
- Other causes: Urban runoff can heat water, and releasing very cold water from reservoirs can also negatively impact aquatic life.
- Effects:
  - Decreased dissolved oxygen in the water, which harms or kills aquatic organisms.
  - Disruption of breeding cycles and can lead to the death of sensitive species.
  - Alteration of species composition, as some organisms may not survive the temperature change.

Radiation in water pollution occurs from radioactive materials that contaminate water sources, often from nuclear accidents or waste, emitting harmful ionizing radiation

- Primary cause: Accidental releases from nuclear power plants (e.g., Fukushima) or from nuclear waste that leaks into groundwater.
- Other causes: Improper disposal of radioactive waste from hospitals, research labs, or the nuclear industry.
- Effects:
  - Causes genetic mutations in the DNA of marine organisms, which can lead to cancer.
  - Can cause death, cancer, and infertility in organisms depending on the level of exposure.
  - Contaminates the food chain as radioactive materials build up in organisms.

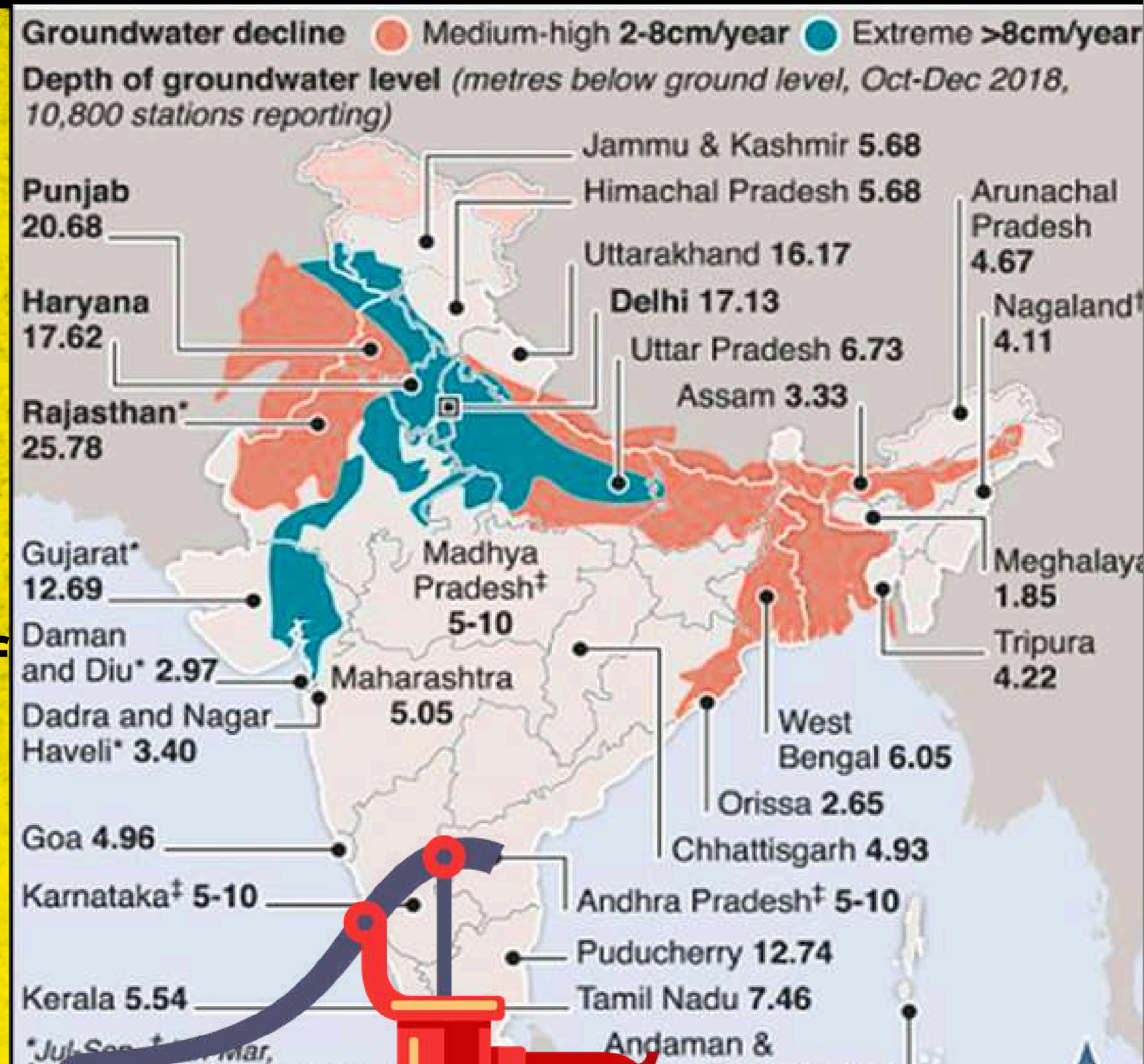


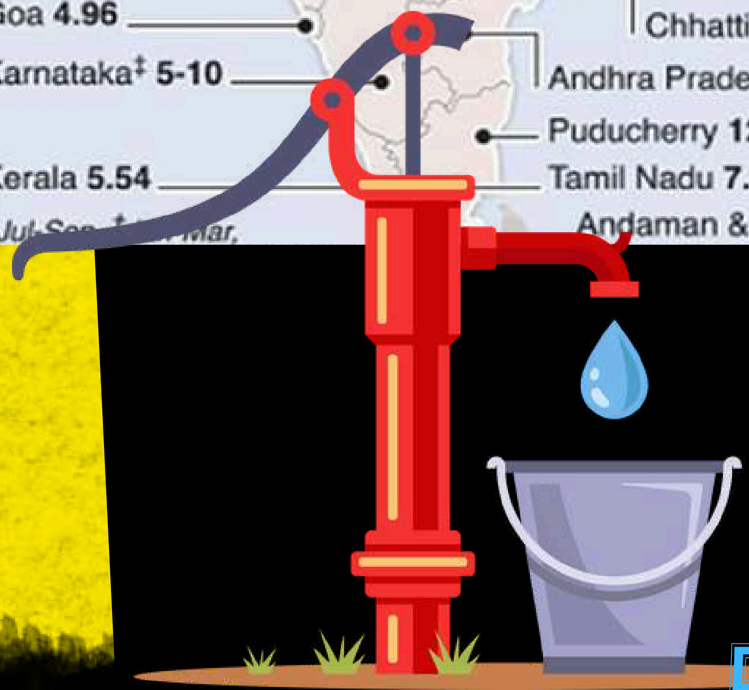
DIRECTION

Groundwater pollution in India is a serious problem caused by both anthropogenic and geogenic factors, leading to widespread contamination with substances like nitrates, fluoride, and arsenic.

Major causes include excessive use of fertilizers, industrial and mining waste, and poor sanitation systems, while natural geological formations are the source of geogenic contaminants.

This has severe health impacts, including blue baby syndrome, kidney damage, and other chronic illnesses.





Causes of groundwater pollution

- Agricultural pollution: Excessive use of nitrogen-rich fertilizers and pesticides is a primary cause of nitrate contamination in groundwater.
- Industrial and mining activities: Discharge of heavy metals (like lead, cadmium, chromium) and toxic chemicals from industries, and improper waste disposal from mining operations, lead to severe pollution in certain areas.
- Unsafe sanitation and waste management: Leakage from septic tanks, sewage systems, and landfills introduces pathogens, organic compounds, and other contaminants into groundwater.
- Natural (geogenic) contamination: Some regions have naturally occurring contaminants like fluoride, arsenic, and uranium in their geological formations.
- Other sources: Contaminants can also originate from road salt, oil spills, and other surface activities.

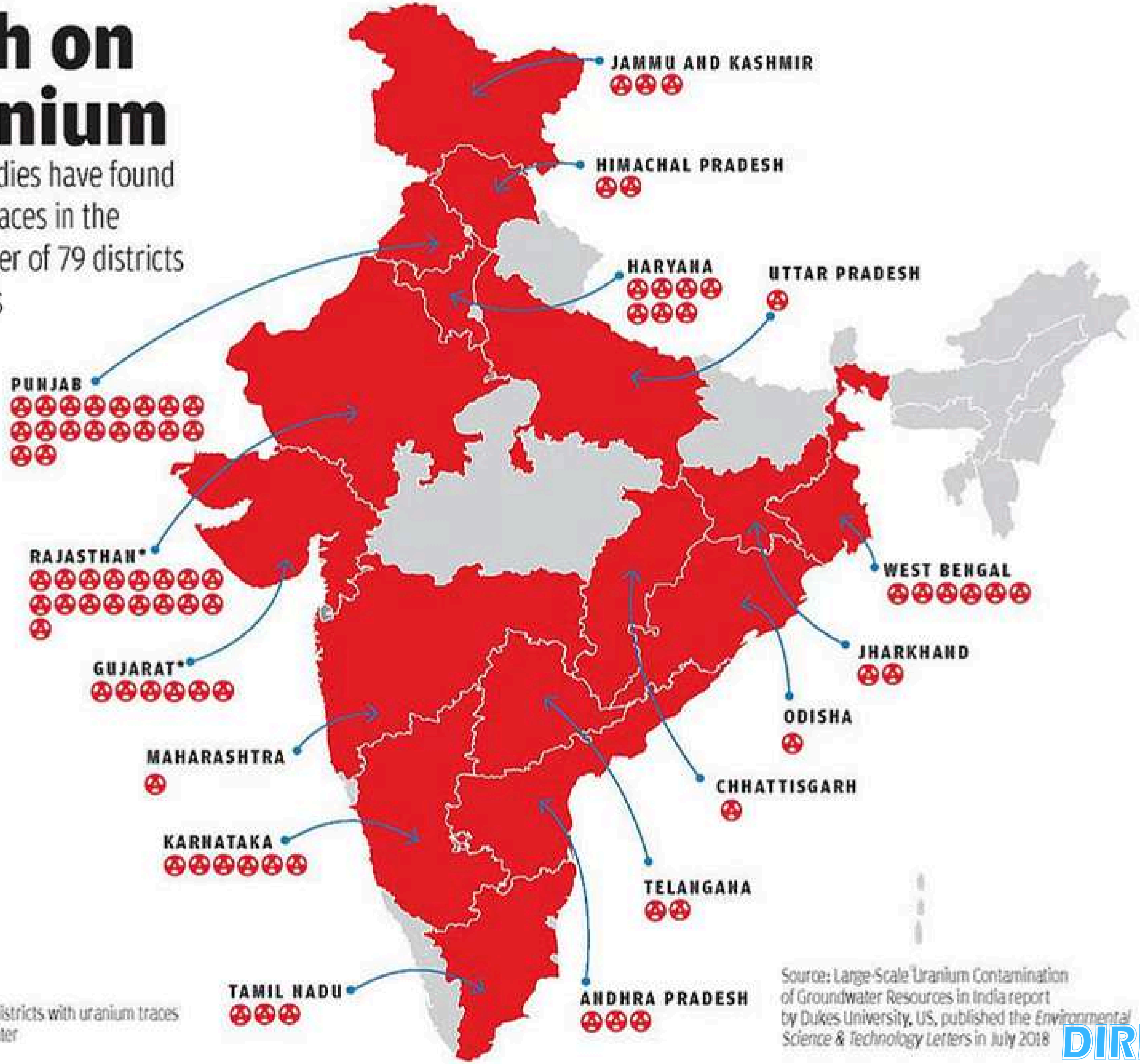
Contaminant	Source(s)	Health Effects
Nitrates	Fertilizers, sewage, septic tanks	Methemoglobinemia ("blue baby syndrome") in infants, which reduces the blood's ability to carry oxygen.
Fluoride	Natural geological deposits	Dental and skeletal fluorosis.
Arsenic	Natural deposits, mining	Various health problems, including skin damage and cancer.
Heavy Metals (lead, cadmium, mercury)	Industrial and mining waste	Kidney damage, liver damage, and other chronic issues.
Uranium	Natural deposits	Renal impairment, bone toxicity, and kidney disease.

Affected regions

- Nitrate: Rajasthan, Karnataka, and Tamil Nadu have reported over 40% of samples exceeding permissible limits, with other states like Maharashtra, Telangana, Andhra Pradesh, and Madhya Pradesh also showing high contamination levels.
- Fluoride: States like Rajasthan, Andhra Pradesh, and Telangana are particularly affected.
- Uranium: Rajasthan and Punjab have been identified as having a significant number of uranium-contaminated samples, with high levels also found in Uttar Pradesh and Delhi.
- Arsenic: Certain areas in states like Bihar, West Bengal, and Punjab are affected.

High on uranium

Recent studies have found uranium traces in the groundwater of 79 districts in 16 states



Number of districts with uranium traces in groundwater

Source: Large-Scale Uranium Contamination of Groundwater Resources in India report by Dukes University, US, published the *Environmental Science & Technology Letters* in July 2018

Red Tide, Blue Tide: Bioluminescence in the Ocean

Bioluminescent waves, "occur when a large bloom of certain plankton, primarily dinoflagellates like Noctiluca scintillans, are disturbed and emit a glowing blue-green light. The "red tide" refers to the reddish-brown color the water appears in daylight due to these blooms, while the "blue waves" are the magical, glowing effect at night when the organisms are agitated by waves, boats, or other movement. This bioluminescence is a defense mechanism, startling predators or attracting larger predators to eat the smaller ones.

Bioluminescent waves can be seen in various locations worldwide and are often more visible in calm, warm water conditions.
Some locations known for bioluminescence include Chennai in India, San Diego, California, and Ha Long Bay in Vietnam.

DIRECTION

Water Pollution Control

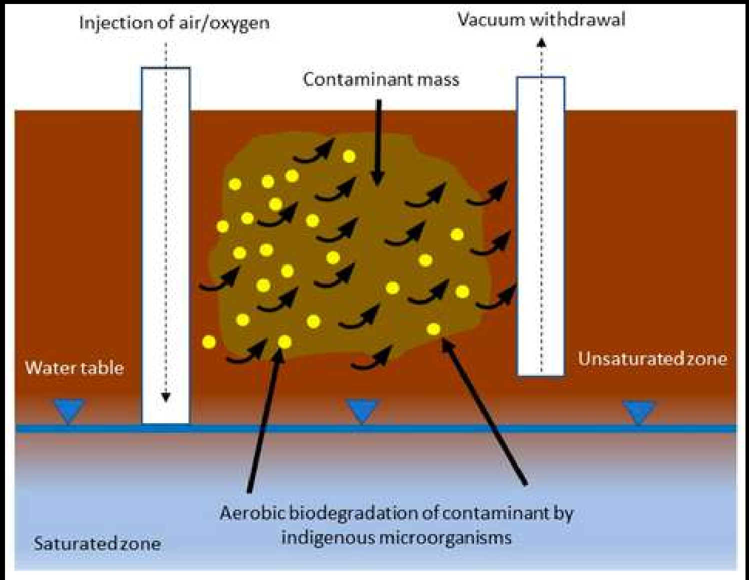
Bioremediation uses microorganisms to clean up water pollution through methods like in-situ (on-site) and ex-situ (off-site) techniques.

In-situ bioremediation

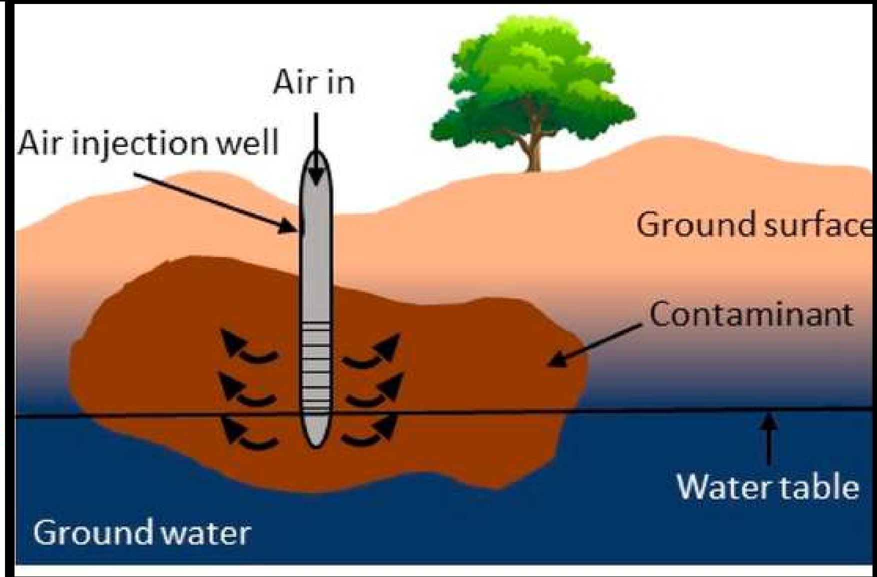
Bioventing: Oxygen is supplied through wells in contaminated soil to stimulate the growth of indigenous bacteria, which can break down organic pollutants.

Biosparging: Air is injected under pressure below the water table to increase dissolved oxygen levels, promoting the degradation of contaminants by naturally occurring microbes.

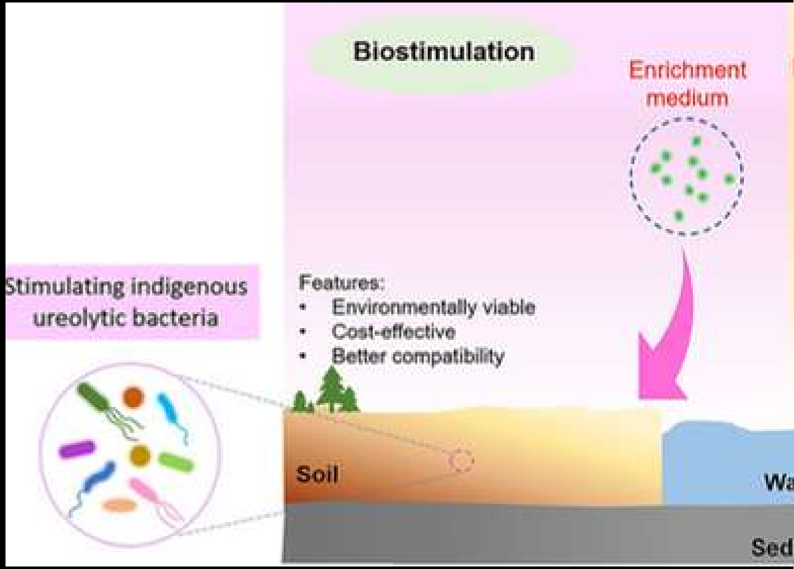
Biostimulation: Nutrients (like nitrogen and phosphorus) or other amendments are added to the site to encourage the growth and activity of naturally occurring microorganisms that can degrade pollutants.



Bioventing



Biosparging



Biostimulation:

Ex-situ bioremediation

Bioreactors: Contaminated soil or water is removed and placed in a controlled vessel where conditions can be optimized for microbial activity. This is a faster process than in-situ methods, notes IntechOpen.

Landfarming: Contaminated soil is excavated and spread in a prepared bed, where it is tilled to encourage aerobic degradation of pollutants.

Bio-piles: A combination of land farming and composting, where contaminated material is piled, and air and nutrients are circulated through it to speed up degradation

Other methods

Bioaugmentation: Microorganisms with specific pollutant-degrading properties are introduced to a contaminated site when indigenous microbial populations are insufficient.

Phytoremediation: Plants are used to help clean up contaminants. They can absorb and break down pollutants or stabilize them in the soil.

Fungal bioremediation: Fungi are used to break down pollutants, a method that is particularly effective for certain types of contaminants

DIRECTION

Oilzapper is an eco-friendly, microbial-based solution for cleaning oil spills and treating oily waste, developed by The Energy and Resources Institute (TERI) in India. It consists of a consortium of bacteria that consume hydrocarbon compounds, breaking them down into harmless byproducts like carbon dioxide and water.

Bioremediation: Oilzapper uses a natural process called bioremediation, which involves stimulating the growth of specific microbes that feed on contaminants.

How it works

- Bacterial consortium: Oilzapper is a "cocktail" of five different bacterial species that are naturally occurring and capable of degrading various hydrocarbons.
- Carrier material: The bacteria are immobilized and mixed with a powdered corncob carrier, which makes the product stable and easy to transport and apply.
- Metabolism: When applied to an oil spill or oily sludge, the bacteria begin to consume the hydrocarbon molecules.
- Biodegradation: Through their natural metabolic processes, the bacteria convert the harmful hydrocarbons into harmless substances like carbon dioxide, water, and fatty acids.

A **bio-toilet** is a water-saving, self-contained sanitation system that uses these bacteria to break down human waste into water, gas, and other byproducts, which is different from traditional flush toilets

DRDO, in collaboration with Indian Railways, has developed the IR-DRDO bio-toilet system for railway coaches, which uses anaerobic bacteria to treat human waste on-board. The bacteria convert human waste into water and gases, which are then treated before the water is discharged after chlorination.

- Anaerobic digestion: A bio-digester tank, filled with anaerobic bacteria, is installed under the lavatory.
- Waste conversion: The bacteria break down the waste into liquid and gas.
- Gas release: The gases are safely released into the atmosphere.
- Water treatment: The treated liquid is then discharged after being disinfected with chlorine.
- Benefits: This system eliminates the discharge of untreated human waste onto the tracks, which improves hygiene, prevents corrosion, and reduces the load on existing sewage systems

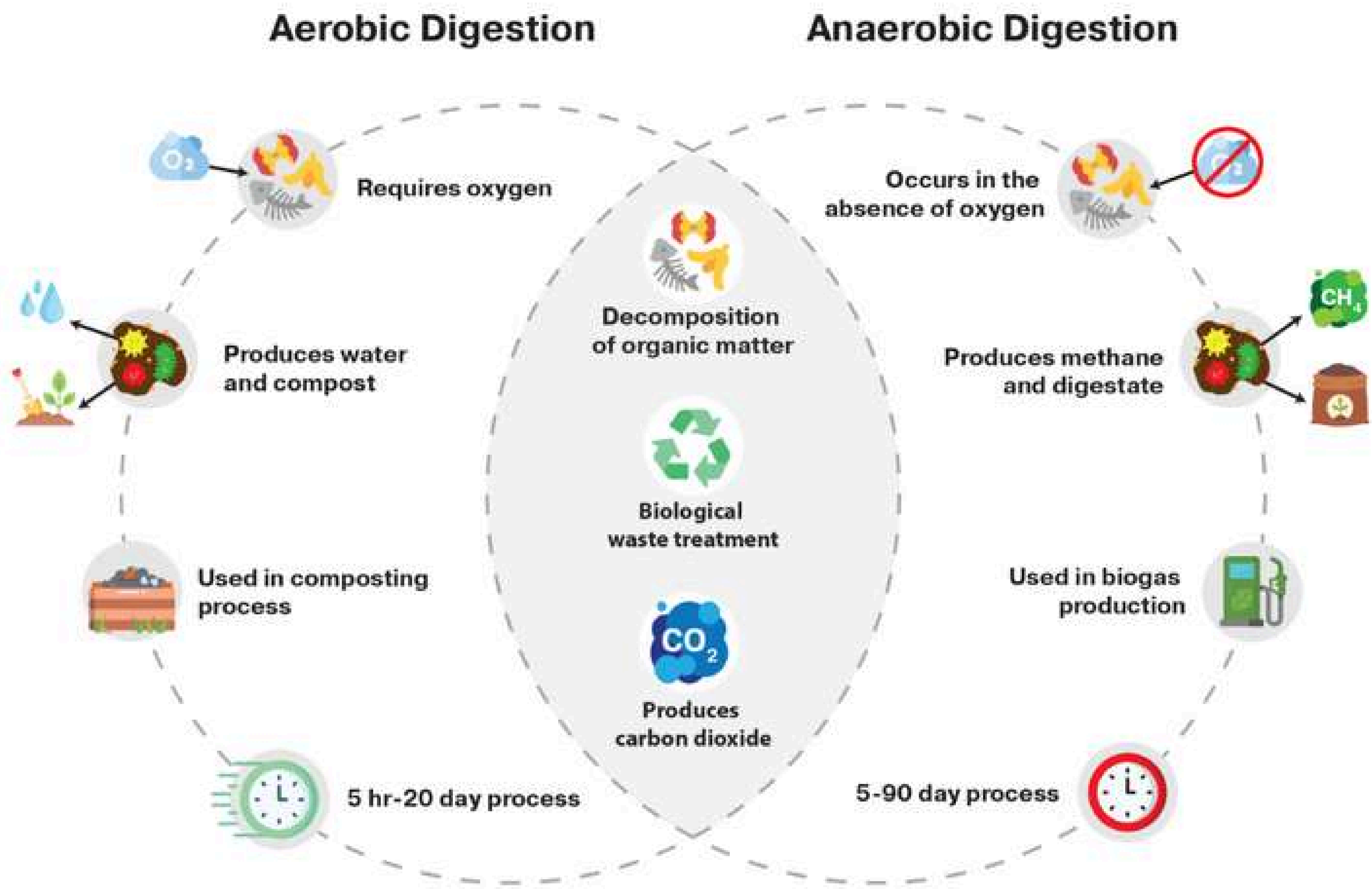
Aerobic and anaerobic digestion are both processes for breaking down organic matter, but they differ fundamentally in their requirement for oxygen. Aerobic digestion requires oxygen and is faster, producing carbon dioxide and water, while anaerobic digestion occurs without oxygen and generates biogas (a mix of methane and carbon dioxide). Anaerobic digestion can be slower and requires sealed tanks, but it has higher organic loading rates and produces a valuable energy source (biogas).

Aerobic digestion

Requires oxygen: Performed by microorganisms in the presence of oxygen, typically in an oxygenated atmosphere or through mechanical aeration.
Process: Breaks down organic matter into carbon dioxide, water, and heat.
Speed: Generally faster than anaerobic digestion.
Byproducts: Primarily carbon dioxide, a less potent greenhouse gas compared to methane.
Energy efficiency: Less energy efficient as it requires energy for aeration.
Common applications: Wastewater treatment and composting.

Anaerobic digestion

Does not require oxygen: Performed by microorganisms in the absence of oxygen, in sealed, airtight containers.
Process: Breaks down organic matter through fermentation into biogas.
Speed: Slower than aerobic digestion.
Byproducts: Biogas, a mix of methane and carbon dioxide, which can be captured and used for energy.
Energy efficiency: More energy efficient in terms of operational costs and energy demands, despite requiring more upfront capital for sealed digesters.
Common applications: Production of biogas for energy generation and treatment of sludge and wastewater.



Aerobic Digestion
Anaerobic Digestion
O_2
Requires oxygen
Produces water and compost
Used in composting process
5 hr-20 day process
Decomposition of organic matter
Biological waste treatment
CO_2
Produces carbon dioxide
Occurs in the absence of oxygen
O_2
CH_4
Produces methane and digestate
Used in biogas production
5-90 day process

Core components and processes

- Bio-digester tank: A sealed tank, often below ground, where the biological decomposition of waste takes place.
- Microbial culture: A mixture of specialized bacteria used to break down organic waste.
- Anaerobic bacteria: Bacteria that break down waste in the absence of oxygen. They are crucial to the bio-toilet's function and can survive a wide range of temperatures.
- Decomposition: The process where bacteria convert waste into water, methane gas, and other byproducts.
- Ventilation system: A system that reduces odor and allows for gas exchange within the toilet.

Types of bio-toilets and systems

- Dry toilet: A type of bio-toilet that does not use water for flushing.
- Composting toilet: A toilet that uses a predominantly aerobic process to treat human waste by composting.
- Self-contained: A bio-toilet that is a single, compact unit with no need for a connection to a traditional sewage system.

DIRECTION

Benefits of Bio Toilets

- **Odor Control:** Unlike traditional septic tanks, bio toilets minimize bad smells using odor eliminator and odor control system technologies.
- **Eco-Friendly:** They reduce water consumption and prevent contamination of natural water bodies.
- **Easy Maintenance:** With the use of septic tank cleaning bacteria, maintaining a bio toilet is hassle-free.
- **Versatile Applications:** Bio toilets are used in homes, public spaces, and remote areas like construction sites and railway stations.
- **Cost-Effective:** Eliminates the need for expensive sewage infrastructure.
- **Promotes Hygiene:** Reduces the risk of waterborne diseases by safely disposing of waste.

Water Treatment Plant Process

Types of Water Treatment Plants water treatment plants are categorized based on their purpose and process design.
Each type plays a unique role in the water purification ecosystem.

1. Municipal Water Treatment Plants

These plants treat surface or groundwater for public consumption. Their goal is to supply safe, potable water to homes and businesses through citywide distribution systems.

2. Industrial Water Treatment Plants

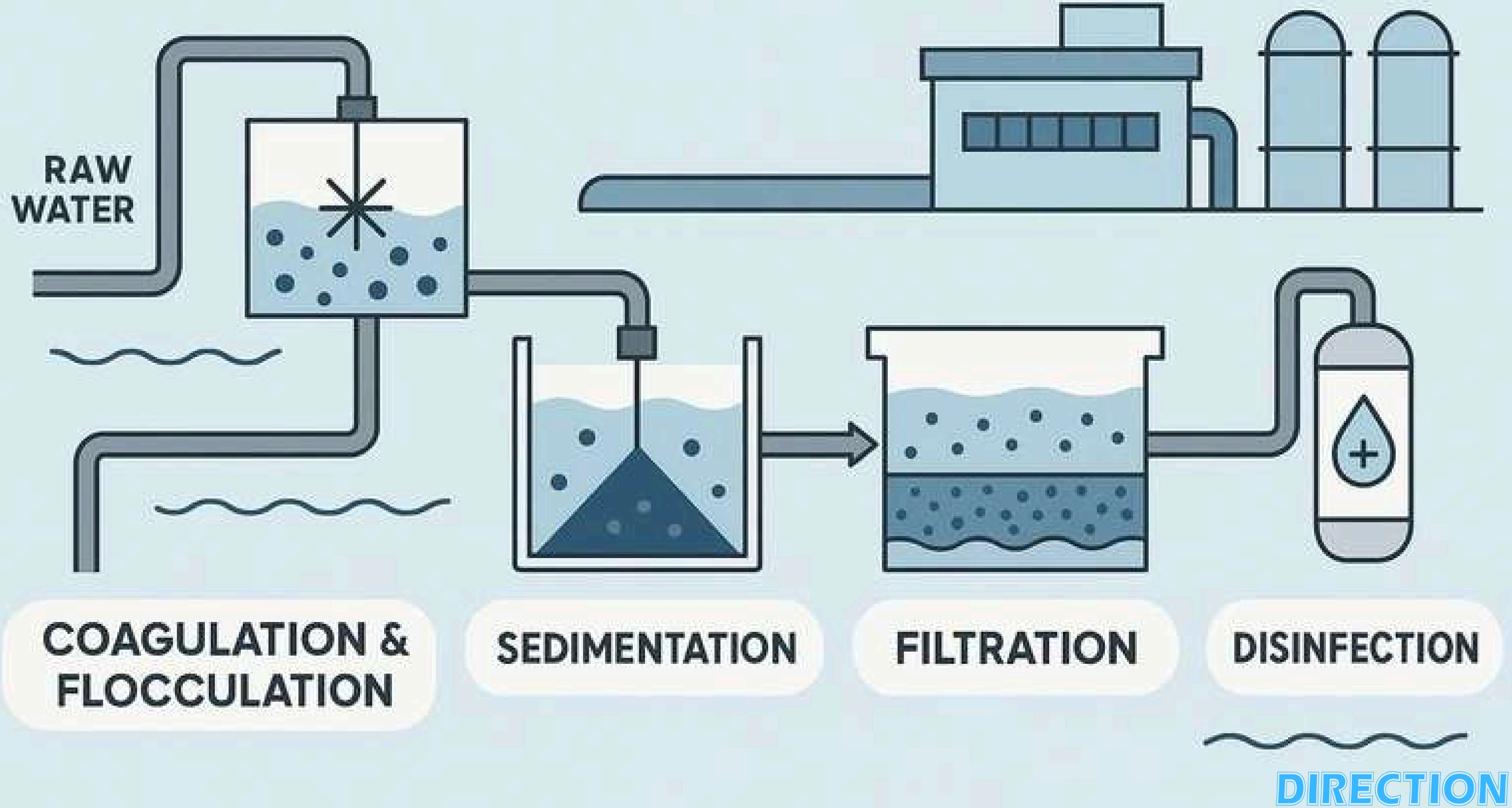
Industries like power plants, refineries, and manufacturing facilities use water in large volumes. These plants treat raw water for use in processes and purify wastewater before discharge or reuse.

3. Wastewater Treatment Plants (WWTP)

WWTPs process sewage and industrial effluents, removing contaminants before returning the water to nature or reusing it. This type of plant is crucial for environmental protection and resource conservation.

DIRECTION

WATER TREATMENT PLANT PROCESS



Stages of Water Purification

1. Intake and Screening

The process starts by collecting raw water from sources like rivers or lakes. At the intake point, coarse screens filter out leaves, sticks, plastics, and other large objects to prevent damage to equipment.

2. Coagulation and Flocculation

In coagulation, chemicals like alum are added to neutralize particles in the water. This is followed by flocculation, where gentle mixing causes the particles to stick together into flocs, which are easier to remove.

3. Sedimentation

The water flows into sedimentation tanks where gravity helps the flocs settle at the bottom. This step significantly reduces turbidity and particle load before filtration.

4. Filtration

The clarified water is passed through filters made of sand, gravel, or activated carbon. These filters remove any remaining impurities, including bacteria, organic matter, and fine particles.

5. Disinfection

To ensure the water is microbiologically safe, disinfectants like chlorine, chloramine, ozone, or ultraviolet (UV) light are used. This kills or inactivates pathogens like viruses, bacteria, and protozoa.

6. Storage and Distribution

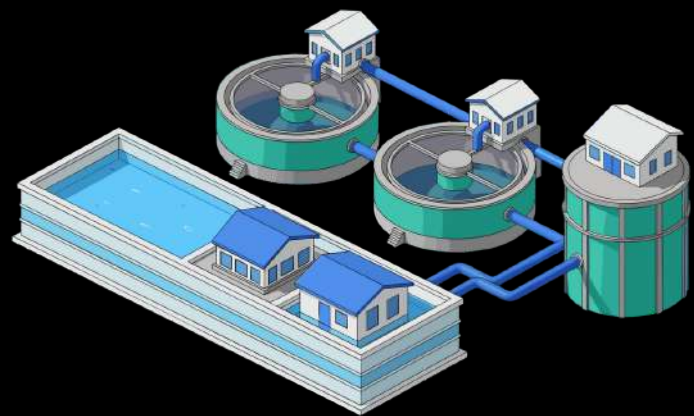
The clean water is then stored in reservoirs and distributed through a network of pipelines to residential, commercial, and industrial users.

Processes of Water Purification

Physical Processes These involve mechanical removal of particles, such as:

- Screening
- Sedimentation
- Filtration

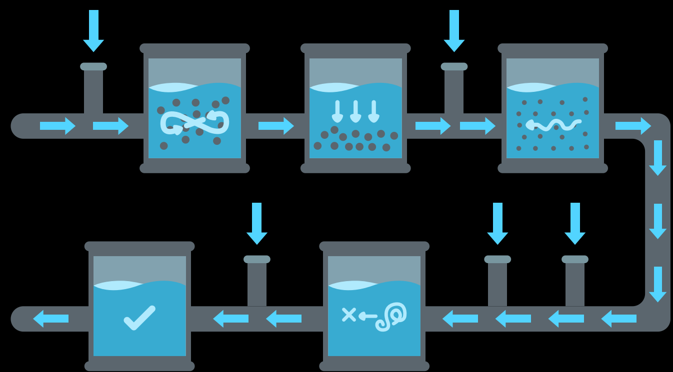
Chemical Processes Chemicals help bind, neutralize, or kill contaminants. Common chemical processes include:



- Coagulation and flocculation
- Disinfection
- pH adjustment
-

Biological Processes Used mainly in wastewater treatment, biological stages break down organic pollutants using microorganisms. Techniques include:

- Aerobic digestion
- Anaerobic treatment
- Activated sludge process



DIRECTION

India is implementing several measures for wastewater reuse, including new government regulations that mandate bulk users to treat and reuse a portion of their wastewater, with targets of 20% by 2027-28 and 50% by 2031. Other measures include promoting circular economy principles, setting national reuse targets, encouraging advanced treatment technologies, and creating city-level action plans to identify reuse avenues and manage implementation.

Government mandates and policies

- Liquid Waste Management Rules (2024): Requires bulk consumers (over 5,000 liters/day) to treat and reuse at least 20% of wastewater by 2027-28, rising to 50% by 2031. They must register and report compliance monthly.
- National targets: Programs like AMRUT 2.0 aim to recycle 20% of total water demand, while the National Mission for Clean Ganga (NMCG) has a framework for 50% reuse of treated water by 2025 and 100% by 2050.
- Incentives and support: The government is encouraging R&D in water efficiency, implementing volumetric water pricing, and providing support for city-level action plans for wastewater reuse.

DIRECTION

India's water challenges have long demanded both structural and participatory interventions. Against this backdrop, the Government of India launched the Mission Amrit Sarovar in 2022 as a flagship initiative under the Azadi Ka Amrit Mahotsav. The mission aims to construct and rejuvenate 75 water bodies in each district across the country, thereby fostering water conservation, ensuring sustainability, and reviving traditional community water bodies through public participation.

Government and legal measures

- National Programs: Programs like the Namami Gange Programme (for the Ganges) and the National Plan for Conservation of Aquatic Ecosystems (NPCA) aim to clean up rivers, lakes, and wetlands through comprehensive conservation activities.
- Legal Framework: The Water (Prevention and Control of Pollution) Act of 1974 and the Environment (Protection) Act of 1986 provide the legal basis for controlling pollution. The Central Pollution Control Board (CPCB) and State Pollution Control Boards (SPCBs) monitor compliance.
- Industrial Compliance: Industries are required to install ETPs and meet stipulated standards before discharging waste. The government also encourages industries to achieve Zero Liquid Discharge (ZLD).

Enforcement and Monitoring: The CPCB

DIRECTION

The evolution of legislative framework for water pollution in India

The United Nations Conference on the Human Environment at Stockholm in 1972 led to a new era of environmental conservation in India and a slew of legislations to protect the environment were introduced in the country. The United States had already established the United States Environmental Protection Agency (USEPA) in 1970 followed by legislation and rewriting of Clean Water Act in 1972.

The USEPA and Clean Water Act had a significant influence on many developing countries, who adopted the regulatory framework and standards of the United States. The Indian parliament also took lead and passed the Water (Prevention and Control of Pollution) Act in 1974

The Water Act, 1974

The Water (Prevention and Control of Pollution) Act in 1974 (also referred to as the 1974 Water Act) provided for the establishment of the Central Pollution Control Board (CPCB) and State Pollution Control Boards (SPCB) and defined the functions and powers of these bodies. Prior approval from SPCB was made mandatory for any industry operations and functions.

The Water (Prevention and Control of Pollution) Cess Act, 1977

The Water Cess Act, enacted in 1977 and subsequently amended in 1992 and 2003, creates economic instruments for pollution control through the levy and collection of cess on water consumption by industries operating specific activities. [6] This legislation implements the polluter pays principle by requiring industries that consume water and discharge effluents to contribute financially to pollution control efforts.

The cess mechanism serves dual purposes: generating resources for pollution control boards to strengthen their operational capabilities while creating economic incentives for industries to minimize water consumption and pollution generation.

The Environment Protection Act, 1986

Umbrella Legislation and Comprehensive Framework

The Environment Protection Act, 1986, enacted in response to the Bhopal Gas Tragedy and India’s commitments under the Stockholm Conference, serves as umbrella legislation providing comprehensive environmental protection frameworks. This Act empowers the Central Government to take necessary measures for environmental protection and improvement, coordinate activities of various regulatory authorities, and address environmental challenges through integrated approaches.

The National Green Tribunal, established in 2010, as per the National Green Tribunal Act is a specialised judicial body equipped with expertise solely for the purpose of adjudicating environmental cases in the country.
Recognising that most environment cases involve multi-disciplinary issues which are better addressed in a specialised forum, the Tribunal was setup as per recommendations of the Supreme Court, Law Commission and India’s international law obligations to develop national laws on environment and implement them effectively.
The Tribunal is tasked with providing effective and expeditious remedy in cases relating to environmental protection, conservation of forests and other natural resources and enforcement of any legal right relating to environment. The Tribunal’s orders are binding and it has power to grant relief in the form of compensation and damages to affected persons.
What is the Tribunal’s composition?
The Tribunal has a presence in five zones- North, Central, East, South and West. The Principal Bench is situated in the North Zone, headquartered in Delhi.
The Central zone bench is situated in Bhopal, East zone in Kolkata, South zone in Chennai and West zone in Pune.
involving subjects in the legislations mentioned in Schedule I of the National Green Tribunal Act, 2010 may approach the Tribunal.
The statutes in Schedule I are:

- The Water (Prevention and Control of Pollution) Act, 1974;
- The Water (Prevention and Control of Pollution) Cess Act, 1977;
- The Forest (Conservation) Act, 1980;
- The Air (Prevention and Control of Pollution) Act, 1981;
- The Environment (Protection) Act, 1986;
- The Public Liability Insurance Act, 1991;
- The Biological Diversity Act, 2002.

Marine pollution is the introduction of harmful substances or energy into the ocean that cause adverse effects on marine ecosystems and organisms. This contamination includes chemicals, plastic trash, oil, and noise, originating from land-based sources, ships, and atmospheric deposition. It leads to environmental damage, harms marine life, and can impact human health and livelihoods.

- Plastic pollution. ...
- Light pollution. ...
- Noise pollution. ...
- Chemical pollution.

DIRECTION

Plastic pollution

It’s estimated that around eight million tonnes of plastic waste enter our oceans each year, on top of the 150 million tonnes already present in them. While larger pieces of plastic can damage coral reefs or ensnare fish and mammals, over time, they eventually break down into much smaller fragments. These particles, known as microplastics, are potentially even more dangerous, since they are more likely to be mistaken for food by organisms of all sizes. After ingestion, they can harm the internal organs and weaken the immune systems of the animal in question, not to mention filling their stomach with plastic matter that contains zero nutritional value.

Light pollution

Wherever there is human habitation, there will be light. Many towns and cities are built near to coastal areas, meaning the lighting used to illuminate our streets, homes, offices and other public places can infiltrate underneath the waves, as well. The presence of this artificial light during night-time can upset the natural circadian rhythms of fish and other marine animals, which can disrupt their daily routines. Larger fish can prey upon smaller species more easily, while reef dwelling fish can have their reproductive cycles thrown into disarray.

Noise pollution

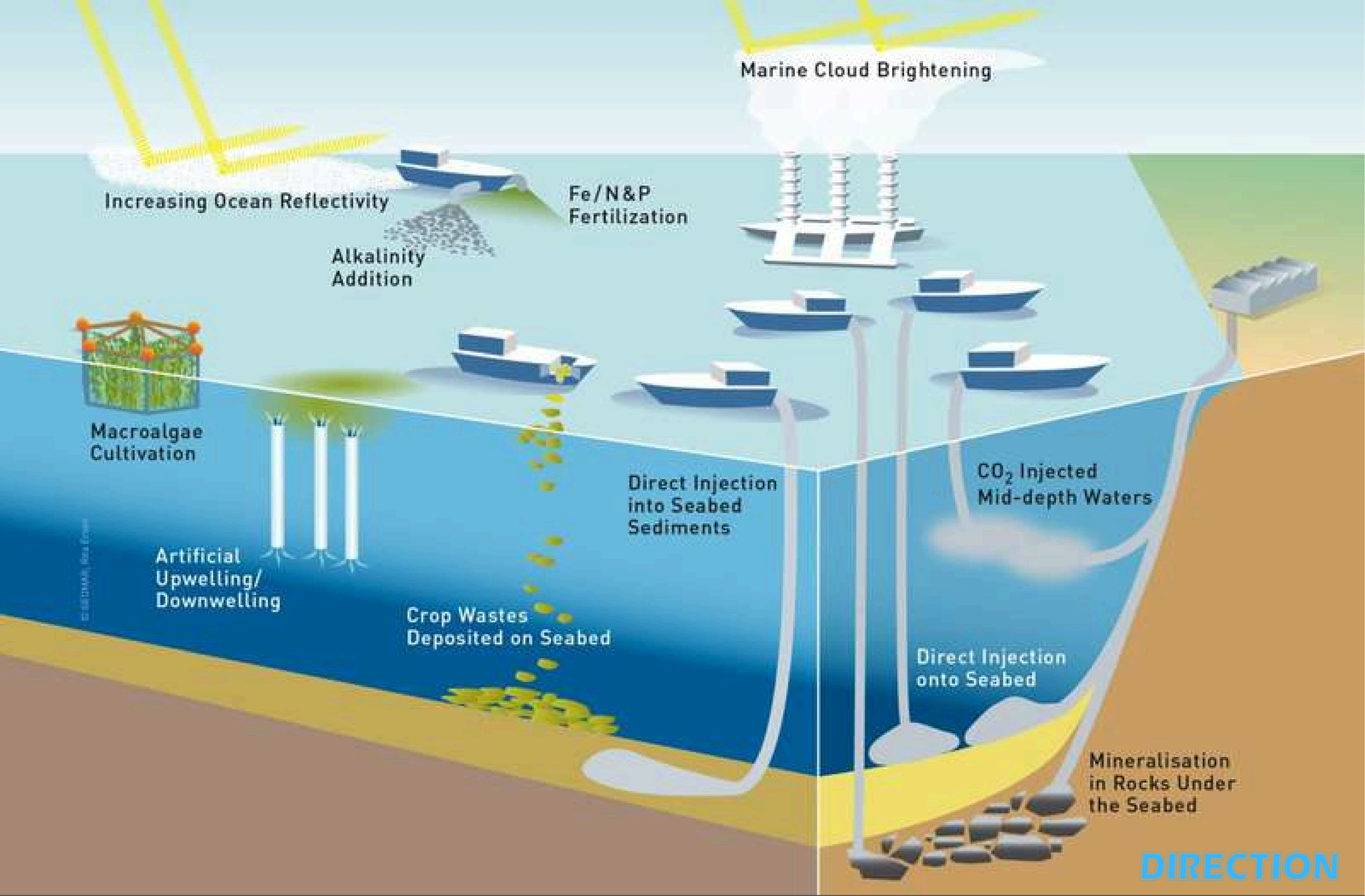
We may traditionally associate noise pollution with industrial sites or construction works, but sounds can actually travel for further and longer underwater than they can in the air. For that reason, noise pollution caused by anthropogenic activity is a much greater threat to marine animals than it is to those living on the land or in the air. Not only can noise pollution confuse animals which depend upon sonar signals to feed, mate and navigate their way around the ocean, but it can shorten their lifespans and threaten the very existence of entire species.

Chemical pollution

Pesticides, fertilisers and herbicides are commonly used by farmers to boost yields and protect against pests and diseases. Unfortunately, heavy rainfall can sweep these chemicals into gutters, streams and rivers, eventually diverting them into marine environments. Although we do possess sustainable solutions for the removal of chemicals like phosphate and ammonia from such environments, they are not always as commonly employed nor as effective as we might like. This leads to a nutritional imbalance in the water, promoting the growth of algal blooms, depriving other animals of the space, sunlight and nutrients they need and destroying the natural balance of ecosystems.

Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter

The "Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972", the "London Convention" for short, is one of the first global conventions to protect the marine environment from human activities and has been in force since 1975. Its objective is to promote the effective control of all sources of marine pollution and to take all practicable steps to prevent pollution of the sea by dumping of wastes and other matter. Currently, 87 States are Parties to this Convention.



Marine Cloud Brightening
Increasing Ocean Reflectivity
Fe/N&P Fertilization
Alkalinity Addition
Macroalgae Cultivation
Artificial Upwelling/ Downwelling
Crop Wastes Deposited on Seabed
Direct Injection into Seabed Sediments
CO_2 Injected Mid-depth Waters
Direct Injection onto Seabed
Mineralisation in Rocks Under the Seabed
DIRECTION

The **four pillars of the International Maritime Organization** (IMO) are the four key conventions that govern the maritime industry: **SOLAS (Safety of Life at Sea), MARPOL (pollution prevention), STCW (training, certification, and watchkeeping for seafarers), and MLC (Maritime Labour Convention).** These pillars establish international standards to ensure safety, environmental protection, proper training, and decent working conditions for seafarers.

SOLAS (International Convention for the Safety of Life at Sea):
Focuses on the safety of ships, their crews, and passengers by setting minimum safety standards for construction, equipment, and operation.

MARPOL (International Convention for the Prevention of Pollution from Ships):
Aims to prevent and minimize pollution from ships, including oil, chemicals, and garbage.

STCW (International Convention on Standards of Training, Certification and Watchkeeping for Seafarers):
Sets the minimum global standards for training, certification, and watchkeeping for seafarers to ensure competency.

MLC (Maritime Labour Convention):
Addresses the rights of seafarers by establishing minimum working and living standards, such as fair wages, working hours, and accommodation.

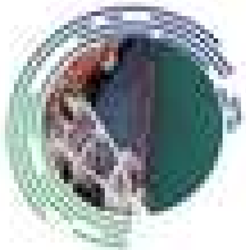
DIRECTION

International Convention for the Prevention of Pollution from Ships (MARPOL)

How does IMO's marine protection treaty make a difference?

IMO MARPOL AT 50

The International Convention for the Prevention of Pollution from Ships (MARPOL) contains six annexes:



OIL
ANNEX I
Prevention of Pollution by Oil (entered into force 2 October 1983)

NOXIOUS LIQUID SUBSTANCES
ANNEX II
Control of Pollution by Noxious Liquid Substances in Bulk (entered into force 2 October 1983)

HARMFUL SUBSTANCES
ANNEX III
Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form (entered into force 1 July 1992)

SEWAGE
ANNEX IV
Prevention of Pollution by Sewage from Ships (entered into force 27 September 2003)

GARBAGE
ANNEX V
Prevention of Pollution by Garbage from Ships (entered into force 31 December 1988)

AIR
ANNEX VI
Prevention of Air Pollution from Ships (entered into force 19 May 2005)

The Convention includes regulations aimed at preventing and minimizing pollution from ships - both accidental pollution and that from routine operations

DIRECTION

The three institutions established by the **UN Convention on the Law of the Sea (UNCLOS)** are the International Tribunal for the Law of the Sea (ITLOS), the International Seabed Authority (ISA), and the Commission on the Limits of the Continental Shelf (CLCS). ITLOS adjudicates legal disputes, the ISA regulates activities in the international seabed, and the CLCS makes recommendations on continental shelf claims.

International Tribunal for the Law of the Sea (ITLOS): An independent judicial body that settles disputes between states regarding the interpretation and application of UNCLOS.

International Seabed Authority (ISA): Manages mineral-related activities and resources in the international seabed area, which lies beyond the limits of national jurisdiction.

Commission on the Limits of the Continental Shelf (CLCS): Examines data submitted by coastal states to make recommendations on the establishment of the outer limits of their continental shelves.

Conserve and sustainably use the oceans, seas and marine resources for sustainable development

14 LIFE BELOW WATER

Established by the UN to "conserve and sustainably use the oceans, seas, and marine resources for sustainable development". It focuses on protecting marine and coastal ecosystems .

- Prevent and reduce marine pollution: This includes all kinds of pollution, with a specific focus on land-based sources, marine debris, and nutrient pollution.
- Protect and restore marine and coastal ecosystems: This means sustainably managing and protecting these areas to strengthen their resilience and ensure healthy, productive oceans.
- Regulate fisheries: Sustainable management is needed to combat overfishing, with a focus on implementing sound regulatory frameworks and strong enforcement.
- Address ocean acidification: This involves taking action to minimize the effects of ocean acidification, which is caused by the absorption of excess carbon dioxide from the atmosphere.
- Support sustainable use: This includes promoting the sustainable use of marine resources for livelihoods and economic benefits, such as through fisheries and tourism.

Plastic pollution

Plastic pollution is the accumulation of plastic waste in the environment that harms ecosystems, wildlife, and human health. This pollution comes from sources like single-use plastics, and once in the environment, plastic can take hundreds to thousands of years to decompose, often breaking down into harmful microplastics

Plastic pollution is an urgent global crisis.

- Over 460 million metric tons of plastic are produced every year for use in a wide variety of applications.
- An estimated 20 million metric tons of plastic litter end up in the environment every year. That amount is expected to increase significantly by 2040.
- Plastic pollution affects all land, freshwater, and marine ecosystems. It is a major driver of biodiversity loss and ecosystem degradation and contributes to climate change.
- Discarded improperly, plastic waste pollutes and harms the environment, becoming a widespread driver of biodiversity loss and ecosystem degradation. It threatens human health, affects food and water safety, burdens economic activities, and contributes to climate change

RIC-Resin Identification Code

DIRECTION

In 1988, the Society of the Plastics Industry introduced RIC system which divided plastic resins

1	2	3	4	5	6	7
PET	HDPE	PVC	LDPE	PP	PS	OTHER
POLYETHYLENE TEREPHTHALATE	HIGH-DENSITY POLYETHYLENE	POLYVINYL CHLORIDE	LOW-DENSITY POLYETHYLENE	POLYPROPYLENE	POLYSTYRENE	OTHER
WATER BOTTLES; JARS; CAPS	SHAMPOO BOTTLES; GROCEY BAGS	CLEANING PRODUCTS; SHEETINGS	BREAD BAGS; PLASTIC FILMS	YOGURT CUPS; STRAWS; HANGERS	TAKE-AWAY AND HARD PACKAGING; TOYS	BABY BOTTLES; NYLON; CDS

Polyethylene Terephthalate (PET)-also defined as PET or PETE is mainly used to manufacture the packaging material for food products such as fruit and drinks, and ravages due to their ability to keep the product from spoiling. It is lightweight, transparent, and also available in some colors. People commonly use PET in water bottles and packaging because of its strength and recyclability. One of the most commonly recycled plastic types. They are safer than the rest of the plastic. They are the most used plastic all around the world as have a high strength-to-weight ratio. Polyethylene terephthalate is easily recycled. Hence it is code as number 1.
Non-biodegradable, contributing to plastic waste. It can be recycled, but the process is challenging and costly, and some chemicals can remain in the environment during its lifecycle.

High-Density Polyethylene (HDPE)- stands for high-density polyethylene, which is a thermoplastic polymer. It is mostly used for Hygiene products like plastic bottles, milk jugs, juice containers, shampoo bottles, body wash products, bleach bottles, cutting boards, and piping and is also used in children's toys. HDPE is known for its high strength-to-density ratio. Used in everything from milk jugs to detergent bottles, it is also readily recyclable.
With its lightweight, durability, and malleability, HDPE is a perfect material for injection molding. It's easily recycled and is quite strong and thick when compared to PET. It is code as number 2.
Strong, durable, and more stable than PET. However, it is not biodegradable, and its degradation can release toxins into the soil and water over time. It is also widely recycled.

DIRECTION

Polyvinyl Chloride (PVC)-it is a “thermoplastic” material. PVC offers a wide variety of applications and advantages across multiple industries in both rigid and flexible forms. In particular, Rigid PVC possesses a high density for plastic, making it extremely hard and generally incredibly strong. PVC has an extremely durable nature and is lightweight, making it an attractive material for construction, plumbing, and other industrial applications.PVC is very dense compared to most plastics, readily available, and cheap. And has excellent tensile strength. Due to being easily recyclable, its code as number 3

Often described as the most toxic plastic, it contains toxic additives like phthalates and heavy metals, which can leach into the environment. PVC is also highly persistent and non-biodegradable.

Low-Density Polyethylene (LDPE)- It is resistant to impact (doesn’t break easily), moisture (waterproof), and chemical resistance (can stand up to many hazardous materials). It is mostly used as bags for groceries, newspaper delivery, dry-cleaning, bread, beverage cups, plastic wraps, and so on, plus product overwraps, bubble wrap, and cereal box liners. Plus there are many industrial and agricultural uses, particularly plastic film and packaging to protect all sorts of products, recycling it is more difficult than HDPE. They are recycled into film plastic, furniture, plastic lumber, rubbish, and compost bins. Due to its different properties, its code is 4.

While flexible and relatively safe to handle, it is not biodegradable and can contribute to pollution if not disposed of properly. It is often disposed of in landfills, where it can remain for hundreds of years, causing environmental damage.

Polypropylene- is a thermoplastic polymer used in a wide variety of applicants. In simple terms plastic is known for being a tough and rigid material. PP is used in automotive parts, containers, and packing material. It resists heat and acts as a barrier against moisture, making it a popular but challenging candidate for recycling.
Polypropylene is one of the foremost common sorts of plastic utilized in the manufacturing process. The code for this 5
Non-biodegradable, though more durable than PET. It can be recycled but is not as widely recycled as PET or HDPE. Its degradation can release harmful chemicals into the environment, and its impact can vary based on its formulation and use.

Polystyrene- may be a synthetic hydrocarbon polymer made up of the monomer referred to as styrene. It can either be solid or foamed form. You may be very familiar with the word Styrofoam (Thermocol). Commonly used polystyrene is transparent, hard, and brittle.
Often found in disposable cutlery and CD cases, PS is lightweight and easy to form. Its recycling is infrequent because of economic and environmental concerns associated with its breakdown. It is mostly used for Plastic forks, DVD cases, the housing of computers, model cars, toys, rulers, and hair combs, disposable cutlery and bowls, packing materials, and egg cartons. Due to various use its code as 6
Non-biodegradable and a major contributor to pollution. It can release styrene, a suspected carcinogen, and other harmful chemicals into the environment.

Other Plastics

Other Plastics are plastic which is different from all plastic. It`s polycarbonate, polylactide, acrylic, acrylonitrile butadiene, styrene, fiberglass, and nylon. plastic CDs and DVDs Baby Bottles Large water bottles with multiple-gall capacity Medical storage containers Eyeglasses Exterior lighting fixtures. It is not very easy to interrupt down these plastics once they're created unless they're exposed to high temperatures.

The effects can vary depending on the specific type. For instance, some polycarbonates can leach bisphenol A (BPA), a known endocrine disruptor, while others like polylactide (PLA) can be compostable under specific conditions.

DIRECTION

Micro and Nano Plastics

Micro(nano)plastics (MNPs) are tiny particles of plastics that are less than 5 millimeters in size. They can be classified into two main categories based on their source:

Primary MNPs are plastic particles that are intentionally manufactured to be small, such as microbeads used in personal care products like exfoliating scrubs and toothpaste. They are also used in industrial processes and products like abrasive blasting or as a raw material to produce other plastics.

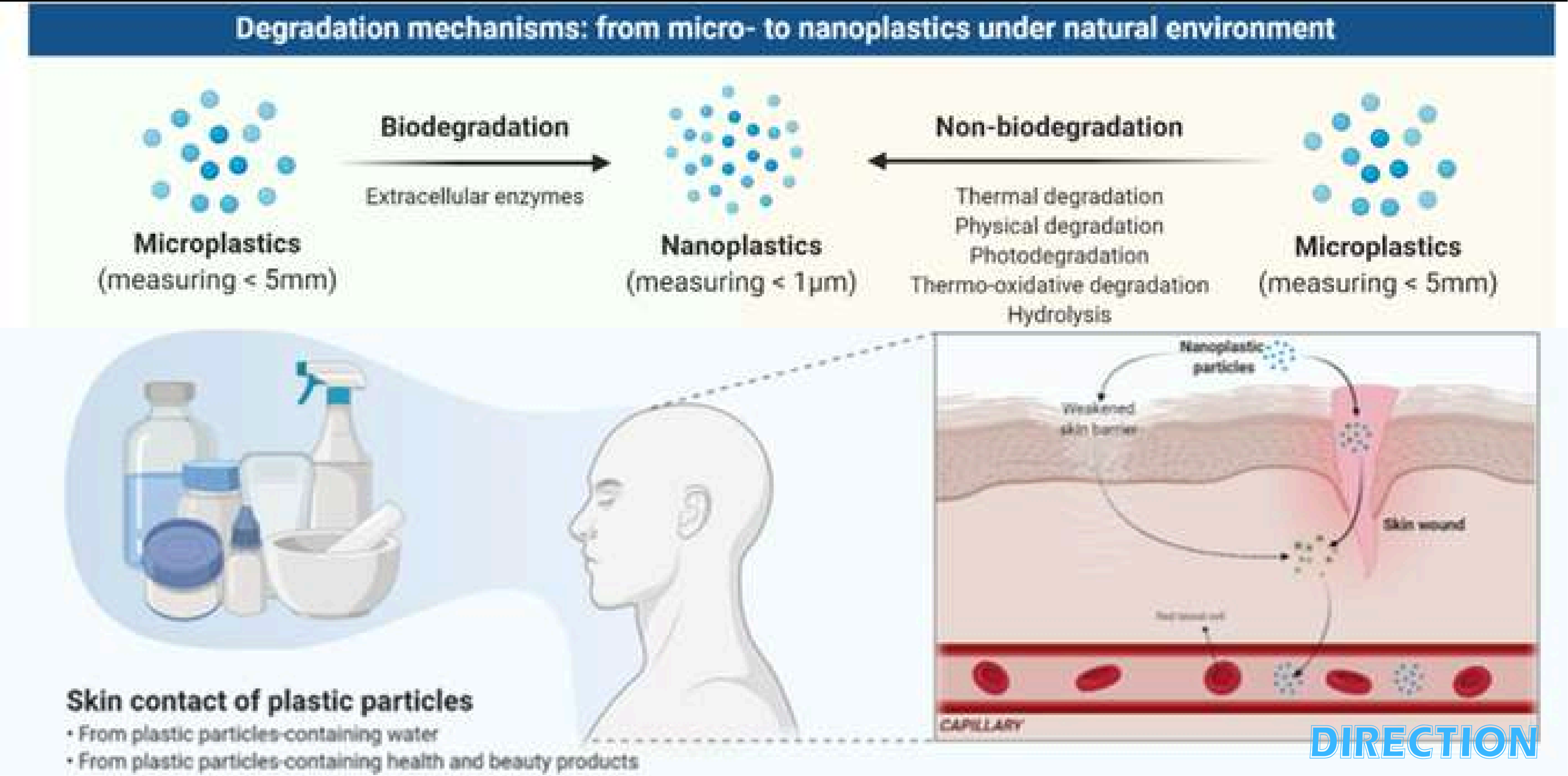
Secondary MNPs are a result of the degradation of larger plastic items such as plastic bags, bottles, and fishing nets, that end up in the environment. These larger plastic items can break down over time due to physical, chemical, or biological processes, such as exposure to sunlight or the mechanical force exerted by sea waves.

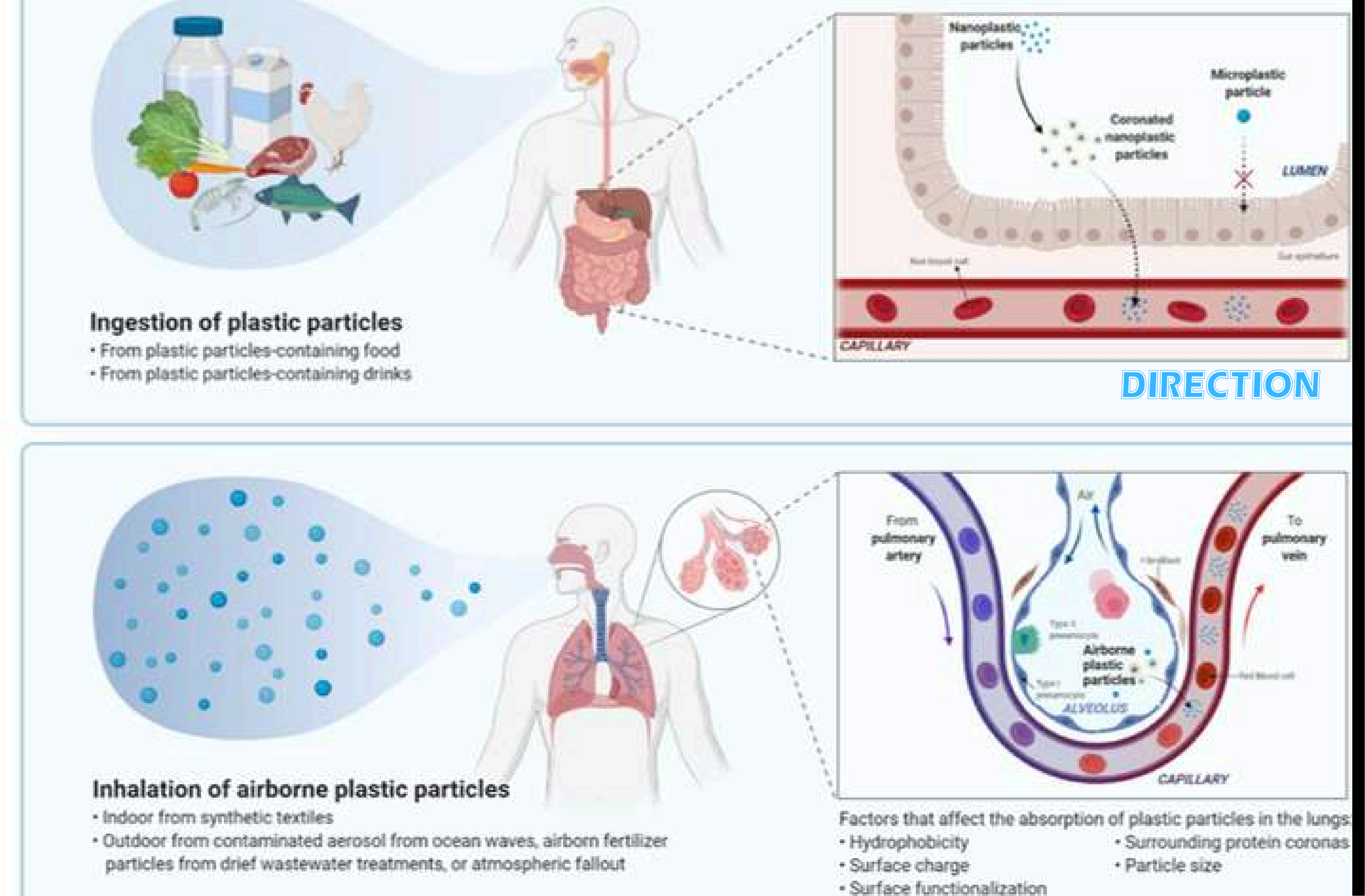
Microbeads Intentionally manufactured small plastic particles, often used as exfoliants in personal care products like cleansers and toothpastes.

How they are a problem: They pass through wastewater systems and into waterways, where they can be mistaken for food by aquatic life.

Progression: They are a type of primary microplastic, but can break down further into even smaller nanoplastics.

Nanoplastics - Extremely small plastic particles, defined as being less than \(1000\) nanometers or one micrometer in size, which are often invisible They are formed when larger plastics, including microbeads, break down into smaller pieces through weathering, sunlight, and wave action.How they are a problem: Because of their tiny size, they can penetrate cell membranes, potentially causing cell damage and inflammation. They can also cross the blood-brain barrier and other biological barriers.




Nanoplastic particles
Microplastic particle
Coronated nanoplastic particles
LUMEN
CAPILLARY
Ingestion of plastic particles
• From plastic particles-containing food
• From plastic particles-containing drinks
DIRECTION
Air
From pulmonary artery
To pulmonary vein
Airborne plastic particles
ALVEOLUS
CAPILLARY
Inhalation of airborne plastic particles
• Indoor from synthetic textiles
• Outdoor from contaminated aerosol from ocean waves, airborn fertilizer particles from drief wastewater treatments, or atmospheric fallout
Factors that affect the absorption of plastic particles in the lungs
• Hydrophobicity
• Surface charge
• Surface functionalization
• Surrounding protein coronas
• Particle size

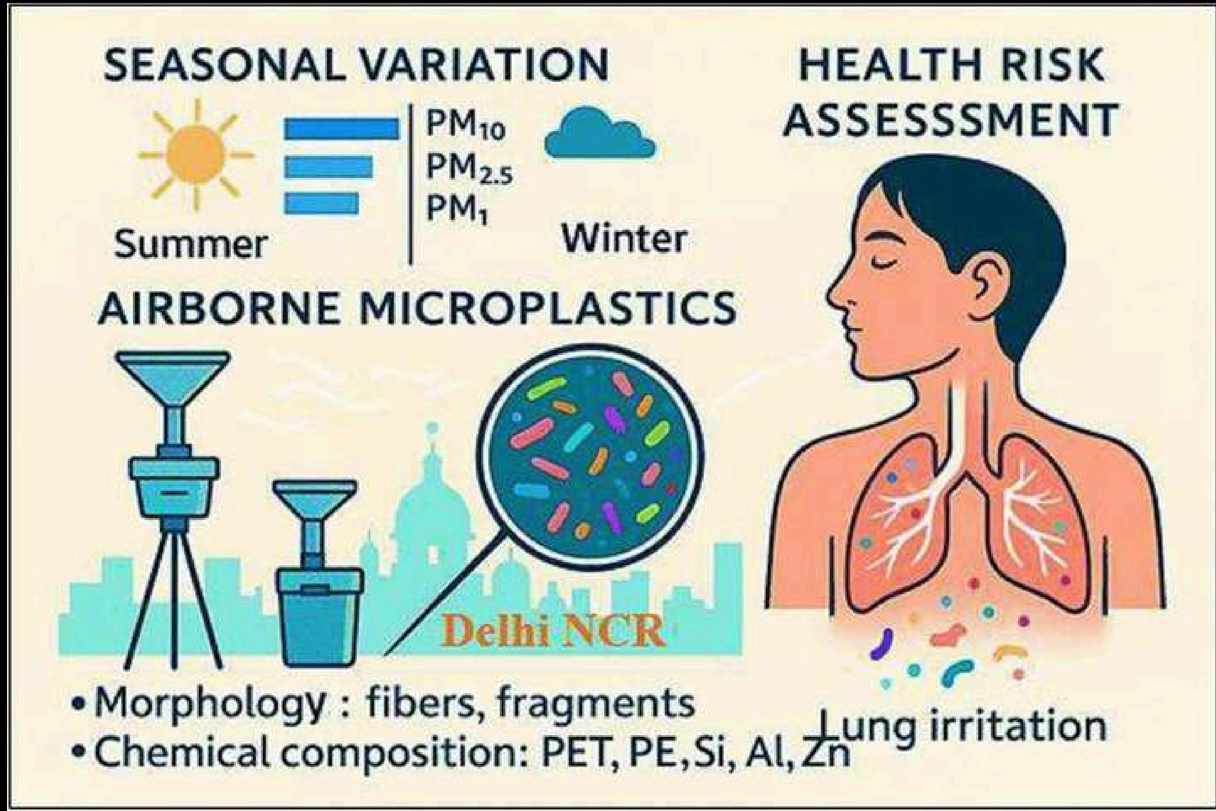
World Environment Day 2025, observed on June 5, 2025, focuses on “Beat Plastic Pollution,” hosted by the Republic of Korea, emphasizing global action against plastic waste.

India’s Plastic Pollution: 2025

- India produces about 9.3 million tonnes of plastic waste every year. This makes India the largest plastic polluter in the world, contributing to 20% of all global plastic pollution.
- When it comes to waste collection, only 81% of plastic waste gets collected. That means 19% is left uncollected, often dumped openly or burned, which harms the environment and human health.
- On average, each Indian uses about 11 kilograms of plastic per year. This amount is growing because of more people moving to cities and more resources, and shopping habits.

1. Delhi
Plastic Waste Generation: Delhi produces about 1,113 tonnes of plastic waste every day. But it can only process 871 tonnes, leaving 242 tonnes unprocessed.
Landfill Overflow: The main landfills at Ghazipur, Bhalswa, and Okhla get over 10,000 tonnes of waste daily. This creates huge “trash mountains” and releases large amounts of methane gas.
Health Impacts: The waste buildup causes serious health problems, like breathing issues and shorter life expectancy.
2. Mumbai
Waste Generation: Mumbai produces around 6,300 tonnes of waste every day, with a big share being plastic.
Recycling Efforts: The city uses the hub-and-spoke model for managing waste. But the huge amount of waste and dependence on informal workers make it hard to manage well.
3. Bengaluru
Daily Waste Production: Bengaluru generates about 6,000 tonnes of waste each day, but only 60% of the plastic waste gets recycled.
Recycling Infrastructure: Karnataka has 143 recycling units that can recycle about 210,000 tonnes of plastic per year — roughly 57% of the total plastic waste generated.
4. Pune
Waste Generation: Pune creates around 2,000 tonnes of solid waste daily, with plastic making up about 30-32% of it.
Infrastructure Challenges: The closure of the Kothrud garbage dump has caused major problems for waste collection nearby, leading to delays and health risks.

Exposure to polymer dust in India poses significant health risks, primarily through the inhalation of airborne microplastics (MPs) and occupational exposure in manufacturing units. These risks include respiratory diseases, cancer, endocrine disruption, and nervous system damage, with studies finding toxic chemicals like lead and diethyl phthalate (DEP) associated with the dust.



General Health Risks from Airborne Polymer Dust

Recent studies in major Indian cities (Kolkata, Delhi, Mumbai, Chennai) reveal high levels of inhalable microplastics in the air and street dust, which can penetrate deep into the lungs and enter the bloodstream.

Inhalation: This is a primary exposure pathway, with one study estimating that an average Kolkata resident inhales about 2.9 grams of microplastics over their lifetime. Inhaled particles can cause mechanical damage, inflammation, and can serve as vectors for other pollutants and pathogens

India’s Fight Against Plastic Pollution:

India has started many programs to control plastic pollution. But progress is still uneven.

- **The Plastic Waste Management Rules were first introduced in 2016. They were updated in 2022 and 2024. These rules say companies must collect, sort, and recycle the plastic they produce. This includes big brands and manufacturers.**
- **In 2021, India banned single-use plastics like plastic bags, straws, and cutlery. But many reports say the ban is poorly enforced in many areas.**
- **Under the Extended Producer Responsibility (EPR) program, companies like Coca-Cola and Mondelez have promised to use 100% recyclable packaging by 2025. These promises follow rules from the Central Pollution Control Board (CPCB).**
- **There are also awareness campaigns, like the Swachh Bharat Mission and a mascot called ‘Prakriti’ introduced in 2022. Schools, NGOs, and communities organize clean-up drives and promote alternatives like paper and cloth bags.**
- **The government set up a National Dashboard to track plastic waste data and progress on reducing single-use plastics.**

Key Government Initiatives and Challenges

Initiative Description Challenges

- Plastic Waste Management Rules Mandates collection, segregation, recycling Inconsistent enforcement, infrastructure
- Ban on Single-Use Plastics (2021) Bans bags, straws, cutlery Varying compliance, public awareness
- Extended Producer Responsibility Producers manage packaging lifecycle Corporate compliance, monitoring
- Swachh Bharat Mission Promotes clean India, reduces plastic use Limited reach, funding constraints
- National Dashboard on Single Use Plastic Tracks progress in waste reduction Data accuracy, local reporting

However, these regulations have faced implementation challenges. The Plastic Waste Management Rules, 2016, aimed to phase out multi-layered plastic (MLP) and promote recycling. But enforcement has been inconsistent across states, and there is limited infrastructure to support the necessary changes. Additionally, while the EPR policy mandates that producers be responsible for plastic collection and recycling, compliance remains low, especially among smaller businesses.

The Global Divide in Plastic Waste Management

The divide between the Global North and Global South also plays a role in India's plastic crisis. High-income countries generate more waste per capita but have efficient waste management systems in place. In contrast, countries in the Global South, like India, struggle with limited infrastructure and rely on open dumping or burning of waste. Despite producing 0.12 kg of plastic waste per person per day (lower than many Western countries), India's lack of proper disposal systems results in higher levels of mismanaged plastic entering the environment.

Persistent Organic Pollutants (POPs)

Persistent Organic Pollutants (POPs) are a group of compounds that possess toxic properties, resist degradation, bioaccumulate and are transported through air, water and migratory species, across international boundaries and deposited far from their place of release, where they accumulate in terrestrial and aquatic ecosystems (UNEP, 2009)

The "dirty dozen" refers to the initial 12 Persistent Organic Pollutants (POPs) identified by the Stockholm Convention. These are a group of chemicals that are toxic, persistent, and can travel long distances, leading to widespread environmental and health concerns. The list includes a combination of pesticides (like DDT, aldrin, dieldrin), industrial chemicals (like PCBs), and unintentional by-products (like dioxins and furans).

The "dirty dozen" chemicals

- Pesticides: Aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, hexachlorobenzene, mirex, and toxaphene.
- Industrial chemicals: Polychlorinated biphenyls (PCBs).
- By-products: Polychlorinated dibenzo-p-dioxins (dioxins) and polychlorinated dibenzofurans (furans).

Nine new POPs At its fourth meeting held from 4 to 8 May 2009, the Conference of the Parties (COP), adopted amendments to Annexes A (elimination), B (restriction) and C (unintentional production) of the Stockholm Convention to list nine additional chemicals as persistent organic pollutants .

The entry into Force of the Amendments adding Nine Chemicals to the Stockholm Convention on Persistent Organic Pollutants took place on 26 August 2010 for 151 of the 152 Parties to the Stockholm Convention.

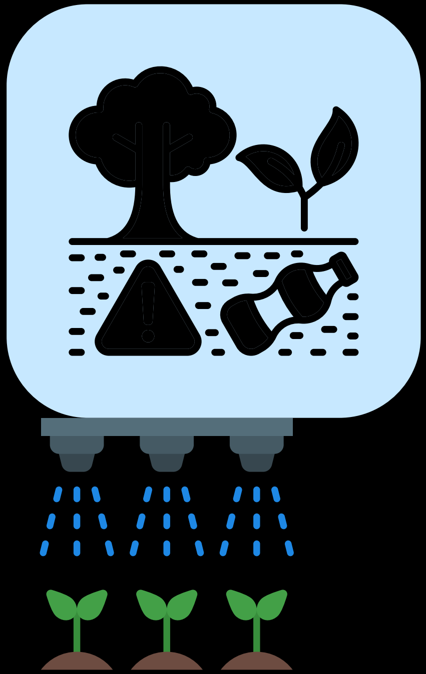
- Pesticides: chlordecone, alpha hexachlorocyclohexane, beta hexachlorocyclohexane, lindane, pentachlorobenzene;
- Industrial chemicals: hexabromobiphenyl, hexabromodiphenyl ether and heptabromodiphenyl ether, pentachlorobenzene, perfluorooctane sulfonic acid, its salts and perfluorooctane sulfonyl fluoride, tetrabromodiphenyl ether and pentabromodiphenyl ether; and
- By-products: alpha hexachlorocyclohexane, beta hexachlorocyclohexane and pentachlorobenzene.

These Nine new POPs are popularly termed as Nasty Nine

22nd Candidate conference of Parties of the Stockholm Convention on POPs held in Geneva 2011 has decided to add 22nd Candidate "Endosulfan" under POPs list . Convention has categorized the chemicals into three Annexes based on the action to be taken in order to reduce and ultimately eliminate these chemicals and its sources from the mother earth.

Specific effects of POPs can include cancer, allergies and hypersensitivity, damage to the central and peripheral nervous systems, reproductive disorders, and disruption of the immune system.

- **Annex A (Elimination):** Parties must take measures to eliminate the production and use of the chemicals listed under Annex A. Specific exemptions for use or production are listed in the Annex and apply only to Parties that register for them.
- **Annex B (Restriction):** Parties must take measures to restrict the production and use of the chemicals listed under Annex B in light of any applicable acceptable purposes and/or specific exemptions listed in the Annex.
- **Annex C (Unintentional production):** Parties must take measures to reduce the unintentional releases of chemicals listed under Annex C with the goal of continuing minimization and, where feasible, ultimate elimination.



Perfluoroalkyl acids (PFAAs) are a class of synthetic chemicals used in various industrial and consumer products, like nonstick coatings and firefighting foams, for their water and oil-repellent properties. They are known as "forever chemicals" because the strong carbon-fluorine bonds make them extremely resistant to degradation in the environment. PFAAs can bioaccumulate in humans and wildlife, leading to concerns about potential health effects, such as links to certain cancers, altered metabolism, and weakened immune responses

Chlorinated hydrocarbons are synthetic organic compounds composed of carbon, hydrogen, and chlorine, with common examples including pesticides like DDT, industrial chemicals like PCBs, and solvents like trichloroethylene. They are known for being persistent in the environment, bioaccumulating in the food chain, and posing health risks such as liver/kidney damage, central nervous system effects, and cancer. Many are well-absorbed through the skin, lungs, and digestive tract, and their high lipid solubility causes them to accumulate in the body over time.

Dichloro Diphenyl Trichloroethane (DDT), a first-generation synthetic pesticide, has long carried a dual identity as once celebrated for its role in controlling malaria vectors and agricultural pests, yet increasingly criticised for its environmental persistence and health hazards. Widely used during and after World War II to combat mosquito-borne diseases, DDT became integral to agricultural and public health programs globally.

India, a signatory to the Convention, remains committed to gradually eliminating DDT while exploring safer alternatives for vector control.

In India, DDT agricultural use was banned in 1972, but it continues to be manufactured for disease vector control, especially for export to malaria-prone African regions. In 2006, the World Health Organisation (WHO) permitted indoor residual spraying of DDT as a temporary measure until safer alternatives become accessible.

Although India initially set 2024 as its phase-out deadline, this has now been extended to fulfil export obligations. India roadmap for phasing out DDT remains a work in progress, especially given the limited availability of fully proven alternatives.

The project includes several components aimed at strengthening the country capacity to replace DDT with sustainable alternatives. These include the development of Integrated Vector Pest Management (IVPM) training modules to enhance technical knowledge; standardisation and scale-up of neem-based pesticide formulations as biodegradable alternatives; development and large-scale production of Bt-based biopesticides for mosquito control; propagation of high-yielding neem cultivars through tissue culture techniques; and the manufacturing of Long-Lasting Insecticidal Nets (LLINs), which are treated with pyrethroid chemicals that kill mosquitoes upon contact.

The use of endosulfan in India is completely banned by the Supreme Court since 2011 due to its severe health and environmental hazards. The pesticide caused a major public health tragedy, particularly in the Kasaragod district of Kerala, which led to widespread activism and legal action.

Background and Tragedy

- Extensive Use: Endosulfan, an organochlorine insecticide, was widely used in Indian agriculture from the 1980s and 1990s on various crops like cashew, cotton, tea, and paddy.
- Kasaragod Incident: In the Kasaragod district of Kerala, the pesticide was aerially sprayed over state-owned cashew plantations for over 20 years (starting in the late 1970s). This led to a high incidence of severe health issues, including congenital deformities, cerebral palsy, mental retardation, and hundreds of deaths, among residents and livestock in the surrounding villages.
- Health and Environmental Impact: Studies linked endosulfan to neurotoxicity, reproductive and developmental damage, and its classification as a persistent organic pollutant means it remains in the environment for extended periods and can travel long distances.

Basel Convention

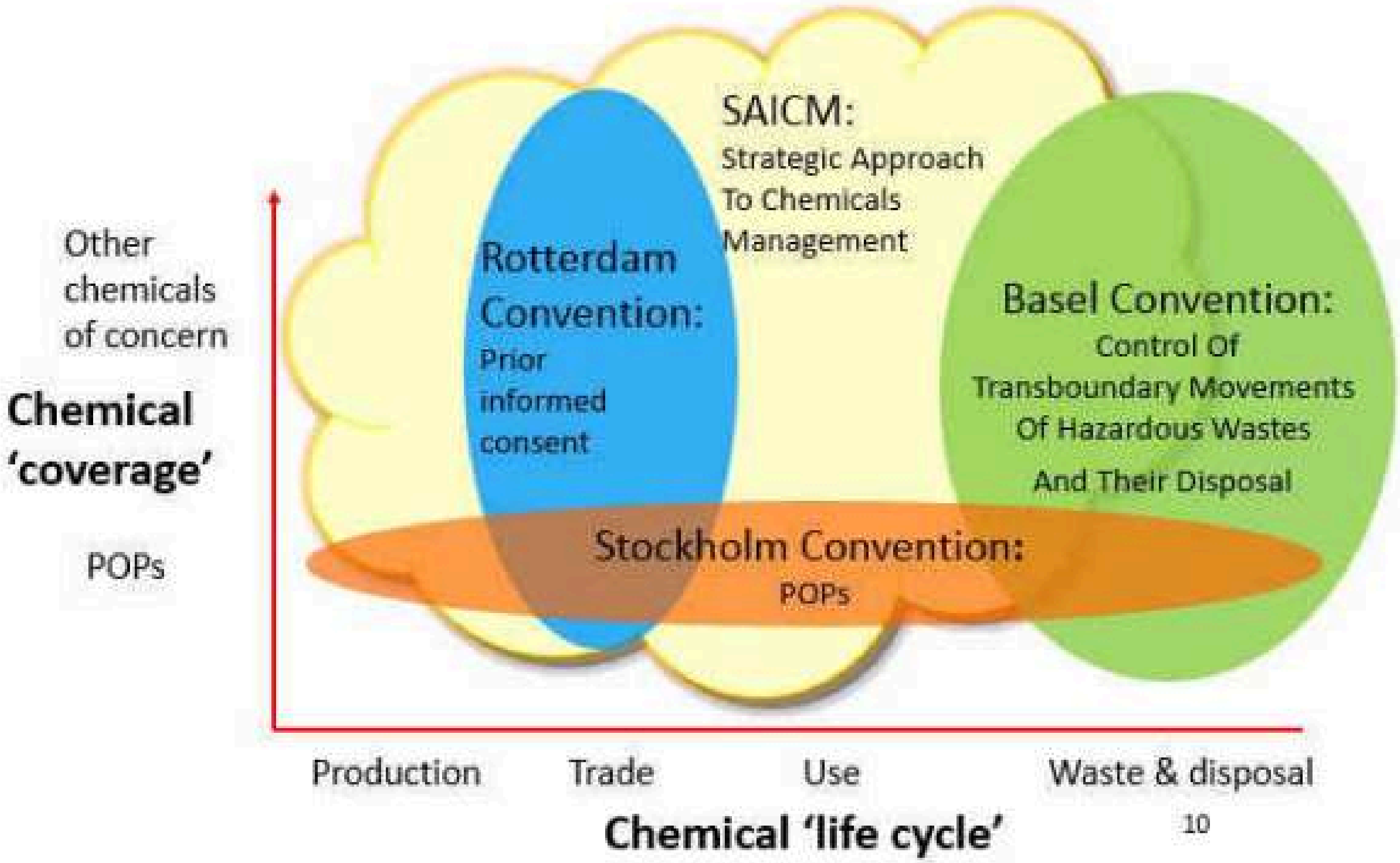
- Adopted **1989**
- Entry into force 5 May 1992
- 188 Parties

Rotterdam Convention

- Adopted **1998**
- Entry into force 24 Feb. 2004
- 160 Parties

Stockholm Convention

- Adopted **2001**
- Entry into force 17 May 2004
- 182 Parties




•Scope: Hazardous wastes and other wastes
•Key provisions:
•Minimization of generation
•Promotion of environmentally sound management
•Conditions and procedure for controlling transboundary movements
BASEL Convention


•Scope: banned or severely restricted chemicals and SHPFs (annex III)
•Key provisions:
•Prior Informed Consent procedure for export/import (annex III)
•Exchange of information on a broad range of potentially hazardous chemicals
Rotterdam Convention


• Scope: POPs
• Key provisions:
• Elimination (POPs in annex A)
• Restriction (POPs in annex B)
• Reduction or elimination (unintentionally produced POPs in annex C)
Stockholm Convention


SUSTAINABLE DEVELOPMENT GOALS
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
10 REDUCED INEQUALITIES
4 QUALITY EDUCATION
7 AFFORDABLE AND CLEAN ENERGY
17 PARTNERSHIPS FOR THE GOALS
8 DECENT WORK AND ECONOMIC GROWTH
15 LIFE ON LAND
3 GOOD HEALTH AND WELL-BEING
1 NO POVERTY
GENDER EQUALITY
11
14 LIFE BELOW WATER
16 PEACE, JUSTICE AND STRONG INSTITUTIONS
2 ZERO HUNGER
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
6 CLEAN WATER AND SANITATION
13 CLIMATE ACTION
Chemicals and wastes are essential for the implementation of goals on **poverty reduction**, **health**, **gender**, **water**, **cities**, **oceans**, **food** and **sustainable consumption and production**

United Nations Office for Disaster Risk Reduction

The International Strategy for Disaster Reduction (ISDR) of the United Nations (U.N.) defines a hazard as "a potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation."

Disaster, whether natural or anthropogenic, are sudden adverse unfortunate extreme events or hazards which cause great damage to human beings as well as plants and animals.

"All the extreme events are hazards but not all the hazards are disasters". "A hazard may become disaster only when it strikes the inhabited area causing damages to human life and property. "

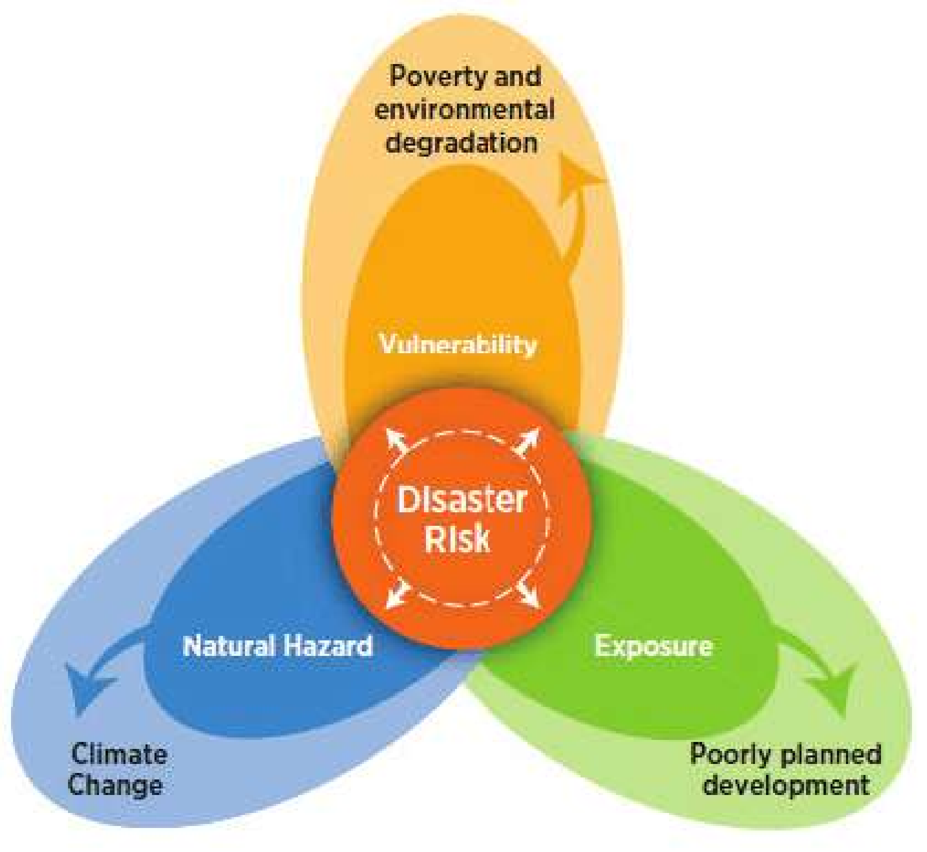
A hazard is a potential source of harm or danger, while a disaster is the actual event where that harm occurs, causing widespread damage, disruption, or loss of life. Think of a hazard as the threat and a disaster as the realization of that threat causing significant negative impacts. A hazard can exist without becoming a disaster, but a disaster is always caused by an underlying hazard.

Hazard	Disaster
A potential threat or a dangerous situation that poses a risk to people, property, or the environment.	An event that causes significant damage, disrupts normal functioning, and results in widespread loss of life, property, or environmental damage.
Potential, not actual, harm.	Actual, catastrophic event.
The "cause" or precursor to a disaster.	The "effect" or consequence of a hazard.
An earthquake is a hazard. A strong storm system is a hazard. A chemical spill is a hazard.	An earthquake that causes buildings to collapse is a disaster. A hurricane that leads to widespread flooding and destruction is a disaster. A chemical spill that causes an evacuation and long-term health effects is a disaster.
Can range from minor to severe, but does not necessarily cause widespread harm.	Is a catastrophic event that exceeds a community's capacity to cope.

Disaster risk

The definition of disaster risk reflects the concept of hazardous events and disasters as the outcome of continuously present conditions of risk. Disaster risk comprises different types of potential losses which are often difficult to quantify.
It is important to consider the social and economic contexts in which disaster risks occur and that people do not necessarily share the same perceptions of risk and their underlying risk factors.

- Acceptable risk, or tolerable risk, is therefore an important subterm; the extent to which a disaster risk is deemed acceptable or tolerable depends on existing social, economic, political, cultural, technical and environmental conditions. In engineering terms, acceptable risk is also used to assess and define the structural and non-structural measures that are needed in order to reduce possible harm to people, property, services and systems to a chosen tolerated level, according to codes or "accepted practice" which are based on known probabilities of hazards and other factors.
- Residual risk is the disaster risk that remains even when effective disaster risk reduction measures are in place, and for which emergency response and recovery capacities must be maintained. The presence of residual risk implies a continuing need to develop and support effective capacities for emergency services, preparedness, response and recovery, together with socioeconomic policies such as safety nets and risk transfer mechanisms, as part of a holistic approach.



The potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability and capacity.

Sendai Framework

The Sendai Framework is the successor instrument to the Hyogo Framework for Action (HFA) 2005-2015: Building the Resilience of Nations and Communities to Disasters.

Priorities for action

Taking into account the experience gained through the implementation of the Hyogo Framework for Action, and in pursuance of the expected outcome and goal, there is a need for focused action within and across sectors by States at local, national, regional and global levels in the following four priority areas:

- **Priority 1 Understanding disaster risk**

Disaster risk management should be based on an understanding of disaster risk in all its dimensions of vulnerability, capacity, exposure of persons and assets, hazard characteristics and the environment. Such knowledge can be used for risk assessment, prevention, mitigation, preparedness and response

- **Priority 2 Strengthening disaster risk governance to manage disaster risk**

Disaster risk governance at the national, regional and global levels is very important for prevention, mitigation, preparedness, response, recovery, and rehabilitation. It fosters collaboration and partnership.

- **Priority 3 Investing in disaster risk reduction for resilience**

Public and private investment in disaster risk prevention and reduction through structural and non-structural measures are essential to enhance the economic, social, health and cultural resilience of persons, communities, countries and their assets, as well as the environment.

- **Priority 4 Enhancing disaster preparedness for effective response and to “Build Back Better” in recovery, rehabilitation and reconstruction**

The growth of disaster risk means there is a need to strengthen disaster preparedness for response, take action in anticipation of events, and ensure capacities are in place for effective response and recovery at all levels. The recovery, rehabilitation and reconstruction phase is a critical opportunity to build back better, including through integrating disaster risk reduction into development measures.

The Sendai Framework focuses on the adoption of measures which address the three dimensions of disaster risk (exposure to hazards, vulnerability and capacity, and hazard's characteristics) in order to prevent the creation of new risk, reduce existing risk and increase resilience. The Sendai Framework outlines seven global targets to guide and against which to assess progress.

SDGs with Targets related to Disaster Risk

Disaster risk reduction cuts across different aspects and sectors of development.

There are 25 targets related to disaster risk reduction in 10 of the 17 sustainable development goals, firmly establishing the role of disaster risk reduction as a core development strategy.

Goal 1. End poverty in all its forms everywhere

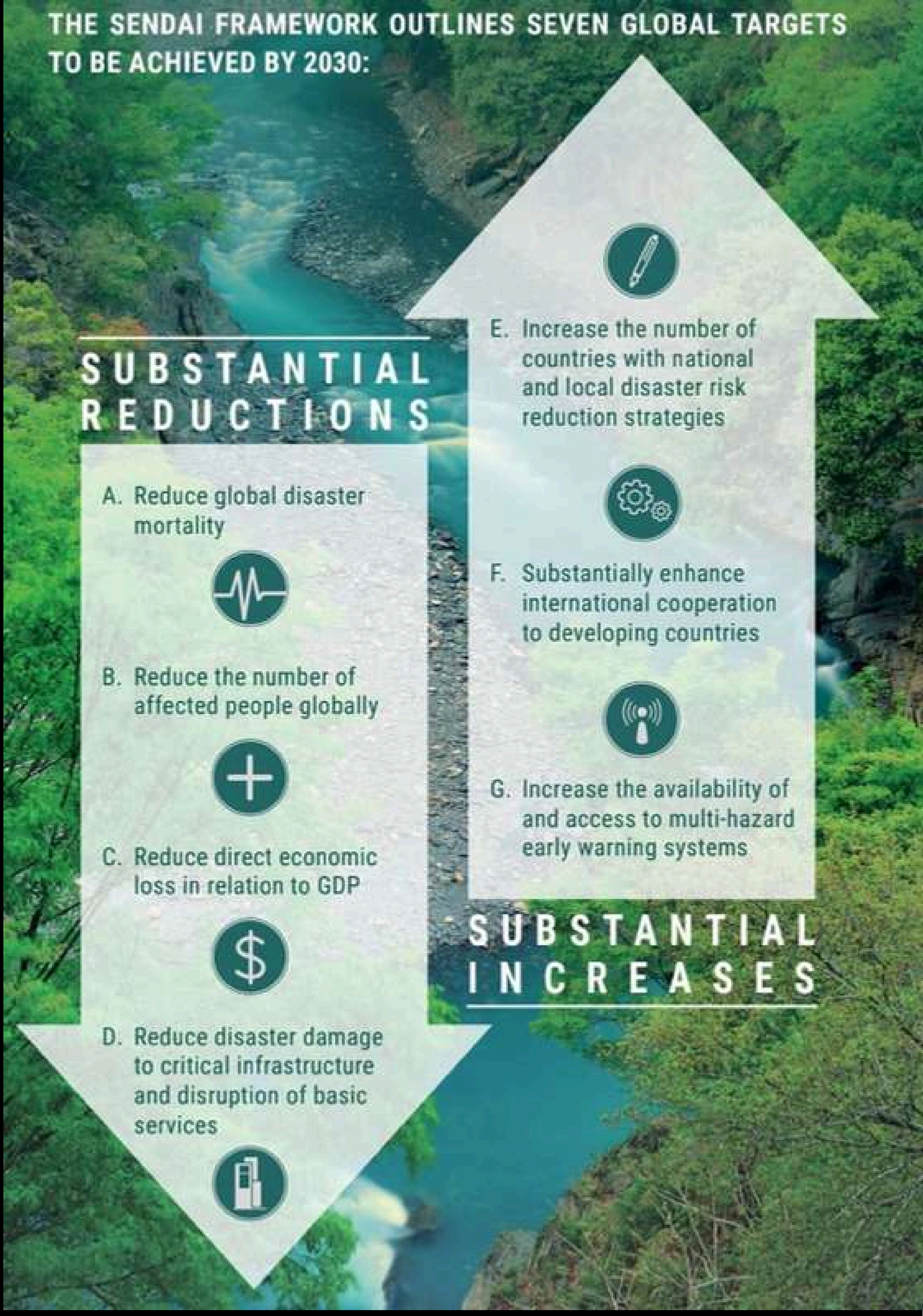
- 1.5 By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters

Goal 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture

- 2.4 By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality

Goal 3. Ensure healthy lives and promote well-being for all at all ages

- 3.d Strengthen the capacity of all countries, in particular developing countries, for early warning, risk reduction and management of national and global health risks



Goal 4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all

- 4.7: By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and nonviolence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development
- 4.a Build and upgrade education facilities that are child, disability and gender sensitive and provide safe, non-violent, inclusive and effective learning environments for all

Goal 6. Ensure availability and sustainable management of water and sanitation for all

- 6.6: By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes.

Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation

- 9.1 Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all.
- Target 9.a: Facilitate sustainable and resilient infrastructure development in developing countries through enhanced financial, technological and technical support to African countries, least developed countries, landlocked developing countries and small island development states.

Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable

- 11.1: By 2030, ensure access for all to adequate, safe and affordable and basic services and upgrade slums.
- 11.3: By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries.
- 11.4: Strengthen efforts to protect and safeguard the world's cultural and natural heritage
- 11.5 By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations
- 11.b By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels
- 11.c: Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials

Goal 13. Take urgent action to combat climate change and its impacts

- 13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries
- 13.2 Integrate climate change measures into national policies, strategies and planning.
- 13.3 Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning
- 13.a Implement the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goal of mobilizing jointly $100 billion annually by 2020 from all sources to address the needs of developing countries in the context of meaningful mitigation actions and transparency on implementation and fully operationalize the Green Climate Fund through its capitalization as soon as possible.
- 13.b Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries, including focusing on women, youth and local and marginalized communities

Goal 14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development

- 14.2 By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans

Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

- 15.1 By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements.
- 15.2 By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally
- 15.3 By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world
- 15.4 By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for 19 sustainable development.
- 15.9 By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts.

Natural Processes or Natural Hazards

The natural processes (or hazards) that are the triggers for natural disasters are broadly classified into six categories . The definitions and descriptions of each hazard are as follows:

Geophysical: This is also termed as geological hazard and originates from the solid crust of the Earth. The events associated with this hazard include earthquakes, volcanic activity, and dry mass movement.

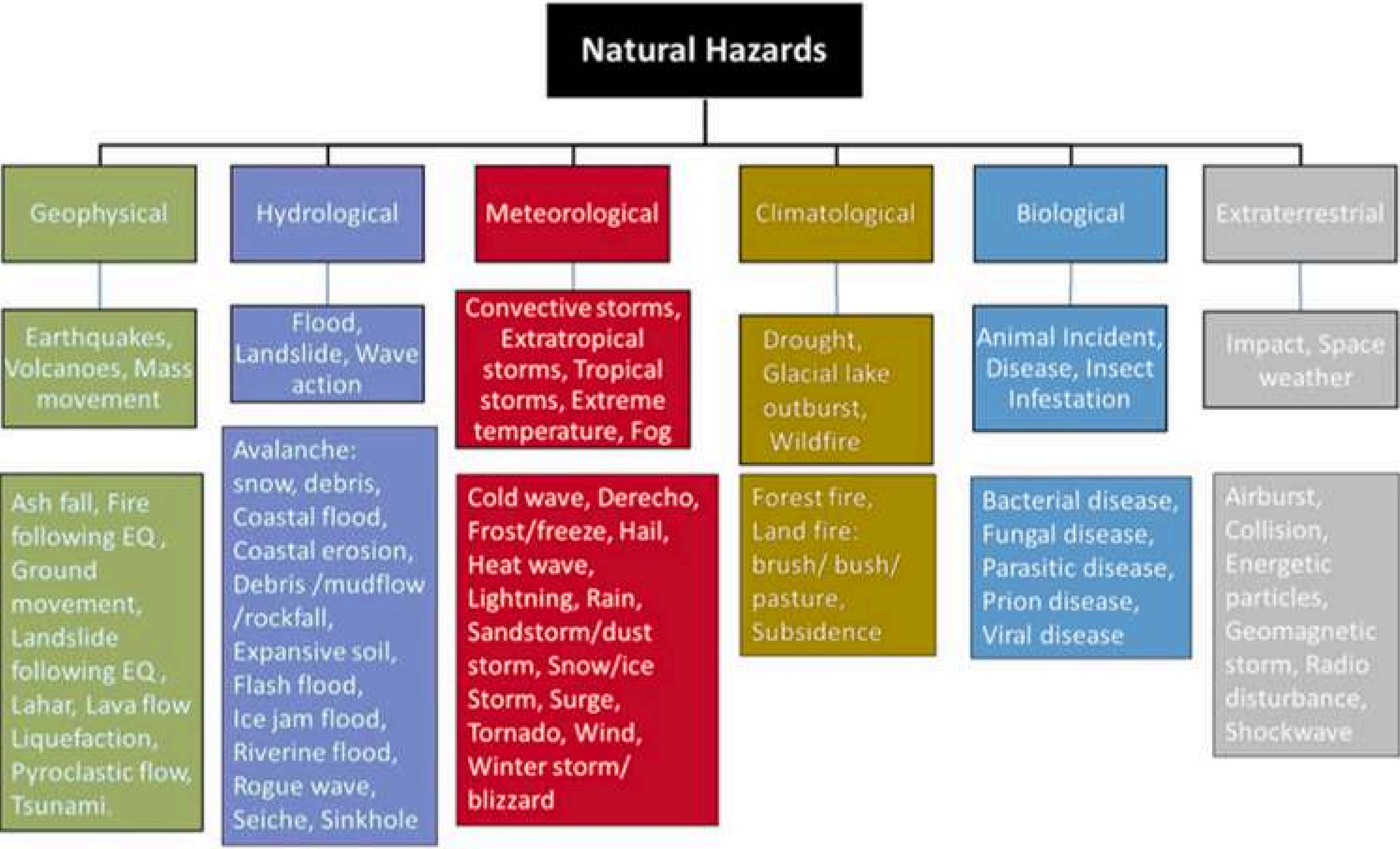
Hydrological: This hazard is associated with the occurrence, movement, and distribution of fresh and saltwater over or beneath the Earth's surface. The events created by this hazard include floods, landslides, and scour and wave action.

Meteorological: This hazard constitutes short-lived events having a time-span of minutes to a few days and are caused by micro- (<1 km) to meso-scale (2~2000 km) atmospheric conditions that can be exacerbated by global climate change. Convective storms (or tornadoes), extra-tropical storms (occurring in the middle, i.e., 30° to 60° latitude), tropical storms (occurring up to 30° latitude), fog, and sudden extreme temperature variation are included in this category of hazard.

Climatological: A hazard linked with variability in climate over a broad time-span ranging from intra-season to multi-decade at a meso- to macro- (>2000 km) scale. Droughts, wildfires, glacial movement, and glacial lake outburst are some of the events associated with this hazard.

Biological: A hazard originating from a biological substance, e.g., venom, mold, or a vector carrying disease-causing organisms, exposure to which poses a threat to other living beings or humans. Locust swarms, algal blooms, venomous wildlife infestation, and vector-borne diseases such as plague, malaria, dengue, and COVID-19 are some examples of this hazard.

Extraterrestrial: A hazard originating outside the Earth's atmosphere that may be caused by residues of asteroids, meteorites, comets, or human space debris, when these enter Earth's atmosphere, or the impact caused by these objects on Earth's surface. This hazard may also be caused by interplanetary conditions such as solar flares that can cause disruption in the Earth's magnetosphere, thermosphere, or ionosphere.

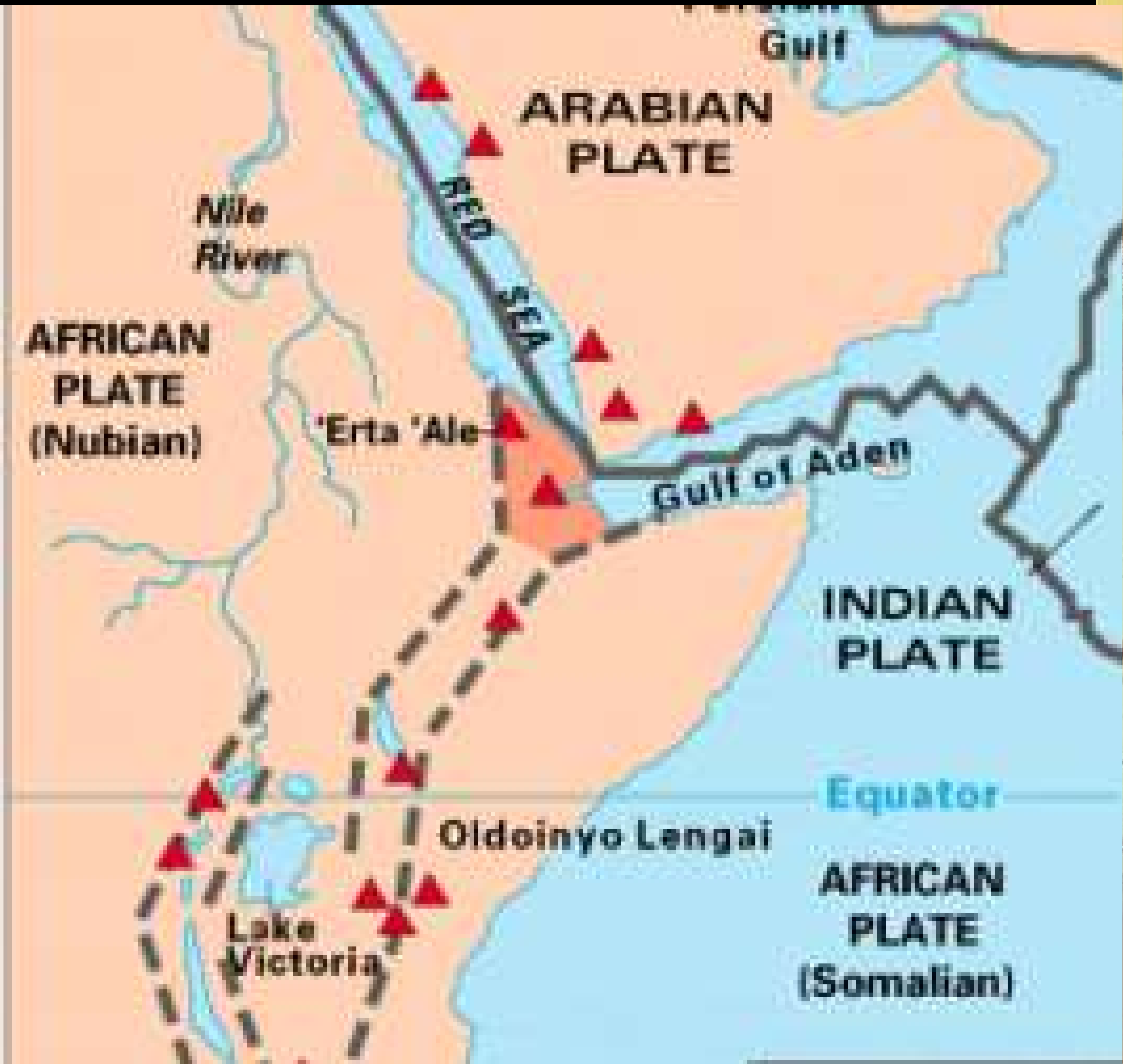

Natural Hazards
Geophysical
Hydrological
Meteorological
Climatological
Biological
Extraterrestrial
Earthquakes, Volcanoes, Mass movement
Flood, Landslide, Wave action
Convective storms, Extratropical storms, Tropical storms, Extreme temperature, Fog
Drought, Glacial lake outburst, Wildfire
Animal Incident, Disease, Insect Infestation
Impact, Space weather
Ash fall, Fire following EQ, Ground movement, Landslide following EQ, Lahar, Lava flow Liquefaction, Pyroclastic flow, Tsunami.
Avalanche: snow, debris, Coastal flood, Coastal erosion, Debris /mudflow /rockfall, Expansive soil, Flash flood, Ice jam flood, Riverine flood, Rogue wave, Seiche, Sinkhole
Cold wave, Derecho, Frost/freeze, Hail, Heat wave, Lightning, Rain, Sandstorm/dust storm, Snow/ice Storm, Surge, Tornado, Wind, Winter storm/ blizzard
Forest fire, Land fire: brush/ bush/ pasture, Subsidence
Bacterial disease, Fungal disease, Parasitic disease, Prion disease, Viral disease
Airburst, Collision, Energetic particles, Geomagnetic storm, Radio disturbance, Shockwave

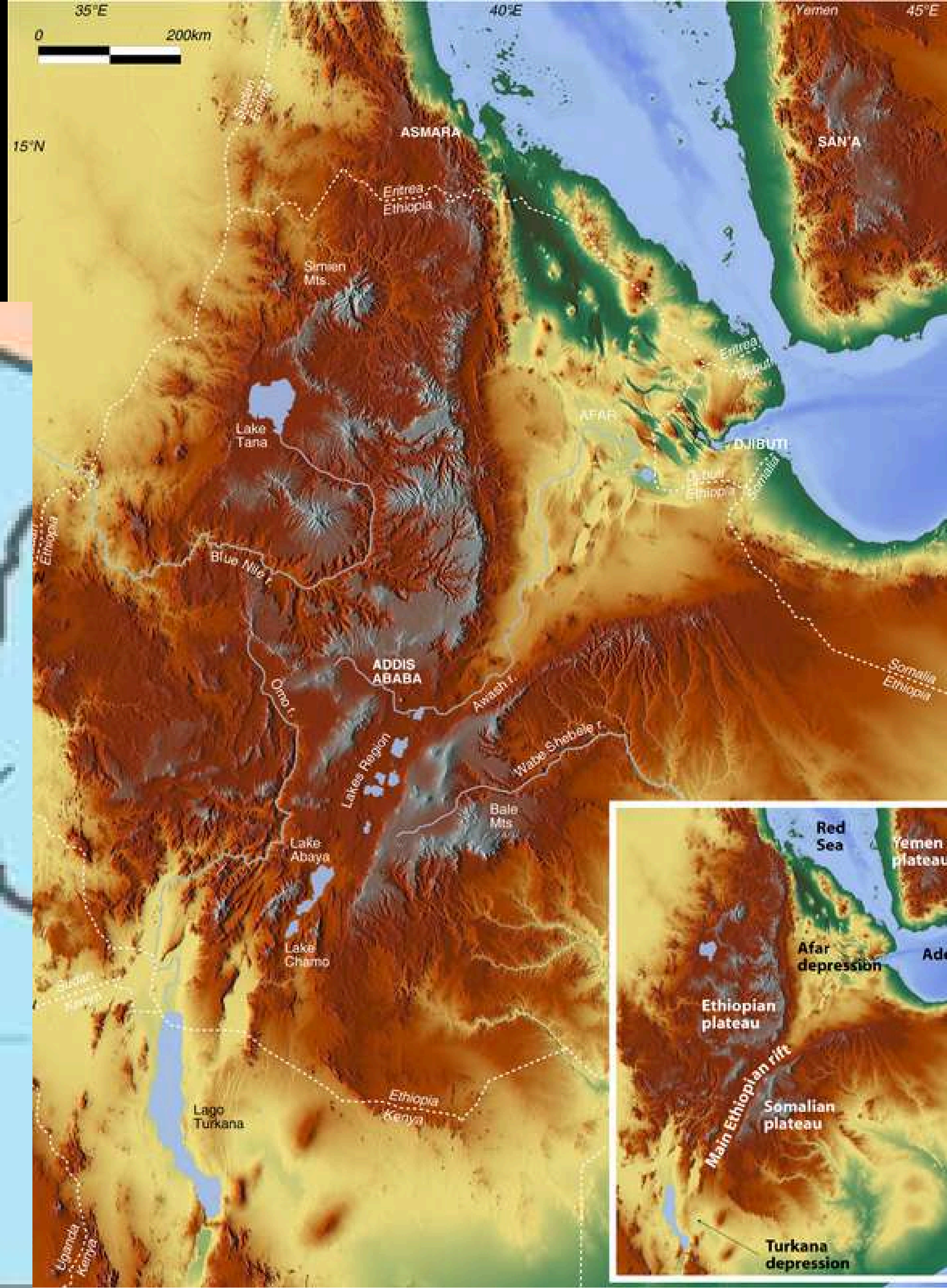
Earthquake and related hazards

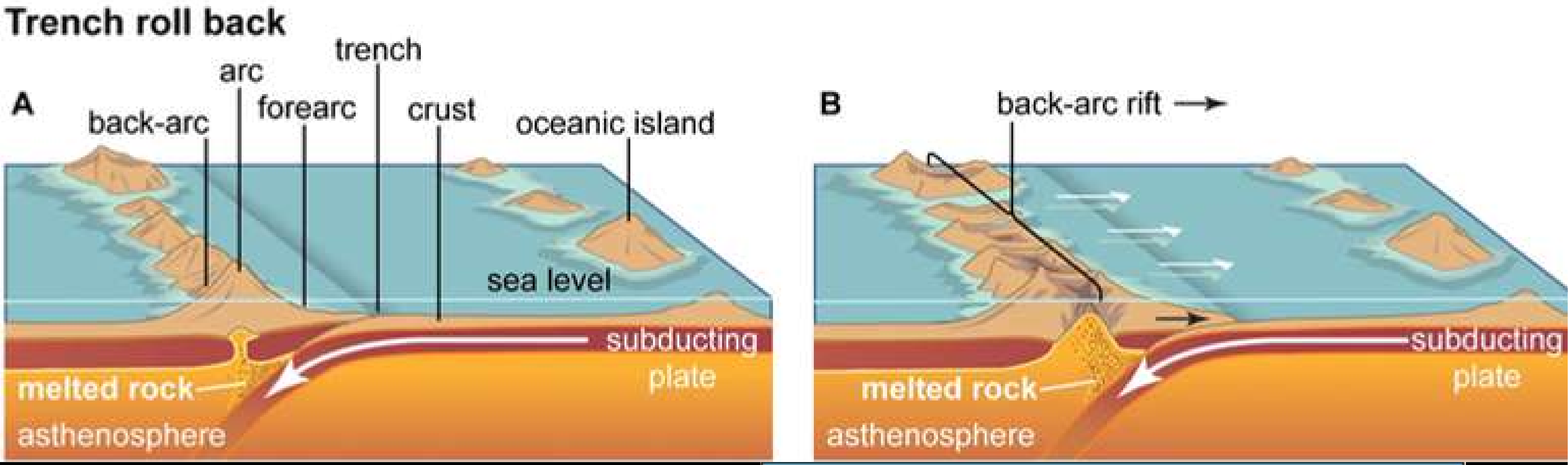
An earthquake is a phenomenon that occurs without warning and involves violent shaking of the ground and everything over it. It results from the release of accumulated stress of the moving lithospheric or crustal plates. The earth's crust is divided into seven major plates, that are about 50 miles thick, which move slowly and continuously over the earth's interior and several minor plates. Earthquakes are tectonic in origin; that is the moving plates are responsible for the occurrence of violent shakes.

- **GROUND RUPTURE** Deformation on the ground that marks, the intersection of the fault with the earth’s surface. Effects of ground rupture are fissuring, displacement of the ground due to movement of the fault.
- **GROUND SHAKING** Disruptive up, down and sideways vibration of the ground during an earthquake. Effects of ground shaking are damage or collapse of structure; may consequently cause hazards such as liquefaction and landslide.
- **LIQUEFACTION** Phenomenon wherein sediments, especially near bodies of water, behave like liquid similar to a quicksand. Effects of liquefaction are sinking and/ or tilting of structure above it; sandboil; fissuring.
- **EARTHQUAKE-INDUCED LANDSLIDE** Down slope movement of rocks, solid and other debris commonly triggered by strong shaking. Effects of earthquake-induced landslide are erosion; burial and blockage of roads and rivers.
- **TSUNAMI** Series of waves caused commonly by an earthquake under the sea. Effects of tsunami are flooding; coastal erosion; drowning of people and damage to properties.

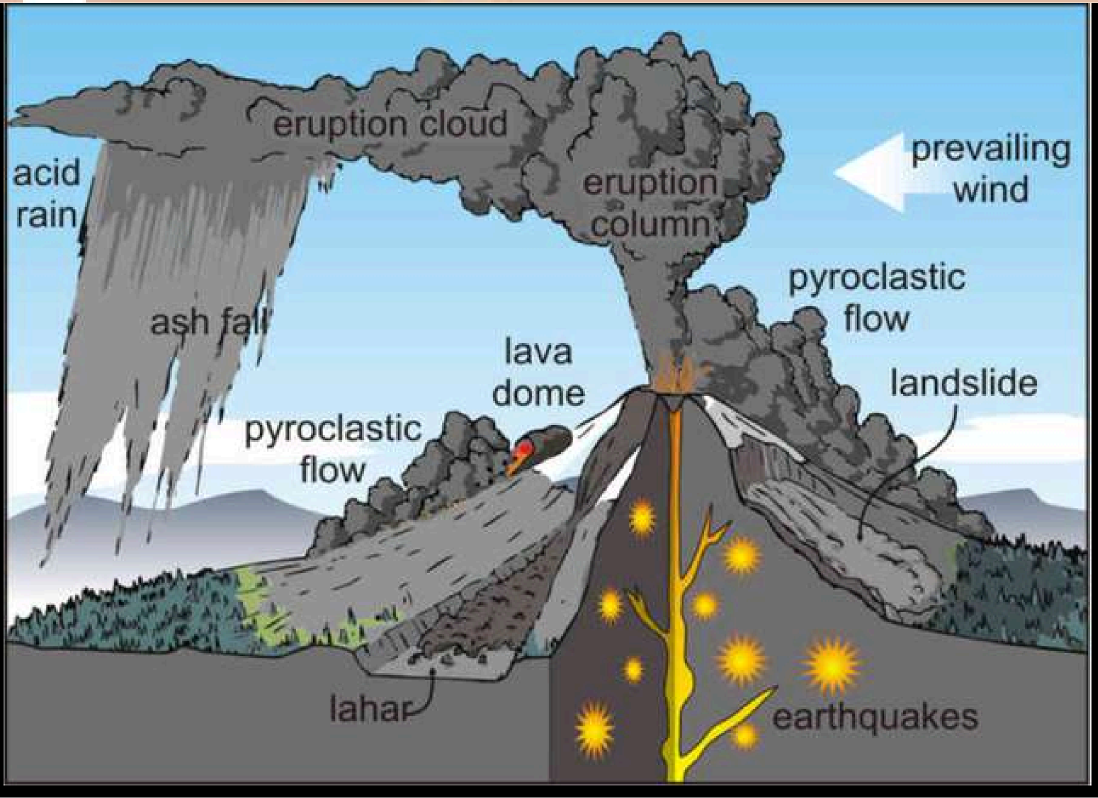
The **Hayli Gubbi volcano in Ethiopia's Afar region** erupted on Sunday for the first time in nearly 12,000 years, sending thick ash plumes across the Red Sea toward Yemen and Oman. The cloud has now extended over the northern Arabian Sea.







Volcanoes produce a variety of hazards, depending on the chemical composition and gas content of the lava



Lava (molten rock) can erupt as fire fountains or lava flows (when it is runny) or as steep-sided domes (when it is viscous). Lava may destroy buildings and infrastructure, but it moves relatively slowly so is rarely a direct threat to people.

Pyroclastic flows are hot avalanches of rock, ash, and gas that travel down volcano slopes at high speeds. They may be very dangerous close to a volcano.

Tephra consists of rock fragments ejected from a volcano. Volcanic ash is tephra smaller than 2 mm (and may be as small as thousandths of a millimetre), while larger fragments are called lapilli or bombs and blocks. Blocks and bombs fall to earth within a few kilometres of a volcano, but ash may be ejected high into the atmosphere and carried hundreds or thousands of kilometres downwind

Lahars are hot or cold mixtures of water and volcanic debris that form when volcanic materials interact with water, ice, snow, or loose wet sediments. Lahars are most dangerous close to a volcano, but large lahars may rapidly travel many tens of kilometres from a volcano, along river valleys, so they can pose a threat to people and infrastructure far beyond the volcano's slopes.

Volcanic gases bubble out of lava or escape through soil or vents in the ground. The most common volcanic gases are water vapour, carbon dioxide, sulphur dioxide, hydrogen, hydrogen sulphide, and carbon monoxide. Some of these gases are irritating or poisonous, or cause breathing problems, and the release of sulphur dioxide may cause acid rain to form. Over long time periods, volcanic gases may affect climate.

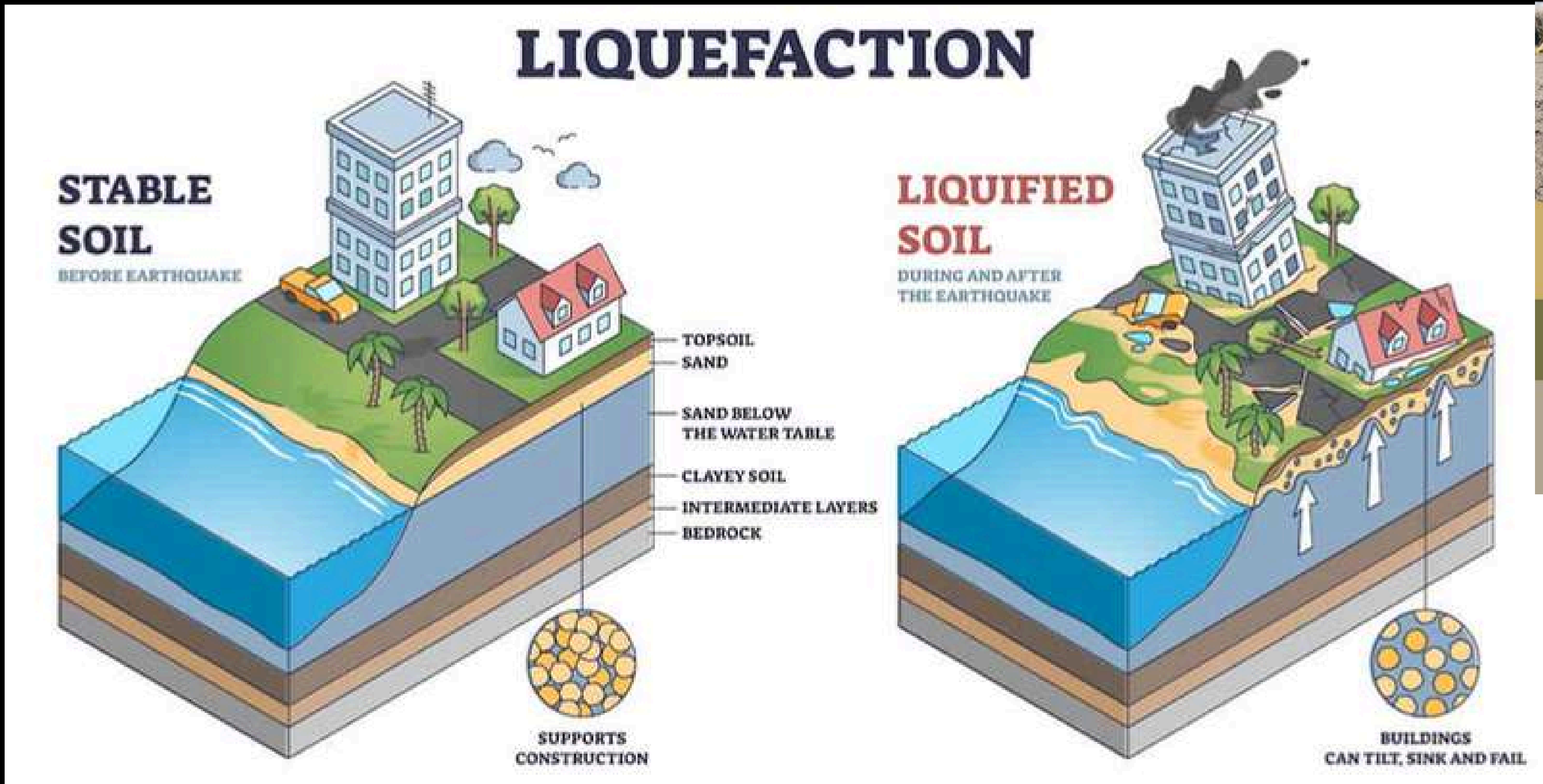
Phreatic explosions are explosions caused by the interaction of water with hot rock or magma (lava).

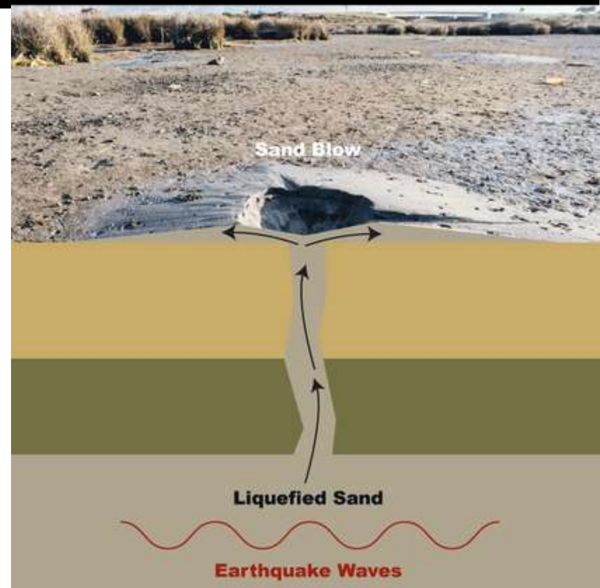
Liquefaction

Soil liquefaction is a geological phenomenon that changes the structure of the Earth's soil. External stressors loosen the soil particles, changing the ground into a less stable base for buildings and other structures.

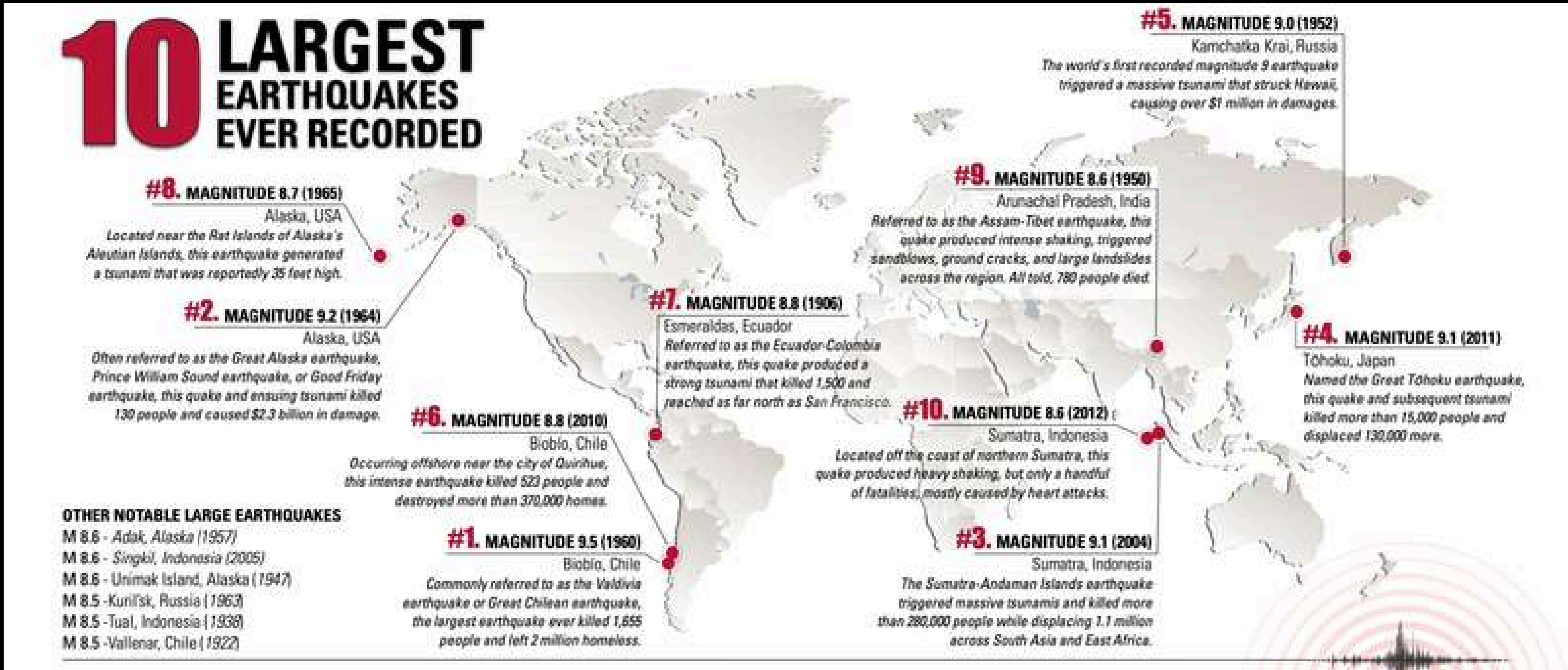
Soil liquefaction occurs when external stressors like earthquakes, blasting, or soil compaction cause soil particles to lose their strength and firmness. The shaking loosens dense soil particles when an earthquake occurs, creating high, unstable pressure. When affected by this phenomenon, the soil particles follow the path of least resistance and become more viscous, resembling quicksand. This type of soil loses its ability to support loads like engineered buildings.

Structures standing on liquefying soil lose their structural integrity, causing them to tilt or collapse. Most objects like cars and trucks sink under the surface, and underground utility lines such as water and natural gas rupture, causing severe damage and presenting a significant threat to life and property.





Magnitude measures the energy released at the source of the earthquake. Magnitude is determined from measurements on seismographs. **Intensity** measures the strength of shaking produced by the earthquake at a certain location. Intensity is determined from effects on people, human structures, and the natural environment.



The Richter Scale

Who discovered the Richter scale?

The first widely-used method, the Richter scale, was developed by Charles F. Richter in 1934 The Richter scale for measuring earthquake magnitude typically ranges from 1 to 10, though it is a logarithmic scale with no theoretical upper limit. Each whole number increase on the scale represents a tenfold increase in the amplitude of the seismic waves and an approximate 31.6-fold increase in the energy released.

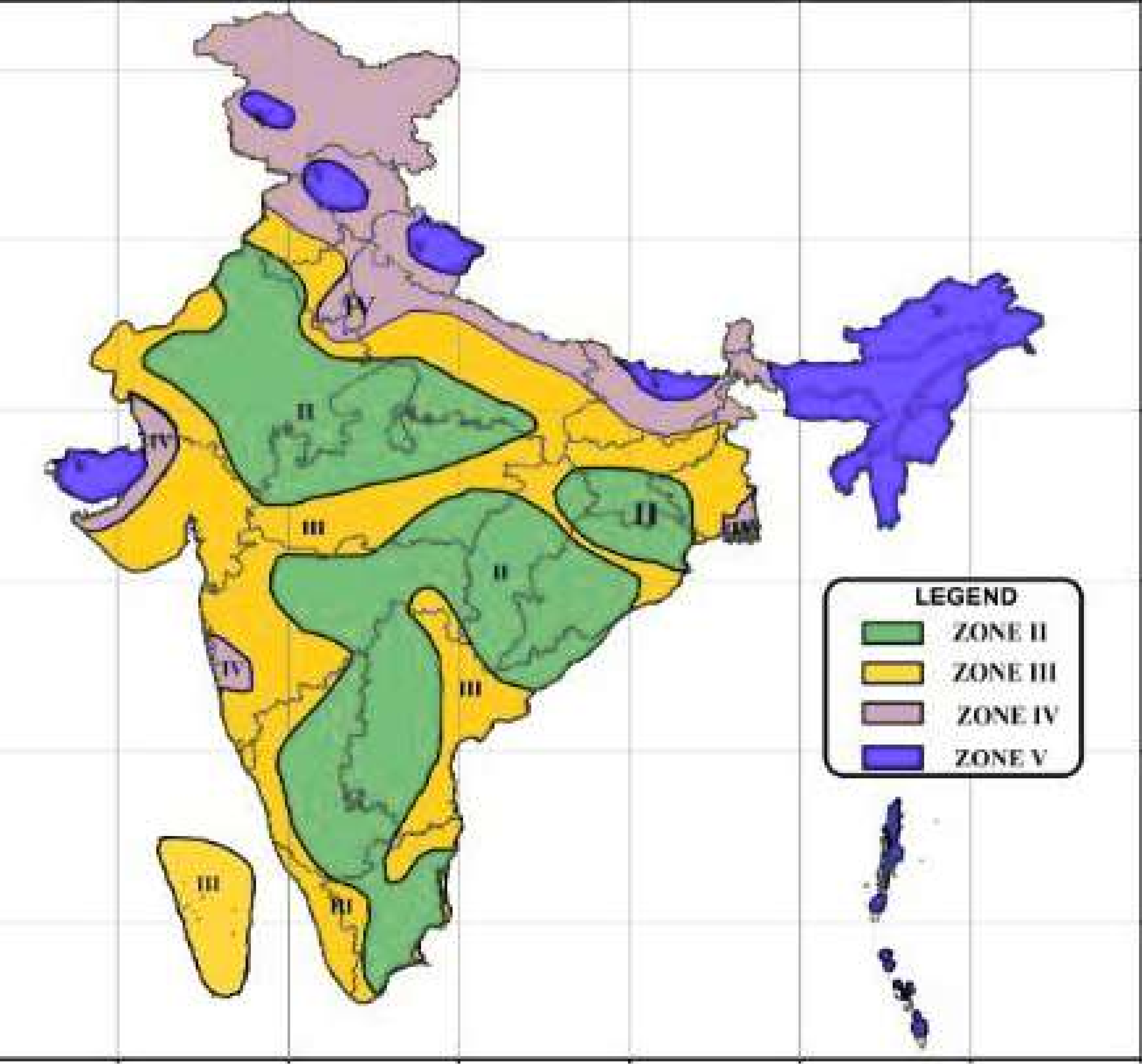
Magnitude	Earthquake Effects
2.5 or less	Usually not felt, but can be recorded by seismograph.
2.5 to 5.4	Often felt, but only causes minor damage.
5.5 to 6.0	Slight damage to buildings and other structures.
6.1 to 6.9	May cause a lot of damage in very populated areas.
7.0 to 7.9	Major earthquake. Serious damage.
8.0 or greater	Great earthquake. Can totally destroy communities near the epicenter.

Modified Mercalli Intensity Scale

The original scale was invented by Giuseppe Mercalli in 1902 and was modified by Harry Wood and Frank Neumann in 1931 to become what is now known as the Modified Mercalli Intensity Scale. To help distinguish it from magnitude scales, the MMI scale uses roman numerals.

Intensity	Shaking	Description/Damage
I	Not felt	Not felt except by a very few under especially favorable conditions.
II	Weak	Felt only by a few persons at rest,especially on upper floors of buildings.
III	Weak	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
IV	Light	Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
V	Moderate	Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
VI	Strong	Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
VII	Very strong	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
VIII	Severe	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
IX	Violent	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
X	Extreme	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.

Seismic Zonation map of the country



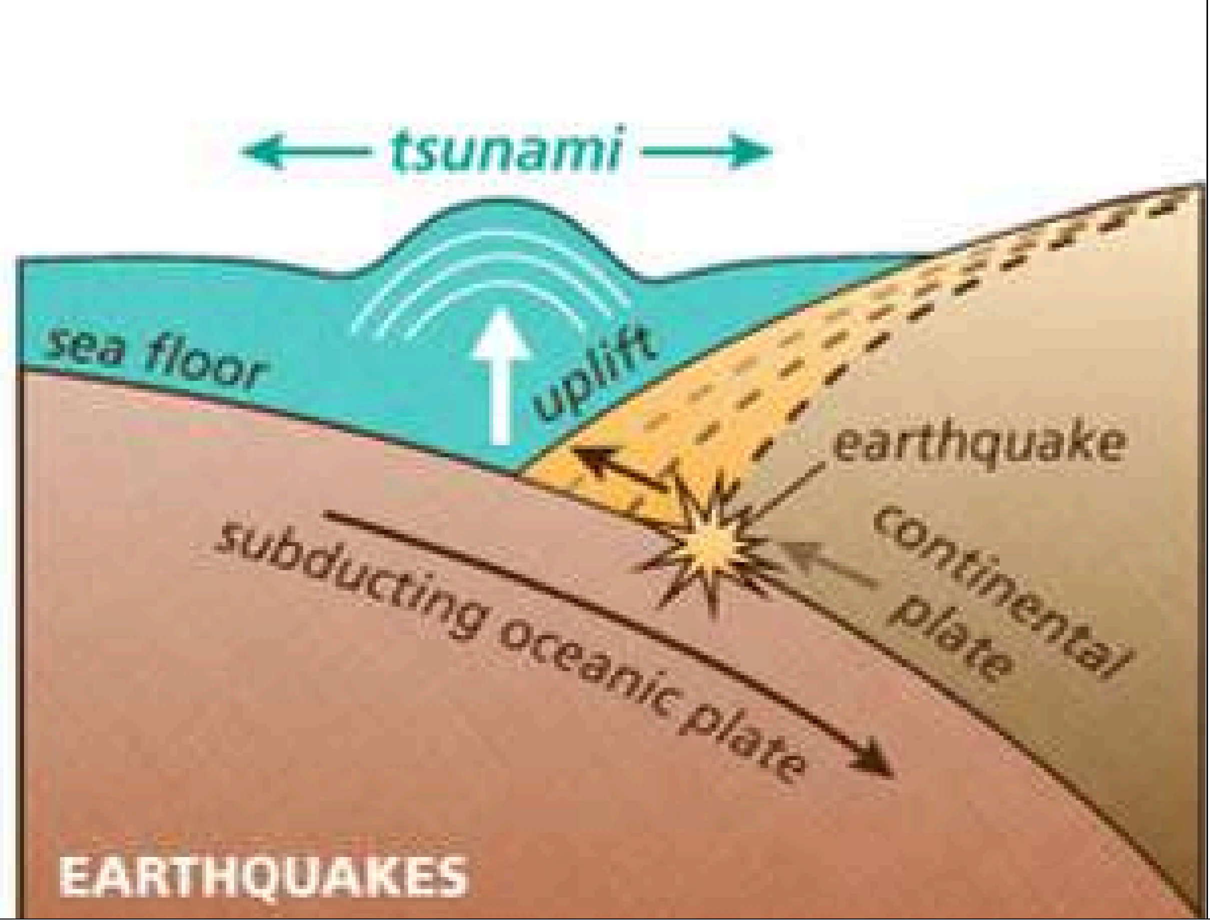
About 59% of land area is liable to seismic hazard damage

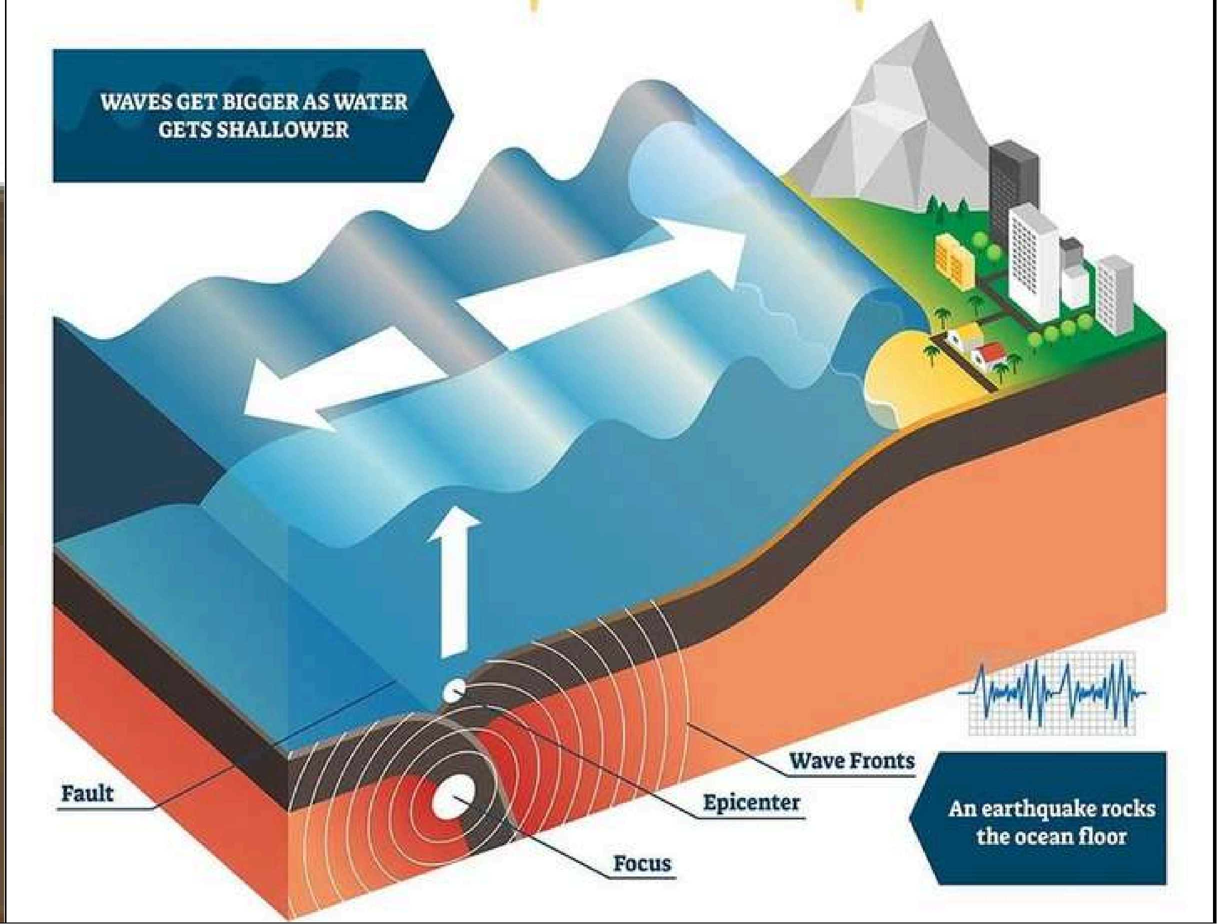
Zone II	40.93
Zone III	30.79
Zone IV	17.49
ZoneV	10.79

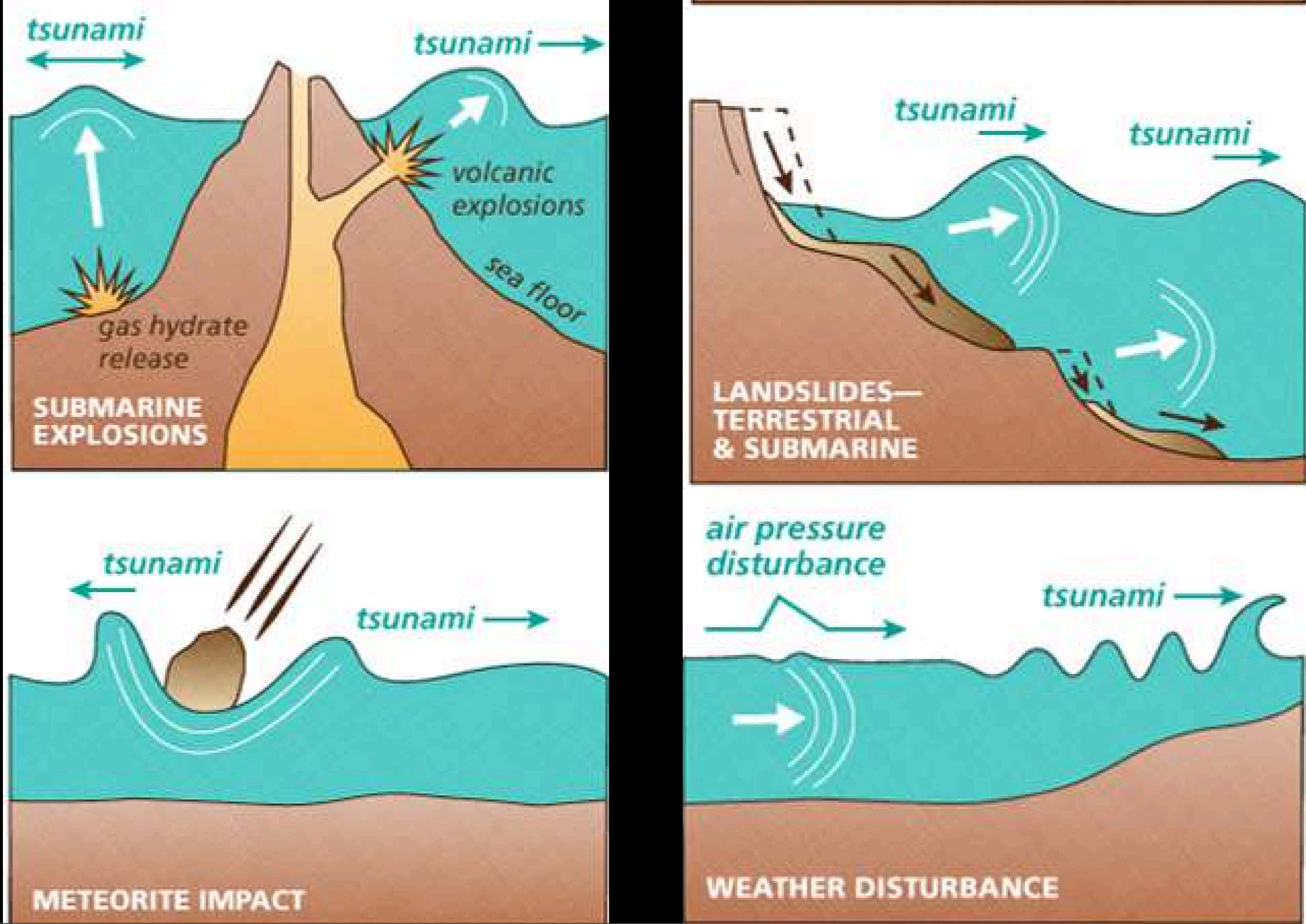
Zone V	Very High Risk Zone Area liable to shaking Intensity IX (and above)
Zone IV	High Risk Zone Intensity VIII
Zone III	Moderate Risk Zone Intensity VII
Zone II	Low Risk Zone VI (and lower)

Tsunami

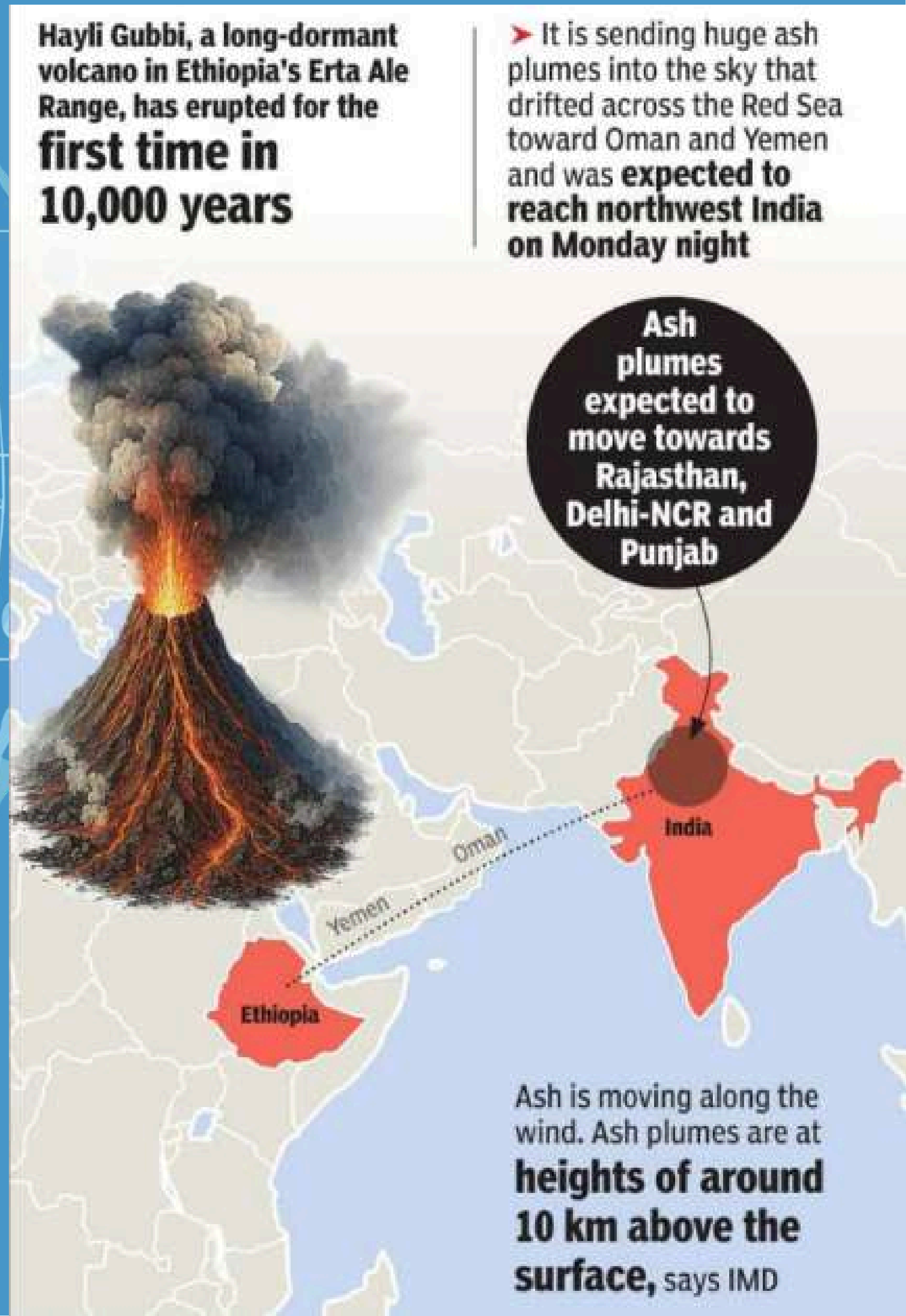
A tsunami is a series of extremely long waves caused by a large and sudden displacement of the ocean, usually the result of an earthquake below or near the ocean floor. This force creates waves that radiate outward in all directions away from their source, sometimes crossing entire ocean basins. Unlike wind-driven waves, which only travel through the topmost layer of the ocean, tsunamis move through the entire water column, from the ocean floor to the ocean surface.






tsunami
tsunami
volcanic explosions
sea floor
gas hydrate release
SUBMARINE EXPLOSIONS
tsunami
tsunami
LANDSLIDES—TERRESTRIAL & SUBMARINE
tsunami
tsunami
METEORITE IMPACT
air pressure disturbance
tsunami
WEATHER DISTURBANCE

The Government of India has put in place an Early Warning System for mitigation of such oceanogenic disasters under the control of Indian National Center for Ocean Information Services (INCOIS), Hyderabad.


Hayli Gubbi, a long-dormant volcano in Ethiopia's Erta Ale Range, has erupted for the first time in 10,000 years
It is sending huge ash plumes into the sky that drifted across the Red Sea toward Oman and Yemen and was expected to reach northwest India on Monday night
Ash plumes expected to move towards Rajasthan, Delhi-NCR and Punjab
India
Oman
Yemen
Ethiopia
Ash is moving along the wind. Ash plumes are at heights of around 10 km above the surface, says IMD

CYCLONE

Cyclones are caused by atmospheric disturbances around a low-pressure area distinguished by swift and often destructive air circulation. Cyclones are usually accompanied by violent storms and bad weather. The air circulates inward in an anticlockwise direction in the Northern hemisphere and clockwise in the Southern hemisphere. Cyclones are classified as: (i) extra tropical cyclones (also called temperate cyclones); and (ii) tropical cyclones.

Tropical cyclones are associated with a variety of hazards.

Damaging or destructive winds may reach speeds in excess of 300 km/h in the most intense systems. The combination of wind-driven waves and the low-pressure of a tropical cyclone can produce a coastal storm surge – a huge volume of water driven ashore at high speed and with immense force that can wash away structures in its path and cause significant damage to the coastal environment. Torrential rainfall results in flash-flooding, flooding, and potential landslides and mudslides.

Their potential for wreaking havoc caused by those associated hazards is exacerbated by the length and width of the areas they affect, their intensity, frequency of occurrence and the vulnerability of the impacted areas.

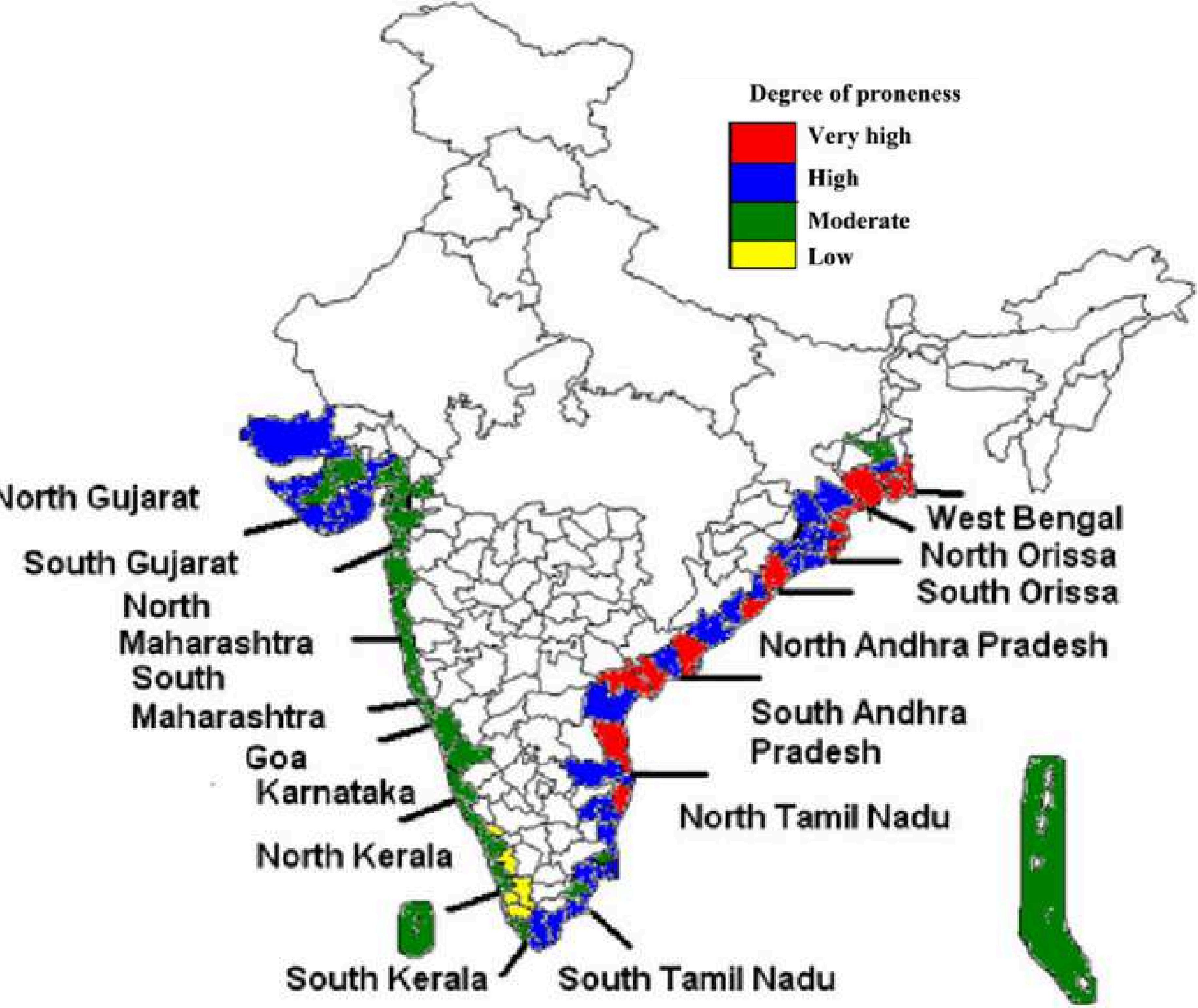
The biggest cyclone in history is subjective, but the deadliest is the 1970 Bhola Cyclone, which killed an estimated 300,000 to 500,000 people in what is now Bangladesh.

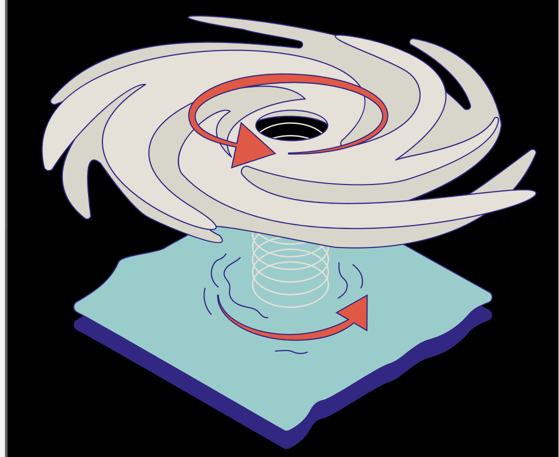
Saffir-Simpson Hurricane Wind Scale (SSHWS)

Category	Wind (mph)	Damage
5	≥ 157	Catastrophic
4	130-156	Catastrophic
3	111-129	Devastating
2	96-110	Extensive
1	74-95	Some

Non-Hurricane Classifications

Tropical Storm	39-73	--
Tropical Depression	≤ 38	--


Degree of proneness
Very high
High
Moderate
Low
North Gujarat
South Gujarat
North
Maharashtra
South
Maharashtra
Goa
Karnataka
North Kerala
South Kerala
South Tamil Nadu
North Tamil Nadu
South Andhra
Pradesh
North Andhra Pradesh
South Orissa
North Orissa
West Bengal



Indian classification of cyclonic disturbances in the north Indian Ocean

Type	wind speed in km/h
Low pressure area (L)	Less than 31
Depression (D)	31–49
Deep depression (DD)	50–61
Cyclonic storm (CS)	62–88
Severe cyclonic storm (SCS)	89–118
Very severe cyclonic storm (VSCS)	119–221
Super cyclonic storm (Sup. CS)	222 or more

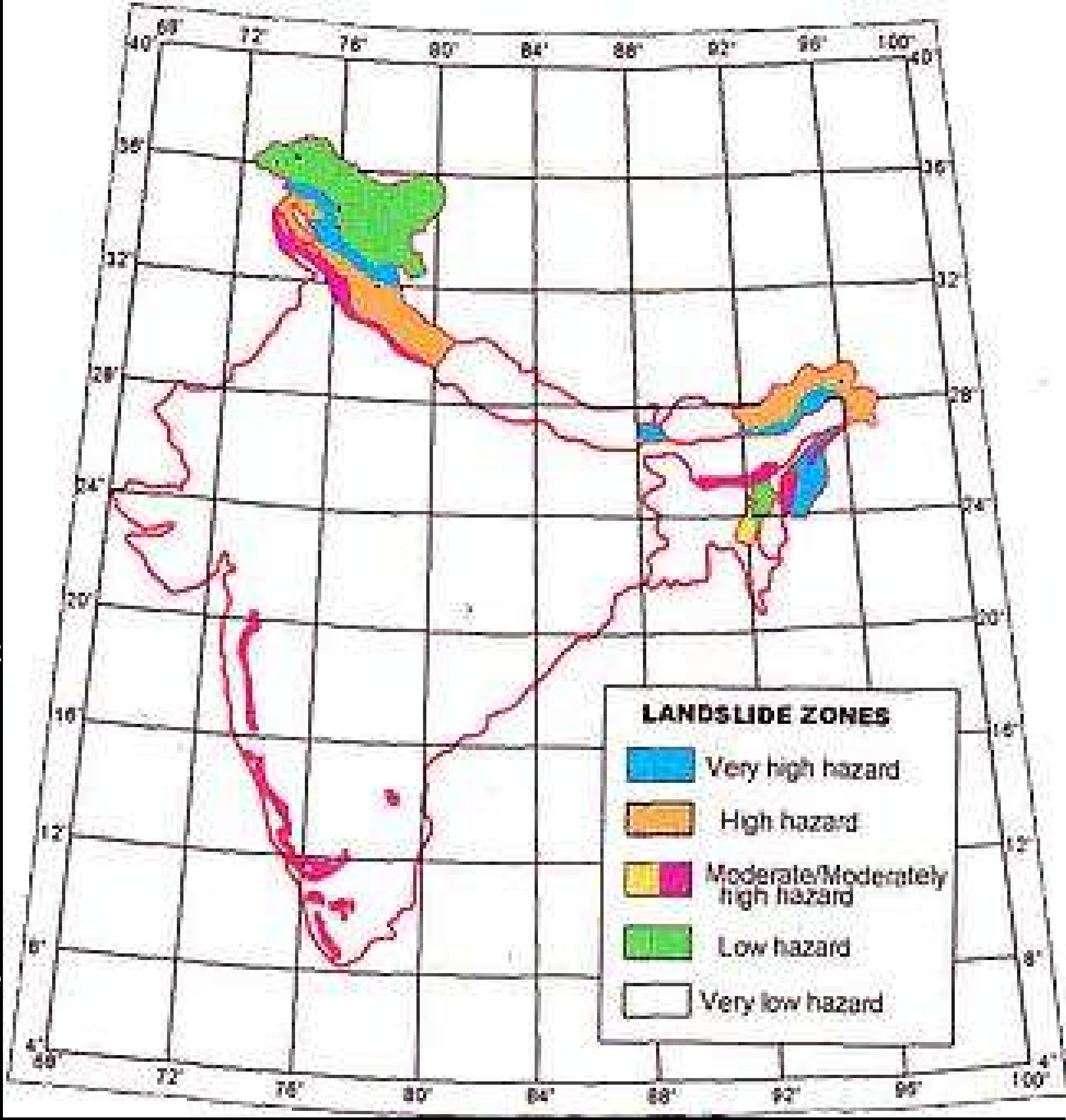
Tropical cyclone names in the North Indian Ocean are assigned by the RSMC The Regional Specialised Meteorological Centre New Delhi, which is run by the India Meteorological Department (IMD).

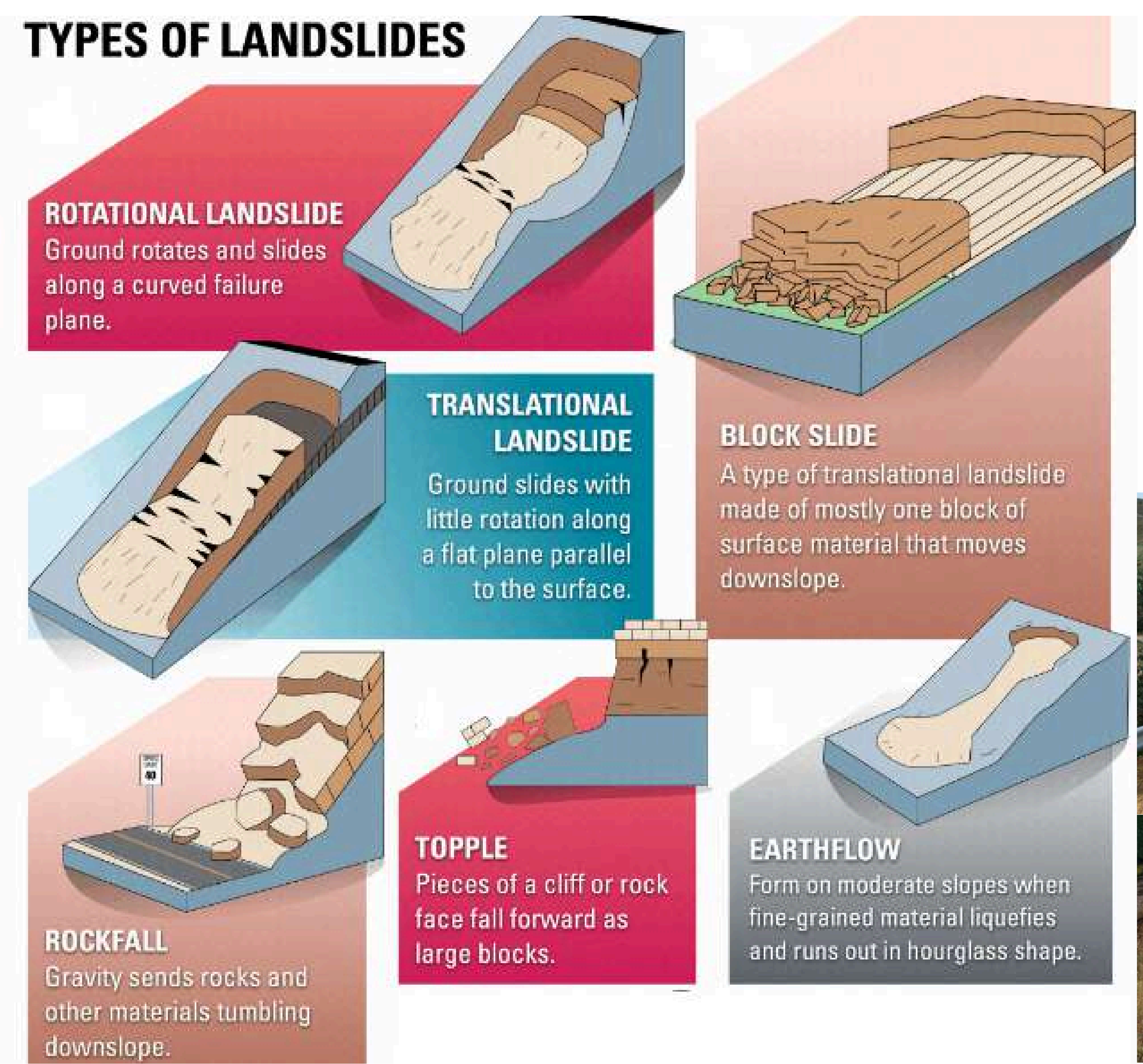
WMO/ESCAP Panel Member countries	Column 1		Column 2		Column 3		Column 4	
	Name	Pron'	Name	Pron'	Name	Pron'	Name	Pron'
Bangladesh	Nisarga	Nisarga	Biparjoy	Biporjoy	Arnab	Omab	Upakul	Upokul
India	Gati	Gati	Tej	Tej	Murasu	Murasu	Aag	Aag
Iran	Nivar	Nivar	Hamoon	Hamoon	Akvan	Akvan	Sepand	Sepand
Maldives	Burevi	Burevi	Midhili	Midhili	Kaani	Kaani	Odi	Odi
Myanmar	Tauktae	Tau'Te	Michaung	Migjaum	Ngamann	Ngaman	Kyarthit	Kjathi
Oman	Yaas	Yass	Remal	Re-Mal	Sail	Sail	Naseem	Naseem
Pakistan	Gulab	Gul-Aab	Asna	As-Na	Sahab	Sa-Hab	Afshan	Af-Shan
Qatar	Shaheen	Shaheen	Dana	Dana	Lulu	Lulu	Mouj	Mouj
Saudi Arabia	Jawad	Jowad	Fengal	Feinjal	Ghazeer	Razeer	Asif	Aasif
Sri Lanka	Asani	Asani	Shakhti	Shakhti	Gigum	Gigum	Gagana	Gagana
Thailand	Sitrang	Si-Trang	Montha	Mon-Tha	Thianyot	Thian-Yot	Bulan	Bu-Lan
United Arab Emirates	Mandous	Man-Dous	Senyar	Sen-Yaar	Afoor	Aa-Foor	Nahhaam	Nah-Haam
Yemen	Mocha	Mokha	Ditwah	Ditwah	Diksam	Diksam	Sira	Sira

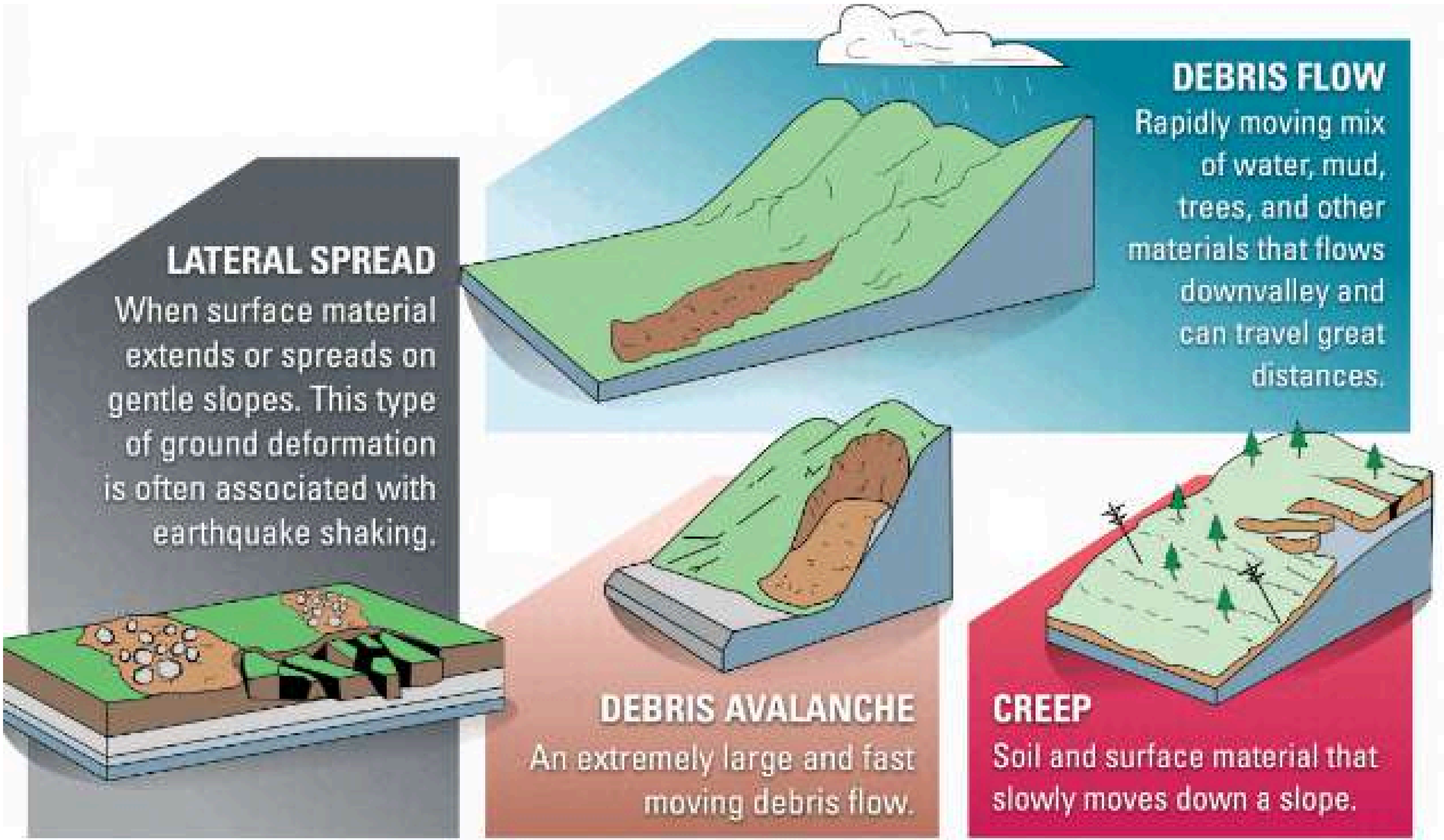
Landslide

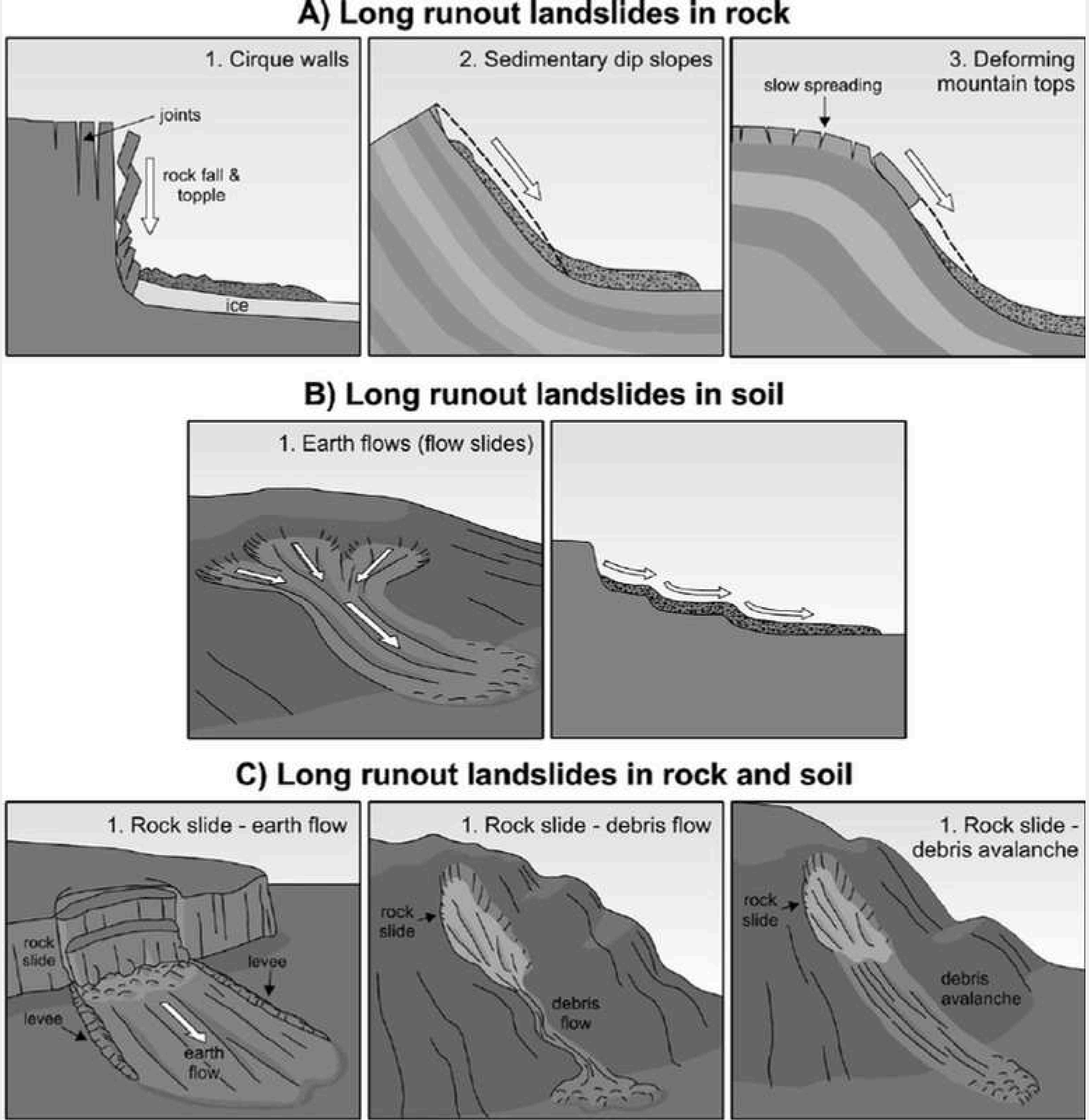
Landslides and avalanches are among the major hydro-geological hazards that affect large parts of India besides the Himalayas, the Northeastern hill ranges, the Western Ghats, the Nilgiris, the Eastern Ghats and the Vindhyans, in that order, covering about 15 % of the landmass.

- The Himalayas alone count for landslides of every fame, name and description- big and small, quick and creeping, ancient and new.
- The Northeastern region is badly affected by landslide problems of a bewildering variety. Landslides in the Darjeeling district of West Bengal as also those in Sikkim, Mizoram, Tripura, Meghalaya, Assam, Nagaland and Arunachal Pradesh pose chronic problems, causing recurring economic losses worth billions of rupees.
- A different variety of landslides, characterized by a lateritic cap, pose constant threat to the Western Ghats in the South, along the steep slopes overlooking the Konkan coast besides Nilgiris, which is highly landslide prone.




TYPES OF LANDSLIDES
ROTATIONAL LANDSLIDE
Ground rotates and slides along a curved failure plane.
TRANSLATIONAL LANDSLIDE
Ground slides with little rotation along a flat plane parallel to the surface.
BLOCK SLIDE
A type of translational landslide made of mostly one block of surface material that moves downslope.
ROCKFALL
Gravity sends rocks and other materials tumbling downslope.
TOPPLE
Pieces of a cliff or rock face fall forward as large blocks.
EARTHFLOW
Form on moderate slopes when fine-grained material liquefies and runs out in hourglass shape.


DEBRIS FLOW
Rapidly moving mix of water, mud, trees, and other materials that flows downvalley and can travel great distances.
LATERAL SPREAD
When surface material extends or spreads on gentle slopes. This type of ground deformation is often associated with earthquake shaking.
DEBRIS AVALANCHE
An extremely large and fast moving debris flow.
CREEP
Soil and surface material that slowly moves down a slope.

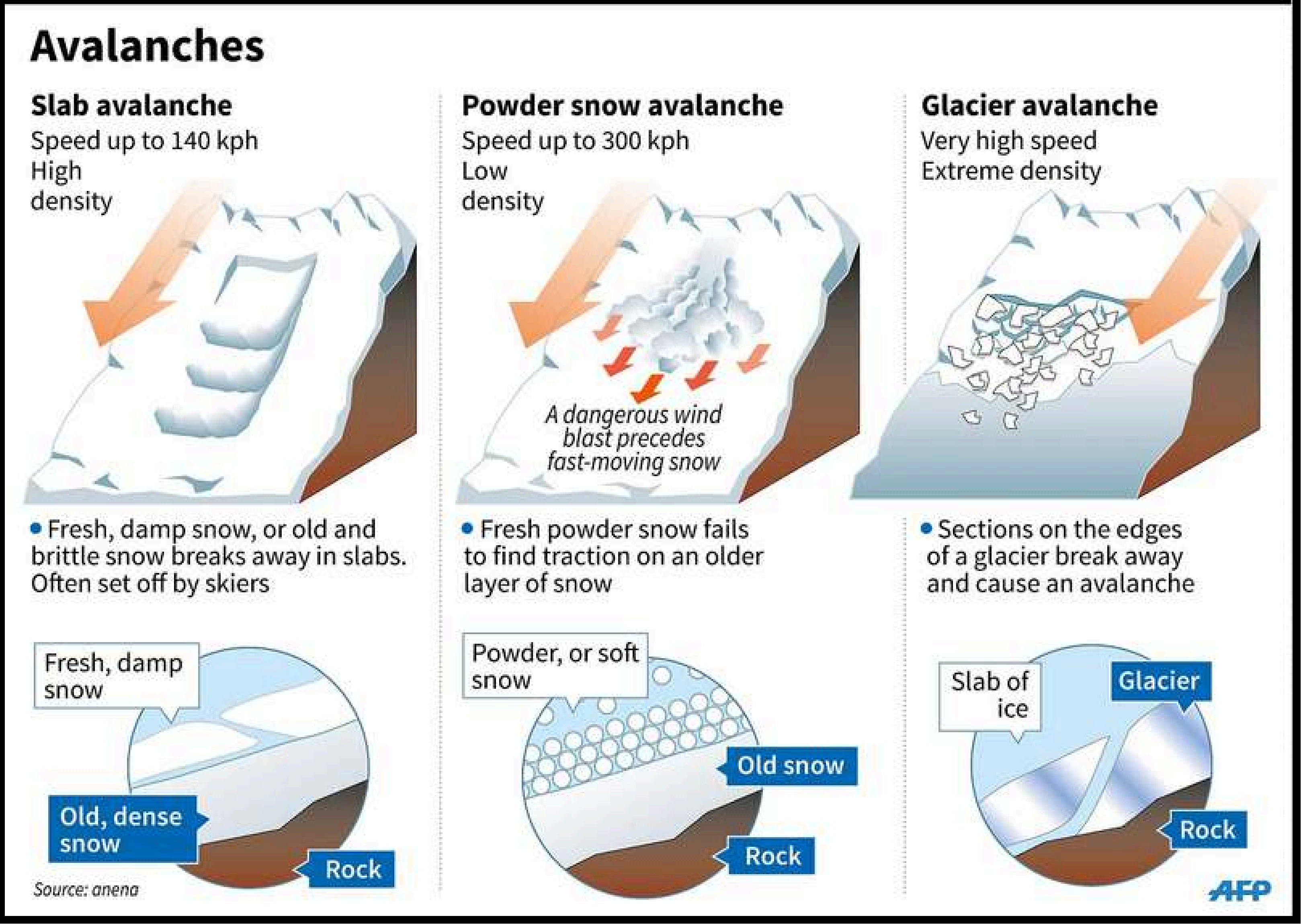

A) Long runout landslides in rock
1. Cirque walls
joints
rock fall & topple
ice
2. Sedimentary dip slopes
3. Deforming mountain tops
slow spreading
B) Long runout landslides in soil
1. Earth flows (flow slides)
C) Long runout landslides in rock and soil
1. Rock slide - earth flow
rock slide
levee
levee
earth flow
1. Rock slide - debris flow
rock slide
debris flow
1. Rock slide - debris avalanche
rock slide
debris avalanche

Avalanche is a natural disaster. It is caused by the melting and sliding of snow from the mountains. The main causes of avalanche disasters are heavy sunlight, human activity, natural, vibration or movement, snowflakes, steep slopes, and temperature. The types of avalanches are slab, loose snow, powder, gliding, and wet avalanches. The Himalayas are well known for the occurrence of snow Avalanches particularly Western Himalayas – the snowy regions of Jammu and Kashmir, Himachal Pradesh and Western Uttar Pradesh.

The Uttarakhand Avalanche 2025 was a deadly avalanche that struck a Border Roads Organisation (BRO) camp on February 28, 2025, near Mana village in the Chamoli district of Uttarakhand, India.

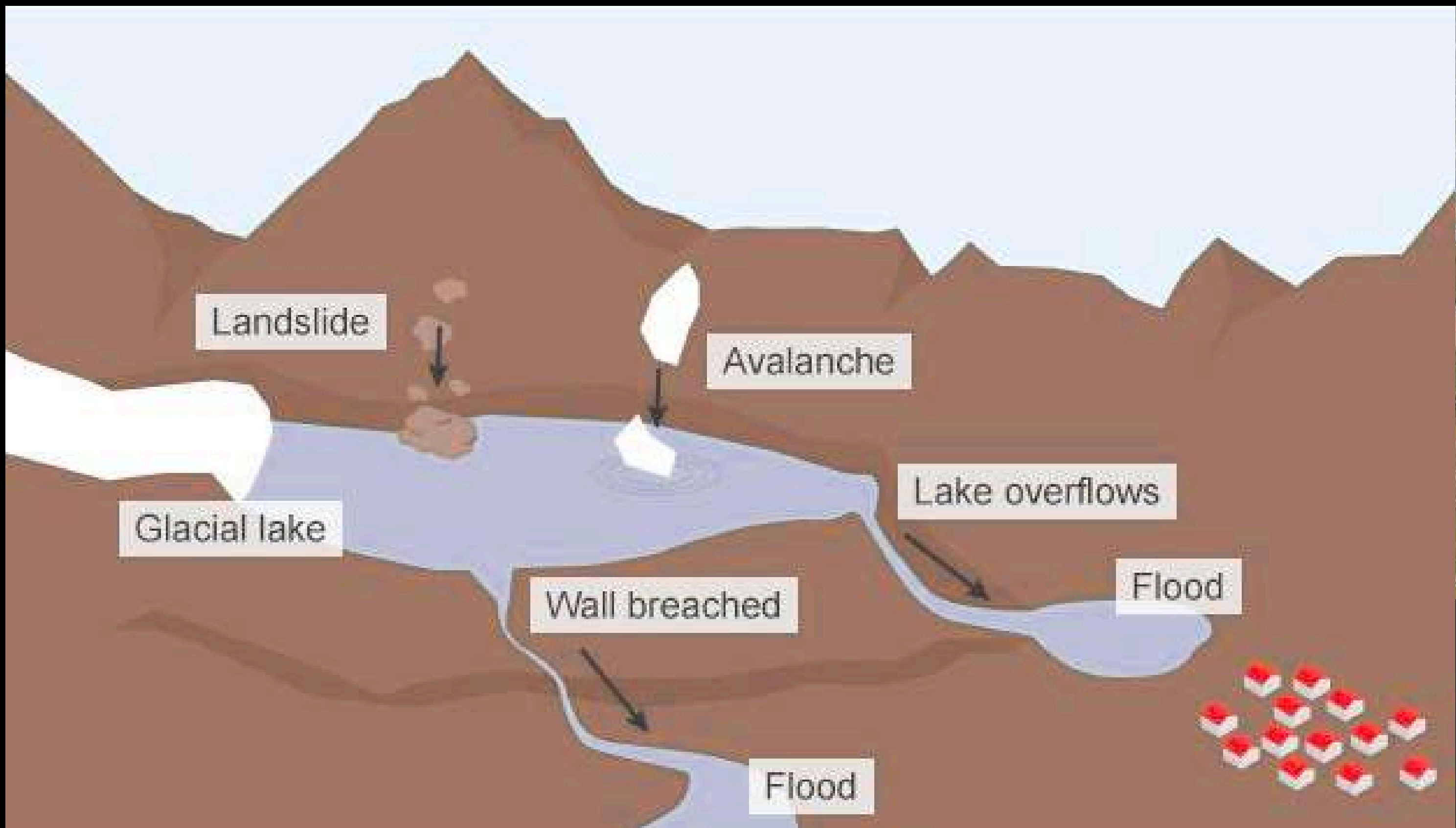
There are three types of snow avalanche zones –

- Red Zone: The most dangerous zone that have an impact pressure of more than 3 tonnes per square metre.
- Blue Zone: Where the avalanche force is less than 3 tonnes per square metre and where living and other activities may be permitted.
- Yellow Zone: Where snow avalanche occurs only occasionally



Glacial Lake Outburst Floods

A Glacial Lake Outburst Flood, or GLOF, is sudden release of water from a lake fed by glacier melt that has formed at the side, in front, within, beneath, or on the surface of a glacier.GLOF can be impounded by moraine complexes, glacial ice or even bedrock and, as a result of breaching, slope failure, overtopping or other failure mechanisms, lead to catastrophic phenomena in the high mountains that threaten people's lives, livelihoods and regional infrastructure.



Causes of GLOFs

- **Climate Change:** Rising temperatures accelerate glacier retreat and melt, leading to the formation of new glacial lakes and increasing the water volume behind existing, often unstable, dams.
- **Natural Triggers:** GLOFs can be triggered by natural events such as:
  - Avalanches and landslides into the lake
  - Heavy rainfall and cloudbursts that increase pressure on the dam
  - Seismic activity (earthquakes) that can destabilize dams

Key GLOF events in India

Sikkim (October 2023):

A catastrophic GLOF from the South Lhonak Lake caused a massive rise in the Teesta River, leading to fatalities, missing persons, and the collapse of the Teesta III dam and several bridges.

Uttarakhand (June 2013)

The Chorabari glacier lake outburst was triggered by intense rainfall, causing floods and landslides that killed thousands and trapped many pilgrims.

Risk in India

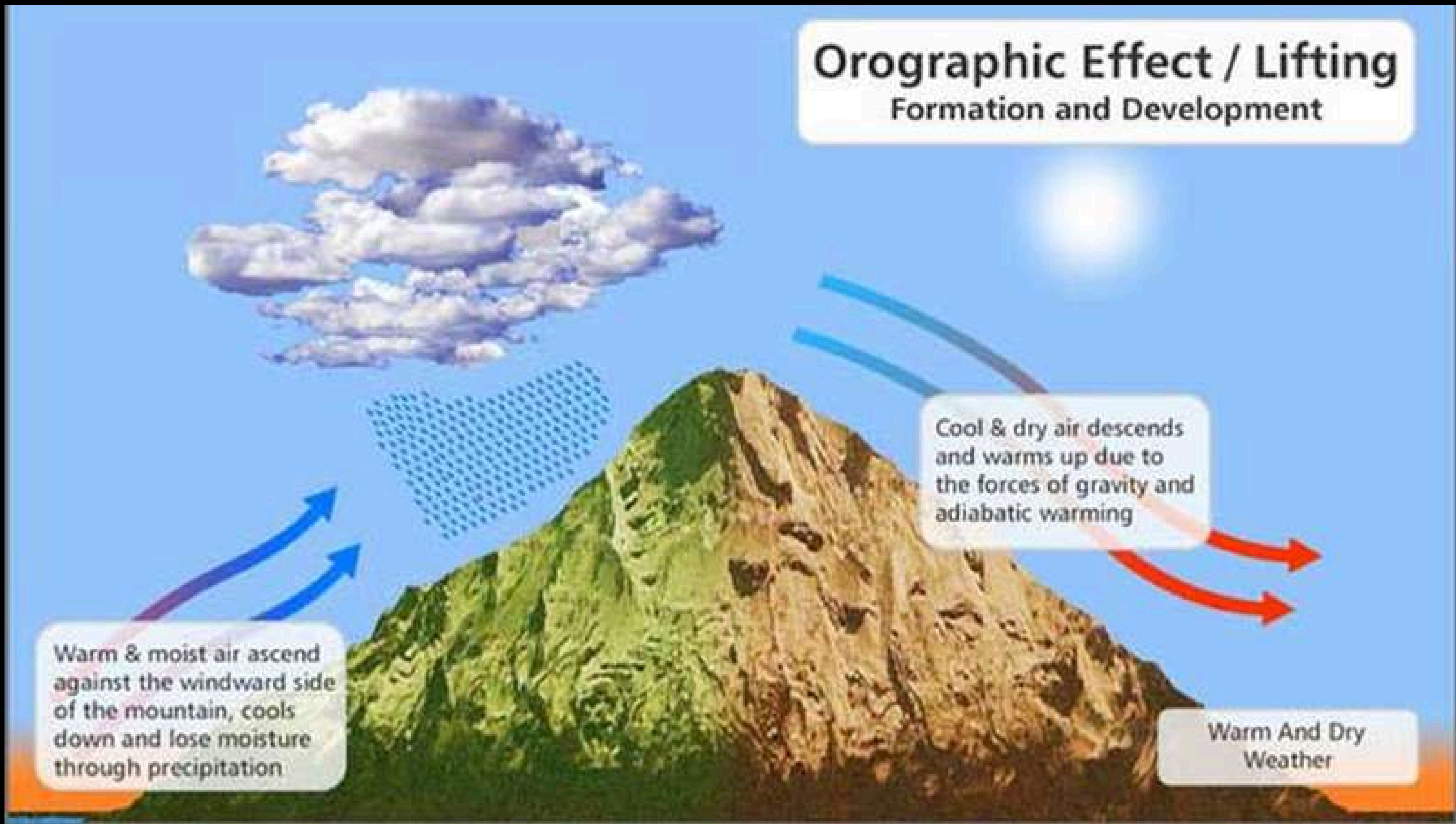
- Growing number of lakes: The Central Water Commission has reported that the number of glacial lakes in the Himalayas has increased, with significant expansion in regions like Ladakh, Uttarakhand, and Sikkim.
- Increased GLOF events: The frequency of GLOF events has risen in recent decades.
- High-risk areas: States in the Indian Himalayan Region, including Sikkim, Uttarakhand, Himachal Pradesh, and Ladakh, are particularly vulnerable.

Government preparedness

- National GLOF program: The Indian government has launched a national program to monitor, mitigate, and prepare for GLOFs through early warning systems, risk assessments, and scientific expeditions.
- Monitoring: India has been monitoring glacial lakes using satellite data to identify potential high-risk areas

Cloud burst

A cloud burst is an extreme weather event defined by an **extremely heavy and sudden downpour of rain**—often more than 100 mm per hour in a localized area of about 20–30 square kilometers. This phenomenon is caused by highly localized convective precipitation, frequently triggered by orographic lifting in mountainous regions where moist air is forced upwards by terrain. The rapid upward movement of warm, moist air causes it to cool and condense, leading to a **super-saturated cloud that eventually "bursts,"** releasing its heavy load of water in a short amount of time.



A cloudburst is caused by the forced ascent of moist air over mountains orographic lift, rapid condensation, and sudden release of accumulated moisture.

Contributing factors

Intensified monsoon: The 2025 monsoon was unusually severe, arriving earlier than expected, due to climate change which has been intensifying the monsoon system.

Atmospheric conditions: A key factor was the interaction of moist, monsoon-laden air with dry, cool westerly winds from the Mediterranean, leading to extreme weather activity.

Mountainous terrain: The Himalayan region's steep mountain valleys concentrate intense rainfall into narrow streams, increasing the potential for flash floods and landslides.

Human impact: Deforestation and unchecked urbanization in vulnerable areas exacerbated the problem. Building in unsafe locations near streams and cutting down forests has disrupted natural water flow and led to water accumulation, amplifying the disaster.

Climate change and glacial melt: Global warming contributes to rising temperatures, which increases the moisture-holding capacity of the atmosphere and can intensify rainfall. Melting glaciers also add to this problem by creating unstable lakes and fragile terrain that worsen the impact of events like cloudbursts.

Key Events-2025

Uttarakhand Flash Flood

A major incident occurred in the Uttarkashi district, particularly affecting the villages of Dharali and Sukhi Top. A torrent of water and debris from the Kheer Ganga river gushed through the area, sweeping away numerous homes, hotels, shops, and roads.

Dehradun: A cloudburst in September , caused flash floods and landslides.

Jammu and Kashmir Cloudbursts: The region experienced multiple cloudburst events leading to significant loss of life and property.

Kishtwar District A cloudburst in the remote village of Chositi triggered flash floods along the Machail Mata Yatra pilgrimage route. The incident resulted in at least 68 deaths and hundreds of injuries, with many people reported missing.

Kathua District Separate incidents of cloudburst and landslips in Kathua left at least seven people dead and several injured.

Ramban and Doda Districts Further heavy rains and cloudbursts caused flash floods and landslides, resulting in more fatalities and the closure of the Jammu-Srinagar National Highway.

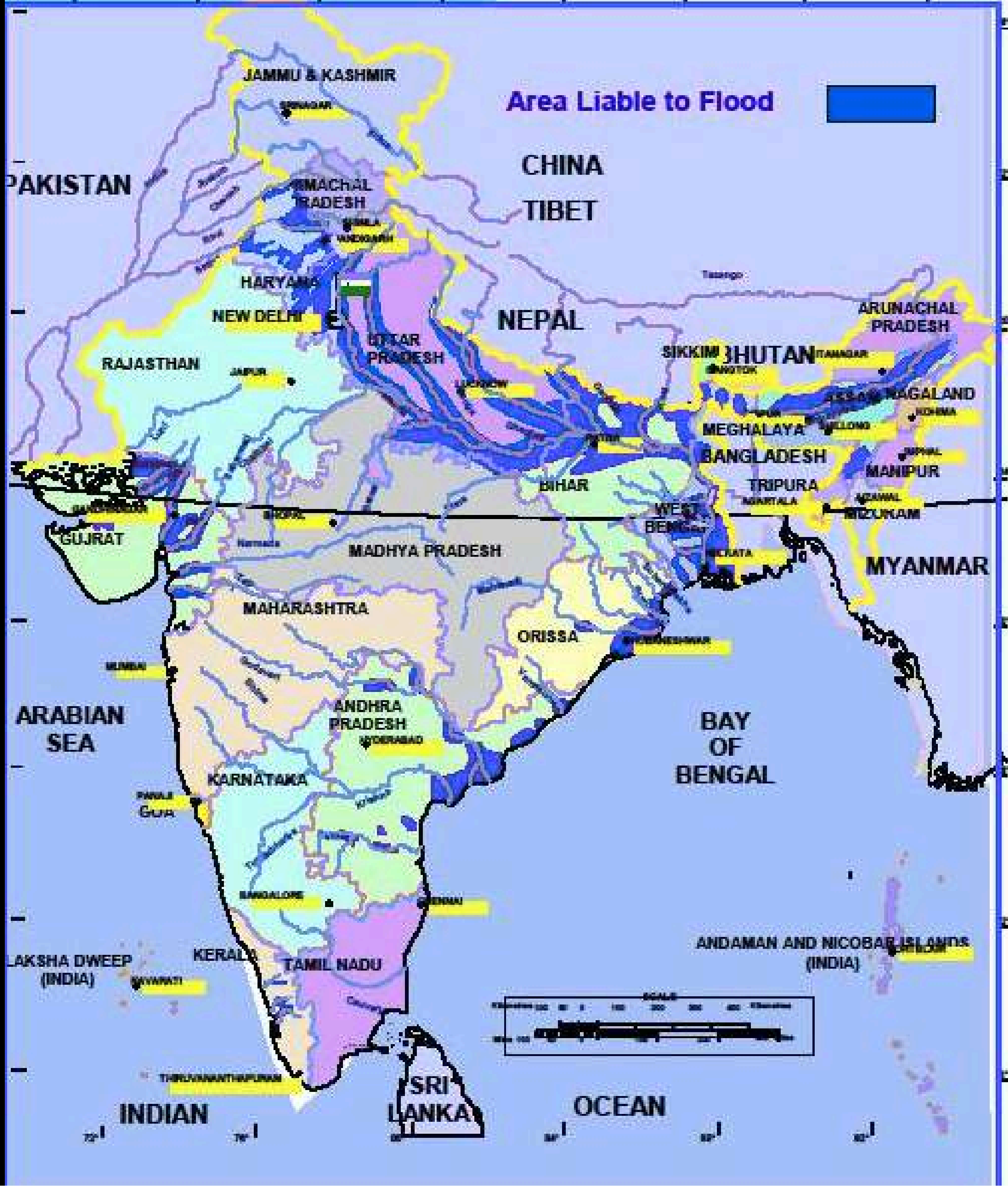
Himachal Pradesh and Punjab: Heavy rains in the catchment areas of Himachal Pradesh led to flash floods in downstream states like Punjab, which experienced its worst floods in decades. Thousands of acres of farmland were inundated, and infrastructure was severely damaged.

Floods

A flood is the overflow of water that inundates normally dry land and can be caused by factors like heavy rain, melting snow, or storm surges

Types of floods in India

- Riverine floods: Occur when rivers overflow their banks due to heavy rainfall or snowmelt. They are common in large river basins like the Ganges and Brahmaputra.
- Flash floods: Rapid, localized floods caused by intense, short-duration rainfall. They are very dangerous and can occur in dry climates or due to events like cloudbursts and dam failures.
- Urban floods: Caused by a combination of heavy rainfall and inadequate drainage systems in urban areas, leading to flooding of streets and buildings.
- Coastal floods: Result from storm surges associated with cyclones, heavy rainfall, and rising sea levels affecting coastal regions.
- Glacial Lake Outburst Floods (GLOFs): Occur when glacial lakes, formed by melting glaciers, burst their moraine dams. These are a significant risk in the Himalayan region.



Flood mitigation strategies

Structural measures:

- Embankments and floodwalls: To confine floodwaters and prevent them from spilling into populated areas.
- Reservoirs: To store excess water and regulate the timing and intensity of floods.
- Channel improvements: Desilting and dredging to increase the capacity of river channels.

Non-structural measures:

- Drainage improvement: Enhancing both natural and artificial drainage systems to manage stormwater.
- Watershed management: Sustainable management of entire river basins to control water flow.
- Land-use planning: Zoning to restrict development in flood-prone areas.
- Early warning systems: Rapid, localized systems to alert communities about impending flash floods.
- Building codes and retrofitting: Implementing stricter building codes and elevating existing structures in vulnerable areas.
- Evacuation plans: Developing and practicing plans to move people to safety during a flood.

Urban Floods

Urban flooding is the inundation of densely populated areas due to heavy rainfall, overflowing rivers, or poor drainage, which leads to waterlogging, infrastructure damage, and health hazards. Factors like increased impervious surfaces from concrete, loss of natural wetlands, and rapid urbanization overwhelm drainage systems, making floods more frequent and severe. Climate change exacerbates the issue through more intense rainfall events, making it a significant challenge for cities worldwide

Urban flooding is significantly different from rural flooding as urbanization leads to developed catchments, which increases the flood peaks from 1.8 to 8 times and flood volumes by up to 6 times. Consequently, flooding occurs very quickly due to faster flow times (in a matter of minutes). Urban areas are densely populated and people living in vulnerable areas suffer due to flooding, sometimes resulting in loss of life. It is not only the event of flooding but the secondary effect of exposure to infection also has its toll in terms of human suffering, loss of livelihood and, in extreme cases, loss of life.

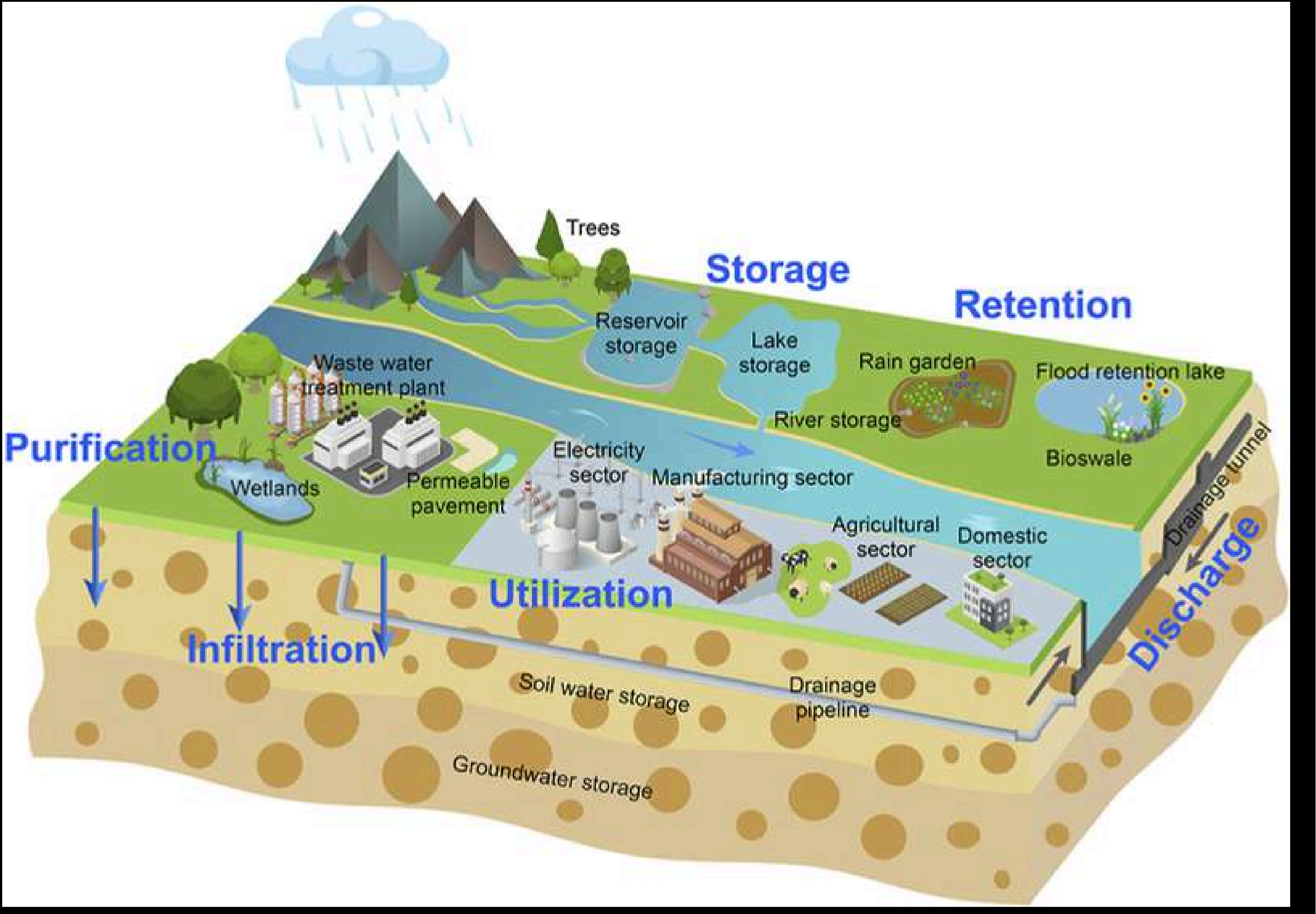
URBAN FLOOD RISK IN INDIA

A special feature in India is that we have heavy rainfall during monsoons. There are other weather systems also that bring in a lot of rain. Storm surges can also affect coastal cities/ towns. Sudden release or failure to release water from dams can also have severe impact. In addition, the urban heat island effect has resulted in an increase in rainfall over urban areas. Global climate change is resulting in changed weather patterns and increased episodes of high intensity rainfall events occurring in shorter periods of time. Then the threat of sea-level rise is also looming large, threatening all the coastal cities. Cities/towns located on the coast, on river banks, upstream/ downstream of dams, inland cities and in hilly areas can all be affected.

Sponge city

Sponge city construction can mitigate natural disasters caused by rainfall, for example; in the rainy season, flooding and waterlogging occur more often in southern cities, while the construction of sponge cities can effectively reduce the urban heat island effect, control urban water pollution, reduce dust and noise

A sponge city is an urban planning concept where cities are redesigned to absorb, clean, and reuse rainwater naturally, similar to how a sponge absorbs water. This approach uses green infrastructure like green roofs, permeable pavements, rain gardens, and wetlands to manage rainfall, which reduces flooding and urban runoff. The stored water is then filtered and can be used for irrigation or other purposes, mitigating flood risks and addressing water shortages.



Lightning

Lightning is caused by the buildup and separation of electrical charges within a thundercloud, leading to a large electrostatic discharge. As ice crystals and water droplets collide, they create a charge separation, with positive charges rising to the top of the cloud and negative charges sinking to the bottom. When the electrical difference becomes too great to be held by the insulating air, it discharges as a powerful bolt of electricity

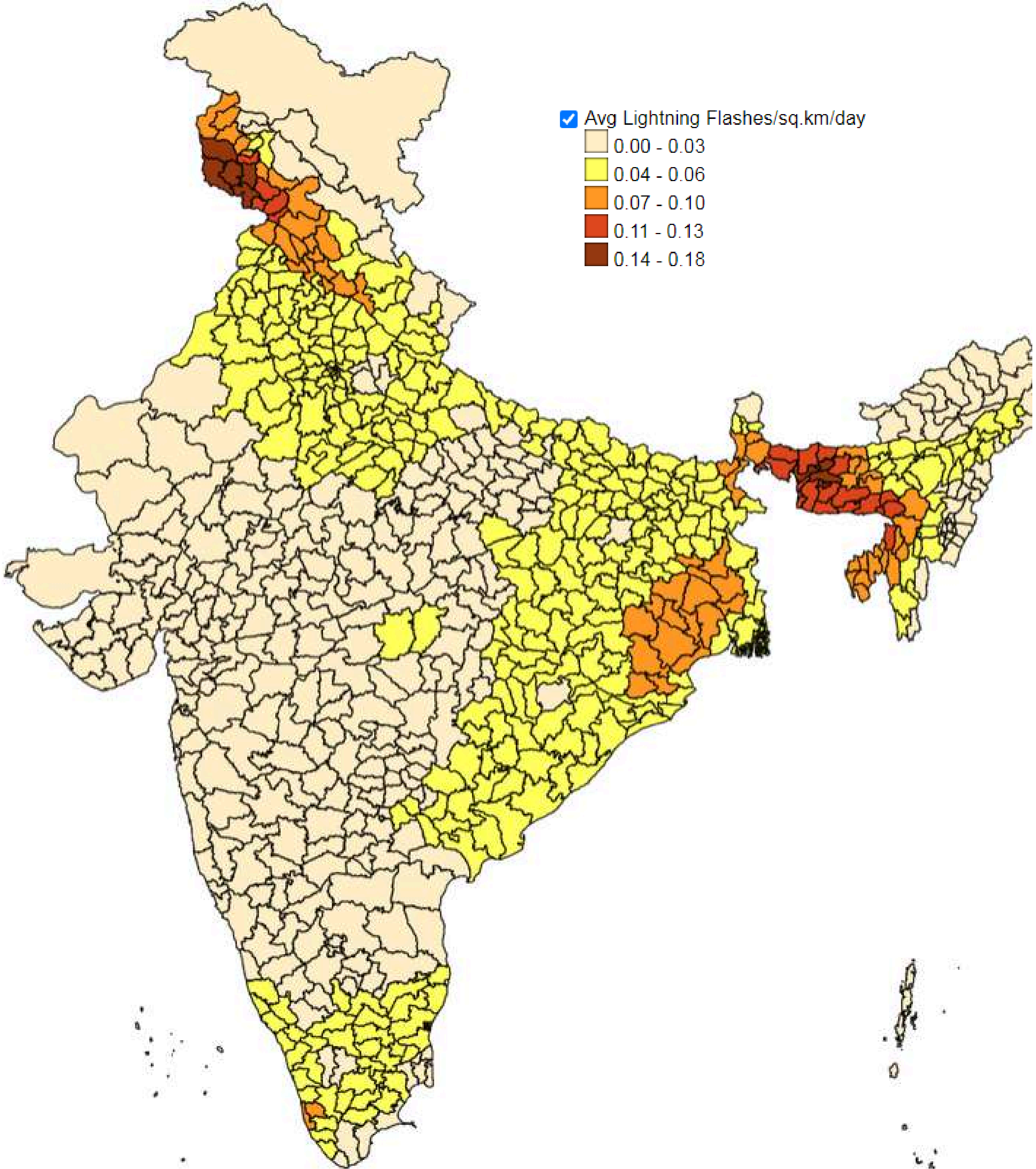
Hazards to people

- Direct strike: The most dangerous, but not the most common, type of strike.
- Ground current: Lightning can spread along the ground, striking people who are not in the direct path of the bolt.
- Side flash: A strike on a nearby object, like a tree, can "flash" to a person nearby.
- Conduction: If lightning hits a metal object, the current can travel to a person in contact with it.
- Injuries: Common injuries include burns, muscle pains, broken bones, and cardiac arrest, as well as confusion, hearing loss, and other neurological issues.

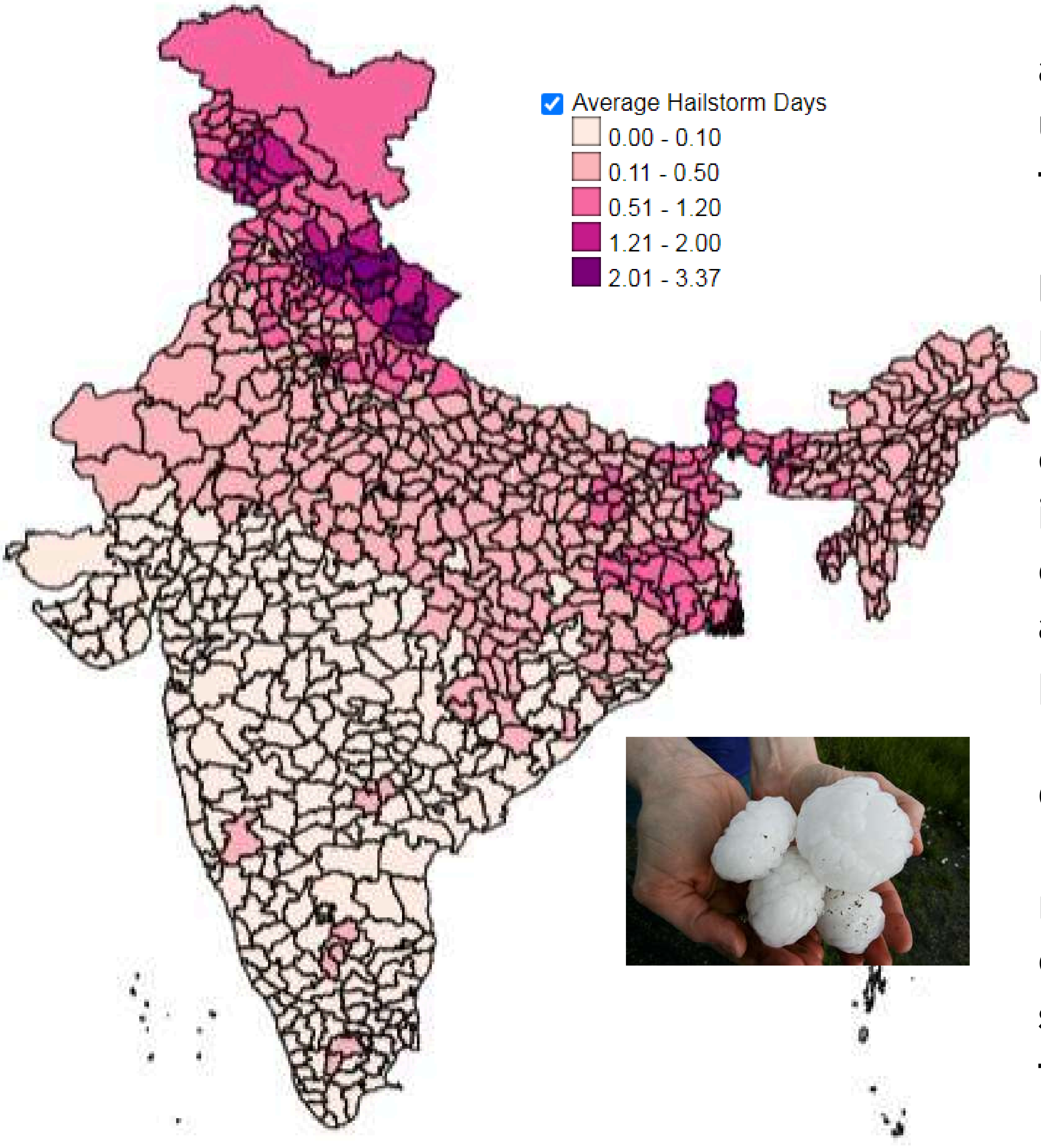
Hazards to property

- Fires: Lightning can easily start fires, including destructive forest fires.
- Structural damage: The intense heat and energy can shatter buildings and cause significant property damage.
- Electrical damage: Power surges from lightning can destroy electronics and appliances.

- With the increasing warming trend, India sees a 7-14 per cent increase in lightning every year. According to existing studies, with every 1oC rise in temperature, there is an 8-10 per cent rise in lightning strikes.
- Geographically, lightning has spread from eastern, northern, and coastal India to the northwest and Himalayan foothills. Rajasthan, Punjab, Haryana, Delhi, and Gujarat are new hotspots, while Bihar, Uttar Pradesh, Madhya Pradesh and Odisha also show increases. Bikaner and Churu now surpass Mayurbhanj and Kutch as the most lightning-prone districts.
- Lightning increases are also seen on plains along the Ganga, Yamuna, Mahanadi, Godavari, Tapti, Narmada basins and their tributaries. This may be due to encroachment and urbanisation in river basins like the Ganga, creating heat islands that cause more evaporation and lightning strikes.
- Overall from 2019-20 to 2024-25, the country has seen a 400 per cent rise in lightning strikes. The increase is sharper in the semi-arid northwest than in eastern states like Odisha. Madhya Pradesh shows the highest rise, affected by multiple weather systems from both the Arabian Sea and Bay of Bengal. Coastal regions show a uniform increase.
- Lightning also has a direct relationship with storms. Typically, each strike is preceded by thunderstorms. But a new trend has emerged, where storms also follow lightning, bringing rain, hail and strong winds. As per the World Meteorological Organization's "State of the Global Climate 2023" report, damages due to storms have increased by up to 62 per cent, higher than that from earthquakes, landslides, floods, droughts and heatwaves



The Union Ministry of Home Affairs has sanctioned a national programme on lightning. Phase I is being implemented as the Mitigation Project on Lightning Safety (MPLS) by the National Disaster Management Authority, along with Union Ministry of Panchayati Raj (with technical support from IMD, Union Ministry of Earth Sciences and the National Remote Sensing Centre) in the 10 most lightning-prone states, 50 most lightning-prone districts and 200 gram panchayats. Its broad framework includes risk assessment and strengthening early warning by risk mapping and installation of electric field meters and public alert poles; community preparedness through awareness drives among vulnerable communities, farmers, cattle-grazers, labourers and tribes in schools and villages; and training for volunteers. The Climate Resilient Observing Systems Promotion Council (CROPC) has already carried out detailed risk mapping and created a panchayat-level micro-zonation atlas for lightning.

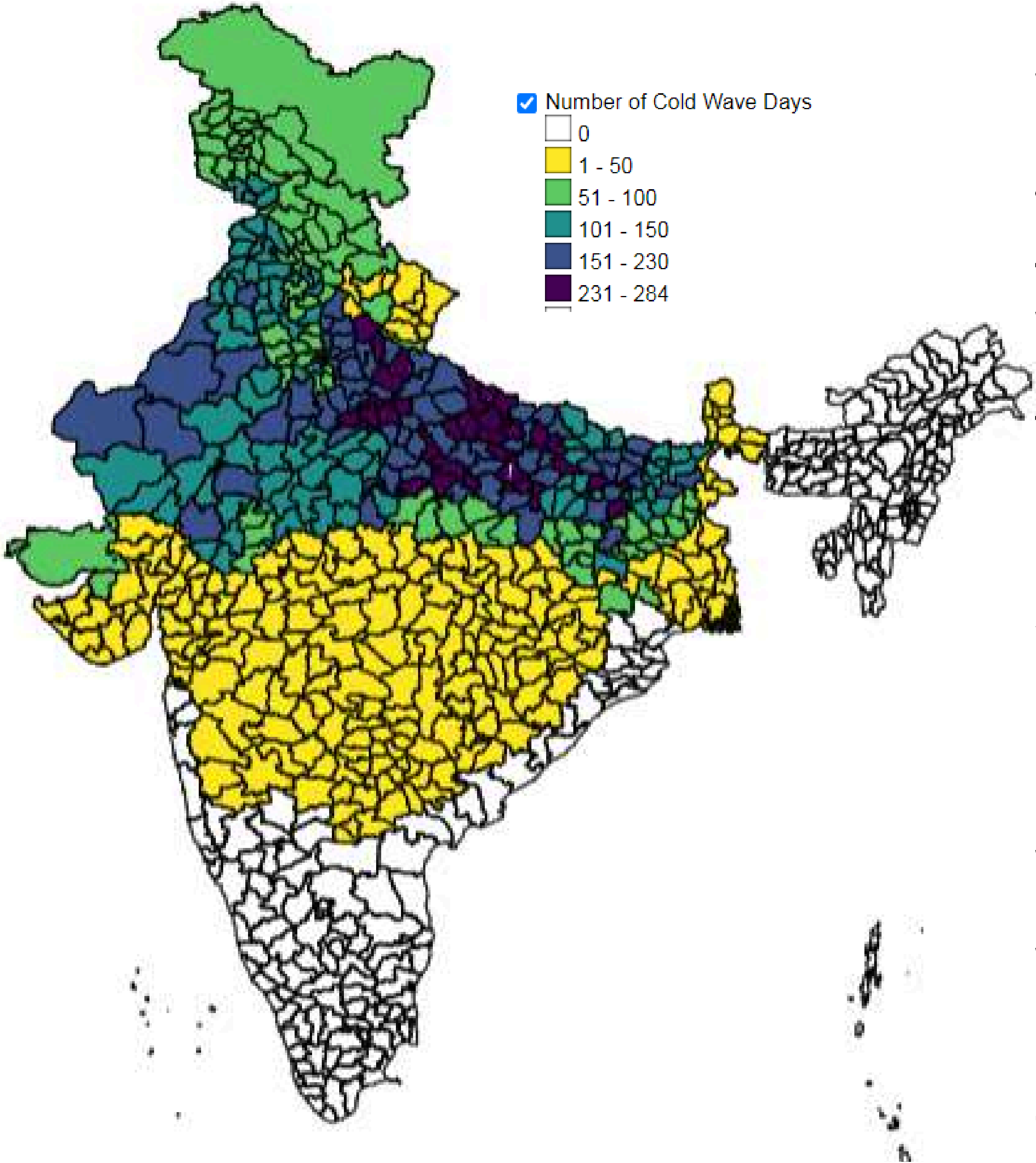


Hailstones are formed when raindrops are carried upward by thunderstorm updrafts into extremely cold areas of the atmosphere and freeze.

Hailstones then grow by colliding with liquid water drops that freeze onto the hailstone's surface.

Hail is a form of precipitation consisting of solid ice that forms inside thunderstorm updrafts. Hail can damage aircraft, homes and cars, and can be deadly to livestock and people.

Hailstorms are a frequent and often damaging weather phenomenon in India, particularly during the pre-monsoon (March-May) and to some extent the winter and post-monsoon seasons. They are less common during the peak monsoon season.



The cold wave conditions signify a certain amount of fall of temperature at a given place with respect to normal climatological value. In India, the cold wave (CW) conditions are generally experienced during the period from November to March

The criteria adopted by IMD to define Cold Wave i

a) Cold Wave is considered when the minimum temperature of a station is 10°C or less for plains and 0°C or less for Hilly regions.

(i) Based on Departure Cold Wave: Negative Departure from normal is 4.5°C to 6.4°C Severe Cold Wave: Negative Departure from normal is more than 6.4°C

ii) Based on Actual Minimum Temperature (For plain stations only) Cold Wave: When minimum temperature is ≤ 04°C Severe Cold Wave: When minimum temperature is ≤ 02°C

b) Cold Wave conditions for coastal stations When minimum temperature departure is -4.5°C or less over a station, “Cold Wave” may be described if the minimum temperature is 15°C or less.

The India Meteorological Department (IMD)

The India Meteorological Department (IMD) is the primary agency responsible for weather monitoring, forecasting, and seismology in India. It provides vital services to the public, government agencies, and specific sectors like agriculture, aviation, and disaster management.

- **Observational Network:** The IMD operates hundreds of surface and glacial observatories, high-altitude stations, meteorological radar stations, and uses data from India's constellation of satellites (e.g., INSAT series).
- **Forecasting:** It issues short-range, medium-range, and long-range forecasts for various weather parameters, including temperature, rainfall, and wind speed.
- **Specialized Warnings:** As a Regional Specialised Meteorological Centre of the World Meteorological Organization (WMO), IMD is responsible for forecasting and issuing warnings for tropical cyclones, heavy rainfall events, cold waves, and other extreme weather conditions in the Northern Indian Ocean region.
- **Colour-Coded Alerts:** The IMD uses a four-tier colour-coded alert system (Green, Yellow, Orange, Red) to inform the public and authorities about the severity of impending weather, helping them prepare for potential risks.
- **Aviation and Agriculture Services:** It provides specialized services, such as agrometeorological advisories for farmers (accessible via the Meghdoot app), and meteorological support for aviation.
- **Seismology:** In addition to weather, the IMD operates seismic monitoring centers for earthquake monitoring and measurement.

Mobile Apps: The IMD offers several mobile applications for localized and specialized information, including:

- Mausam: Provides general weather forecasts and information.
- Meghdoot: Offers agrometeorological advisory services.
- Damini: Provides location-specific lightning alerts.

The IMD uses four colours are orange, red, yellow, and green. The varying shades reflect different degrees of potential risk, which allows people to place a commensurate level of preparedness.

GREEN ALERT (NO ADVISORY)

The green alert means there are normal weather conditions with little or no rain. This is generally accompanied by weak, intermittent rain or dry weather during the monsoon. Essentially, when this Alert is issued, it also means there are no serious weather-related issues, and it is a situation where people can go outdoors and conduct their everyday business as they please.

YELLOW ALERT (BE AWARE)

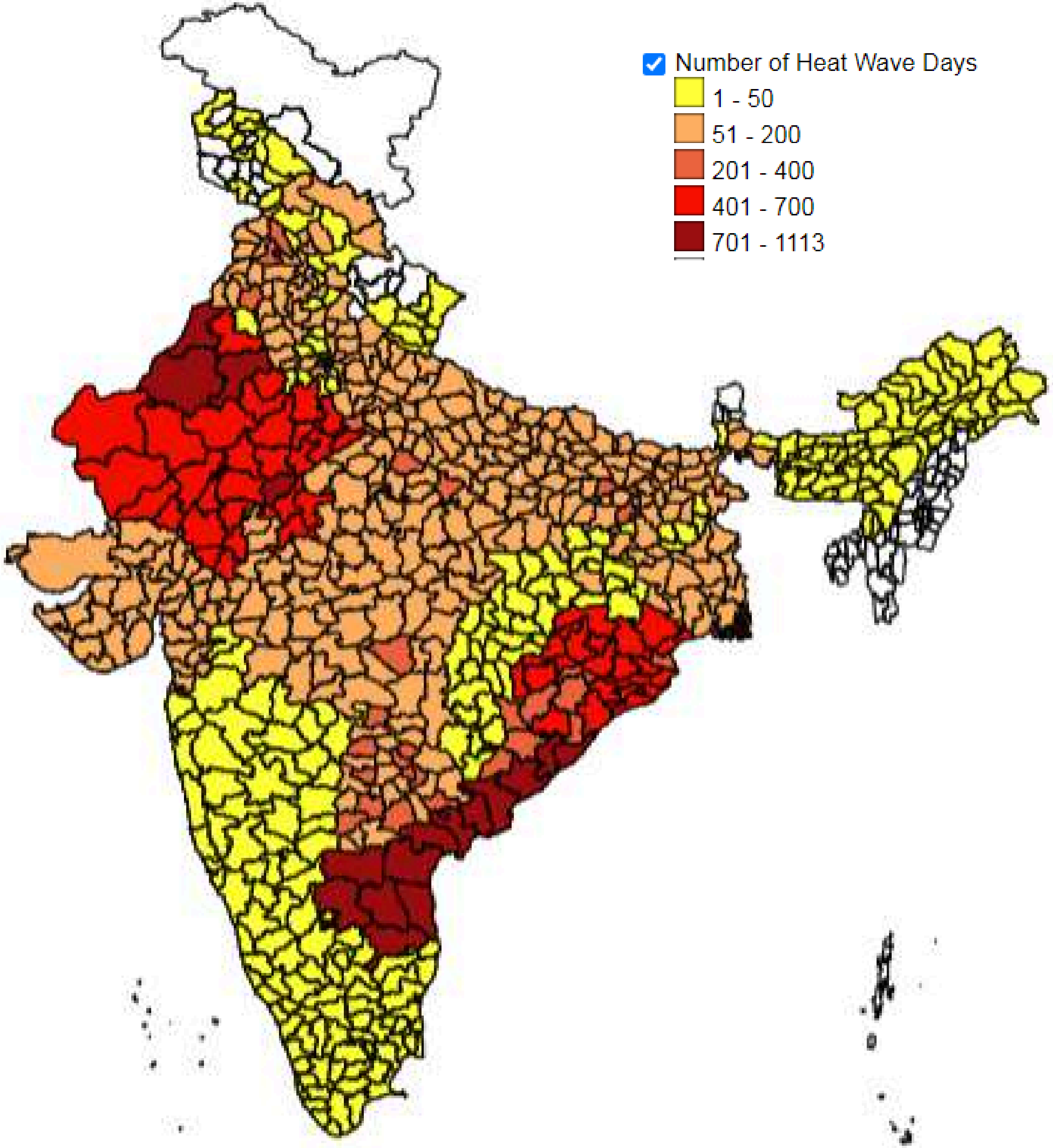
A yellow alert is issued when there is a chance of significant rainfall. It’s important to understand that a yellow alert does not guarantee heavy rain; rather, it indicates a possibility of isolated flooding in low-lying areas and potential disruptions to outdoor activities. Residents in affected areas should remain vigilant, especially in places prone to frost. It's advisable to drive carefully and bring umbrellas.

ORANGE ALERT (PREPARE FOR IMPACT)

An orange alert is issued when intense rainfall is expected; usually, 115.6 mm and up to 204.4 mm of rain are predicted in 24 hours. An orange alert indicates an increased chance of flooding in streets, streams and vulnerable areas. Residents should remain indoors if possible, stock supplies, and be ready for possible transportation issues, loss of power and potential landslides.

RED ALERT (TAKE ACTION)

The red alert is the most serious of weather warnings; extreme heavy rainfall of over 204.5 mm is predicted in 24 hours. A red alert indicates a serious threat to life and property with the potential for a degree of flooding, disruption to essential services and the need to evacuate. Under a red alert, personal safety is paramount; do not travel and obey local authorities.



Heat Wave is a period of abnormally high temperatures, more than the normal maximum temperature that occurs during the summer season in the North-Western parts of India. Heat Waves typically occur between March and June, and in some rare cases even extend till July. The extreme temperatures and resultant atmospheric conditions adversely affect people living in these regions as they cause physiological stress, sometimes resulting in death.

The Indian Meteorological Department (IMD) has given the following criteria for Heat Waves :

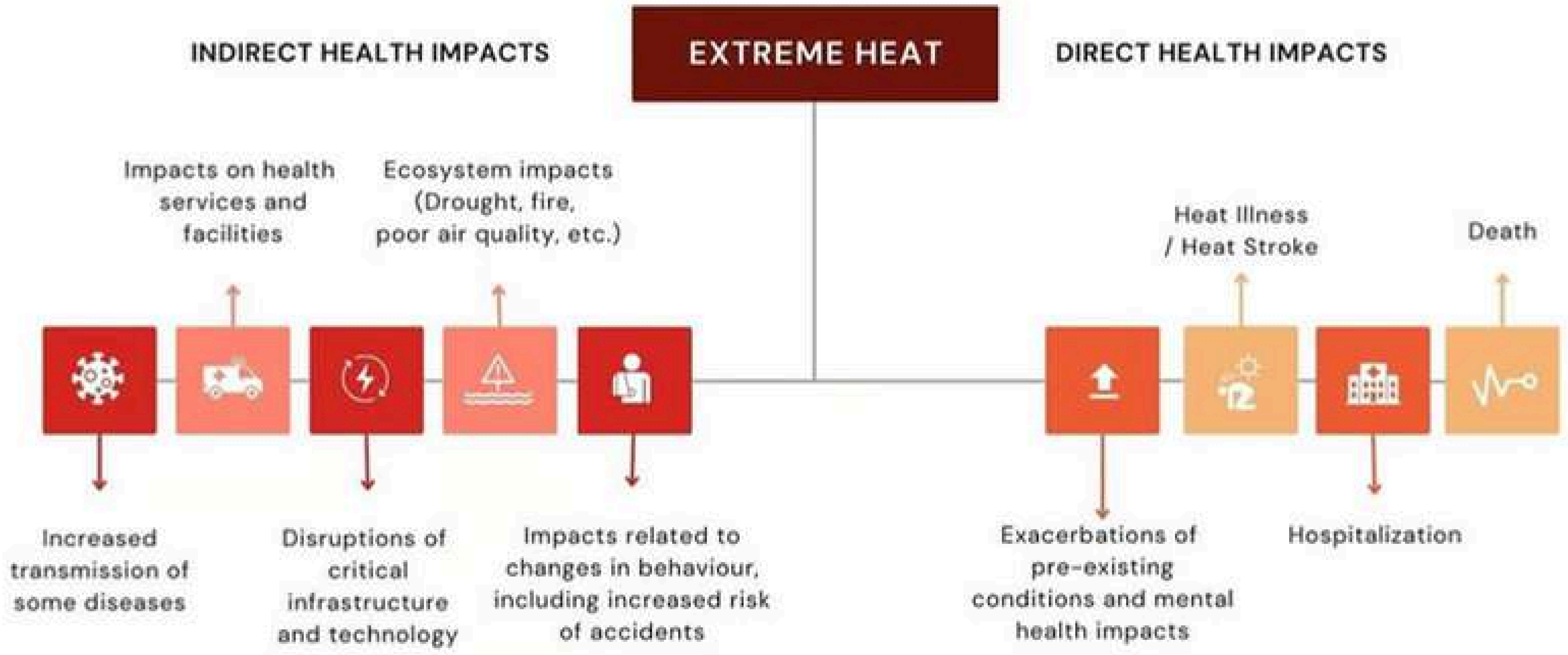
- Heat Wave need not be considered till maximum temperature of a station reaches atleast 40°C for Plains and atleast 30°C for Hilly regions
- When normal maximum temperature of a station is less than or equal to 40°C Heat Wave Departure from normal is 5°C to 6°C Severe Heat Wave Departure from normal is 7°C or more
- When normal maximum temperature of a station is more than 40°C Heat Wave Departure from normal is 4°C to 5°C Severe Heat Wave Departure from normal is 6°C or more
- When actual maximum temperature remains 45°C or more irrespective of normal maximum temperature, heat waves should be declared.

Higher daily peak temperatures and longer, more intense heat waves are becomingly increasingly frequent globally due to climate change. India too is feeling the impact of climate change in terms of increased instances of heat waves which are more intense in nature with each passing year, and have a devastating impact on human health thereby increasing the number of heat wave casualties.

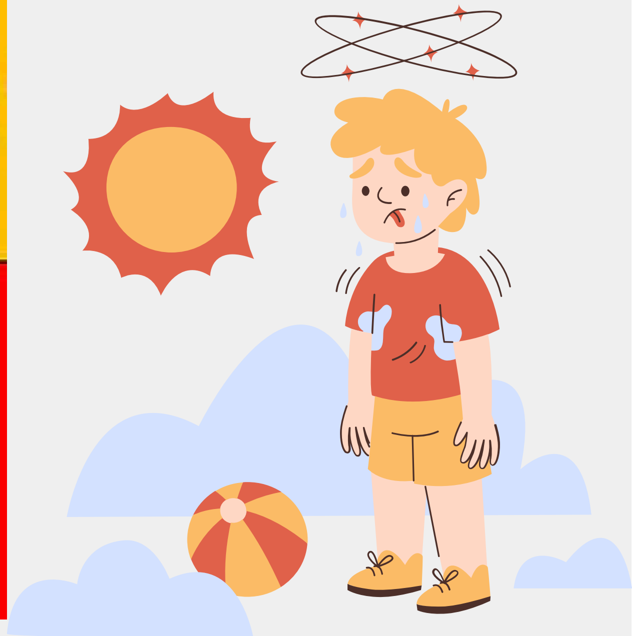
Health Impacts of Heat Waves

The health impacts of Heat Waves typically involve dehydration, heat cramps, heat exhaustion and/or heat stroke.

- Heat Cramps: Ederna (swelling) and Syncope (Fainting) generally accompanied by fever below 39°C i.e.102°F.
- Heat Exhaustion: Fatigue, weakness, dizziness, headache, nausea, vomiting, muscle cramps and sweating.
- Heat Stoke: Body temperatures of 40°C i.e. 104°F or more along with delirium, seizures or coma. This is a potential fatal condition



Colour Code	Alert	Warning	Impact	Suggested Actions
Green (No action)	Normal Day	Maximum temperatures are near normal	Comfortable temperature. No cautionary action required.	Nil
Yellow Alert (Be updated)	Heat Alert	Heat wave conditions at isolated pockets persists on 2 days	Moderate temperature. Heat is tolerable for general public but moderate health concern for vulnerable people e.g. infants, elderly, people with chronic diseases	(a) Avoid heat exposure. (b) Wear lightweight, light-coloured, loose, cotton clothes. (c) Cover your head: Use a cloth, hat or umbrella
Orange Alert (Be prepared)	Severe Heat Alert for the day	(i) Severe heat wave conditions persists for 2 days (ii) Through not severe, but heat wave persists for 4 days or more	High temperature. Increased likelihood of heat illness symptoms in people who are either exposed to sun for a prolonged period or doing heavy work. High health concern for vulnerable people e.g. infants, elderly, people with chronic diseases.	(b) Avoid heat exposure– keep cool. Avoid dehydration. (b) Drink sufficient water- even if not thirsty. (c) Use ORS, homemade drinks like lassi, torani (rice water), lemon water, buttermilk, etc. to keep yourself hydrated
Red Alert (Take Action)	Extreme Heat Alert for the day	(i) Severe heat wave persists for more than 2 days. (ii) Total number of heat/severe heat wave days exceeding 6 days.	Very high likelihood of developing heat illness and heat stroke in all ages.	Extreme care needed for vulnerable people.



Heat Index

The heat index is a measure that combines air temperature and relative humidity to determine how hot it actually feels to the human body, also known as the "apparent temperature". It is important because high humidity slows down the evaporation of sweat, which is the body's natural cooling mechanism, making the heat feel more intense than the thermometer reading

IMD has launched Heat Index

colour codes used for Experimental Heat Index are as follows:

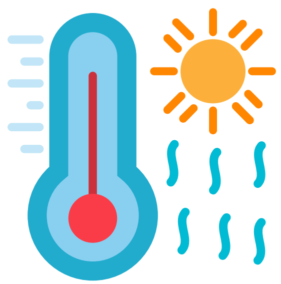
Green: - Experimental heat Index less than 35 deg C

Yellow: - Experimental heat Index in the range 36-45 deg C

Orange: Experimental heat Index in the range 46-55 deg C

Red: - Experimental heat Index greater than 55 deg C

Relative Humidity %	Air temperature °C										
	21	24	27	29	32	35	38	41	43	46	49
0	18	21	23	26	28	31	33	35	37	39	42
10	18	21	24	27	29	32	35	38	41	44	47
20	19	22	25	28	31	34	37	41	44	49	54
30	19	23	26	29	32	36	40	45	51	57	64
40	20	23	26	30	34	38	43	51	58	66	
50	21	24	27	31	36	42	49	57	66		
60	21	24	28	32	38	46	56	65			
70	21	25	29	34	41	51	62				
80	22	26	30	36	45	58					
90	22	26	31	39	50						
100	22	27	33	42							



Serious risk to health - heatstroke imminent

Prolonged exposure and activity could lead to heatstroke

Prolonged exposure and activity may lead to fatigue

Biological

Biological disasters are causative of process or phenomenon of organic origin or conveyed by biological vectors, including exposure to pathogenic micro-organisms, toxins and bioactive substances that may cause loss of life, injury, illness or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage. Examples of biological disasters include outbreaks of epidemic diseases, plant or animal contagion, insect or other animal plagues and infestation.

Biological disasters may be in the form of:-

Biological outbreak disasters •

- Dengue: The annual average number of human life loss has steadily increased across pre-HFA, HFA and post-HFA periods. Likewise, it is showing an increasing trend in most of the states. Himachal Pradesh showed highest deaths per 100,000 population, followed by Kerala.
- JE: In contrast to Dengue, the annual average number of human life loss has decreased across pre HFA, HFA and post-HFA periods. UP ranks highest on total deaths, while Andhra Pradesh in terms of per 100,000 population.
- COVID-19: Maharashtra ranks highest in terms of deaths followed by Karnataka, Andhra Pradesh and Tamil Nadu.

What's the difference between an endemic, epidemic and pandemic disease?

Endemic disease

Constantly present in a population or region, with relatively low spread

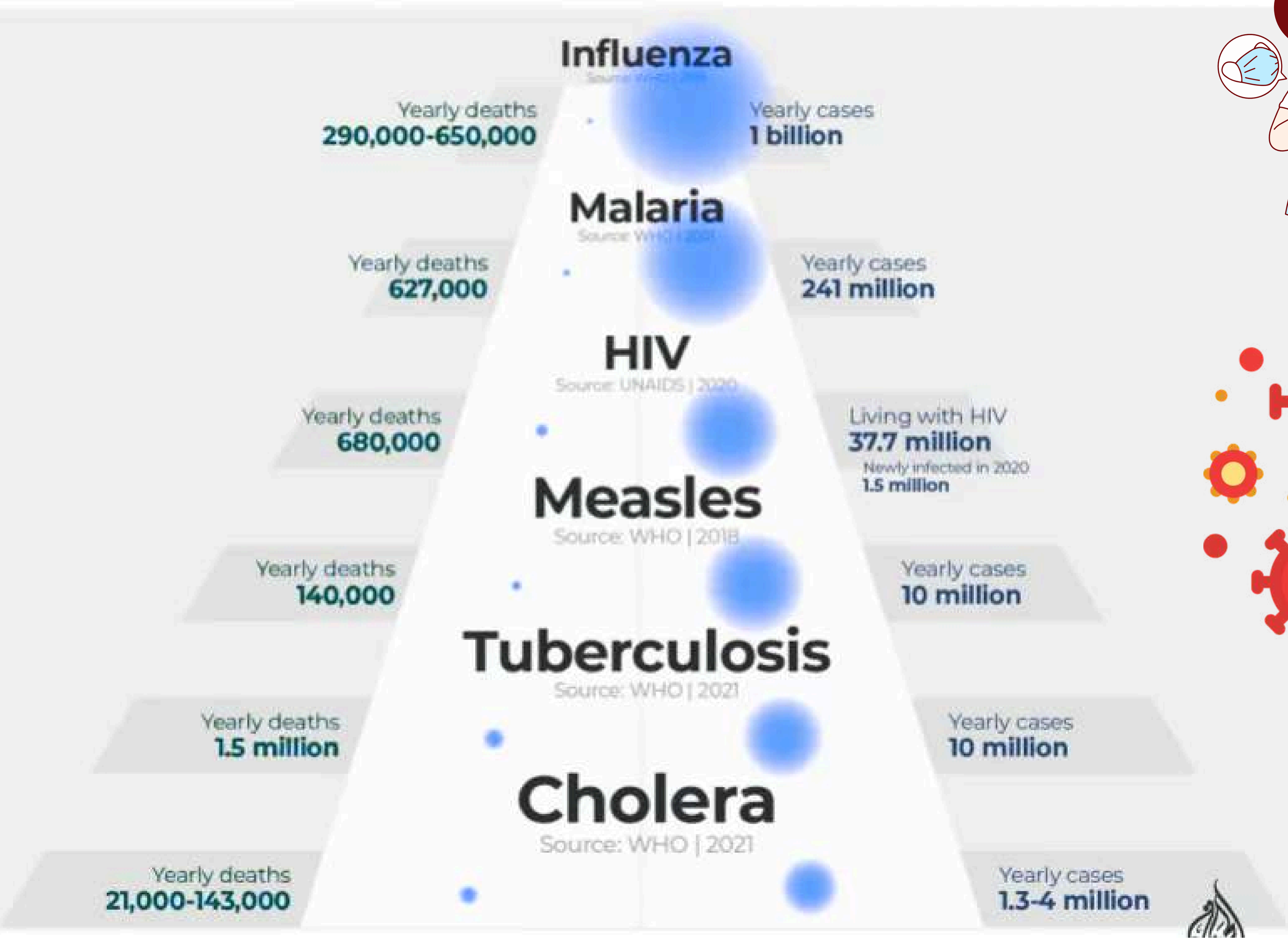
Epidemic disease

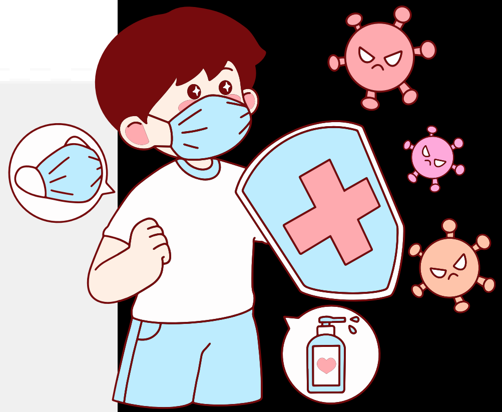
Sudden increase in cases spreading through a large population

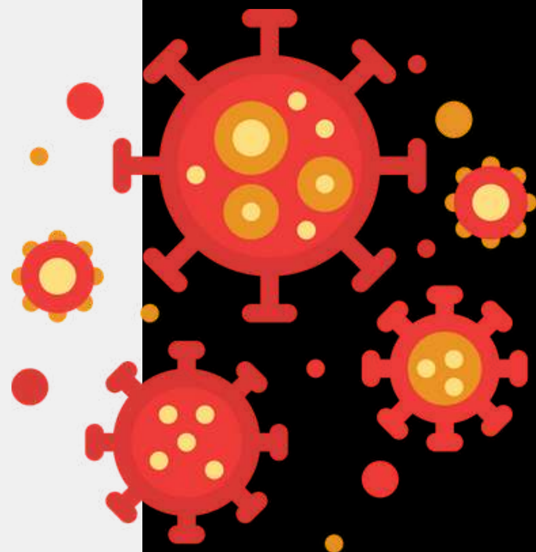
Pandemic disease

Sudden increase in cases across several countries, continents or the world

Endemic diseases are **constantly present** in a population within a particular region, making its spread more predictable.







Epidemic affecting a disproportionately large number of individuals within a population, community, or region at the same time, examples being Cholera, Plague, Japanese Encephalitis (JE)/Acute Encephalitis Syndrome (AES); or,
Pandemic is an epidemic that spreads across a large region, that is, a continent, or even worldwide of existing, emerging or reemerging diseases and pestilences, example being Influenza H1N1 (Swine Flu).

There are several other ways an epidemiologist might describe a disease event:

Sporadic refers to a disease that occurs irregularly or infrequently.5 Foodborne pathogens, such as Salmonella or E. coli, can often cause sporadic disease outbreaks. Tetanus is also a sporadic disease —it only occurs in unvaccinated individuals.6
Cluster refers to a disease that occurs in larger numbers, even though the actual number or cause may be uncertain. An example is the cluster of cancer cases often reported after a chemical or nuclear plant disaster.
Hyperendemic refers to persistent, high levels of disease well above what is seen in other populations. For example, HIV is hyperendemic in parts of Africa, where as many as one in five adults has the disease, in contrast to the U.S., where roughly one in 300 is infected.
Outbreak carries the same definition as an epidemic, but is often used to describe an event that is more limited to a geographic area.8
"Plague" is not an epidemiological term. It refers to contagious bacterial diseases like the bubonic plague, characterized by fever and delirium.

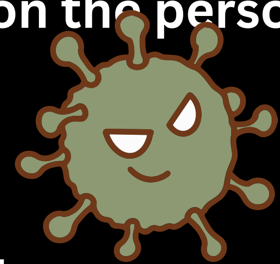
BIOLOGICAL HAZARDS AND THEIR BIOLOGICAL AGENTS

To control a biological hazard, you need to understand what kind of microorganism you're dealing with, how it behaves, and how it reaches its target. Not every microbe is harmful, but there are one that can spread quickly and cause serious problems, especially in vulnerable populations.

Pathogenic vs. Non-Pathogenic Microbes

Most people carry microbes that don't cause disease. These are part of our natural flora. But in the wrong situation, like when someone has a weakened immune system, those same organisms can shift from harmless to harmful. That's what makes some microbes opportunistic: they cause diseases only when the host is unable to fight back.

This is a key reason why biological hazards may have different effects depending on the person exposed.



Host Susceptibility and Virulence Factors

Some pathogens only need a small number of organisms to cause an infection. Others are more aggressive, with virulence factors that help them stick to cells, resist antibiotics, or survive harsh environments. This makes them harder to eliminate and more likely to trigger outbreaks.

Host health also matters. Age, immune status, and underlying conditions can all increase the healt risk.

Biological hazards come from a few well-known sources, many of which are part of daily life, microorganisms that cause problems include:

- Bacteria, like E. coli, Salmonella, and Listeria
- Viruses, such as Hepatitis A and E, and Norovirus
- Fungi, especially molds and yeasts found on damp food or surfaces
- Parasites, including Toxoplasma Gondii and Giardia Lamblia

Contaminated Environments

Water, soil, air, and surfaces can all carry microorganisms if they've been exposed to waste or untreated runoff.

Living Carriers

Humans, animals, and insects can carry pathogens without always showing symptoms. Livestock and rodents are especially common sources in food and agricultural settings. Flies, ticks, and mosquitoes also act as vectors, transferring pathogens between hosts or surfaces.

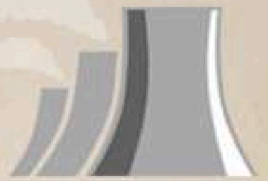
Transmission Routes of Concern

There are four main ways a biological agent can move from one place to another:

- Fecal-oral transmission: Contaminated food or water sources can carry bacteria, viruses, or parasites. Norovirus, Hepatitis A, and Giardia fall into this category.
- Airborne transmission: In crowded workplace settings like hospitals or meat processing plants, droplets or aerosols can spread viruses like influenza or TB.
- Contact transmission: Hands, doorknobs, shared tools, anything touched by someone carrying a biological agent can pass it along. These hazards are often invisible to the naked eye.
- Inoculation or ingestion: A food handler may accidentally introduce a parasite cyst into a salad. A nurse may get a needle injury that introduces bloodborne pathogens.

Radiation emergencies are non-routine situations or events that require a prompt action to mitigate a radio-nuclear hazard or its adverse consequences for human life, health, property or the environment. **Nuclear emergencies** involve release of the energy resulting from a nuclear chain reaction or from the decay of the products of chain reaction (e.g. nuclear power plant accidents such as Chernobyl and Fukushima accidents).

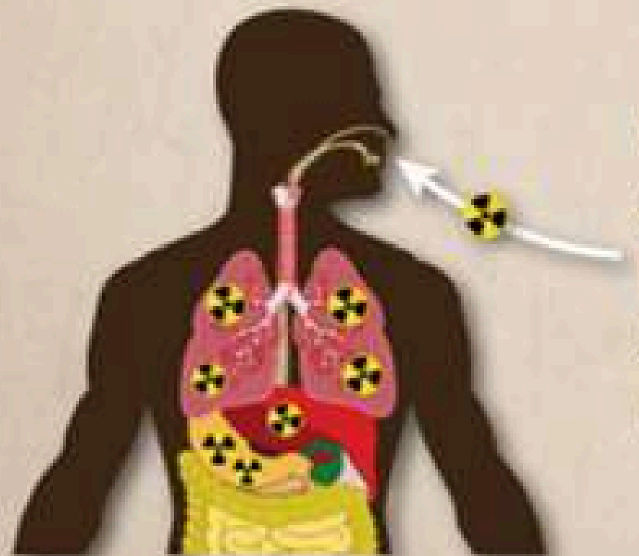
ACCIDENTS



Nuclear power plants have safety and security procedures in place and are closely monitored by the Nuclear Regulatory Commission (NRC). An accident at a nuclear power plant could release dangerous levels of radiation over an area (sometimes called a plume).

What are the main dangers of nuclear power plant accidents?

Radioactive materials in the plume from the nuclear power plant can settle and contaminate people who are outdoors, buildings, food, water, and livestock.



Radioactive materials can also get inside the body if people breathe it in, or eat or drink something that is contaminated.

People living close to the nuclear power plant who are exposed to radiation could experience long-term health effects such as cancer.

Radiological emergencies are situations involving a radiation exposure from a radioactive source. When referring to an emergency situation regardless of its type, "radiation emergency" term is often used.

Radiation emergencies may result from misuse of radioactive sources during industrial, medical or research applications, accidental exposure to uncontrolled (abandoned, lost or stolen) radiation sources, accidents during transport of radioactive materials, but also can be combined with conventional emergencies (a fire or a release of chemical substances), natural disasters, military conflicts, or malicious acts involving radiation sources.

Ionizing radiation and health effects

- Ionizing radiation is a type of energy released by atoms in the form of electromagnetic waves or particle.
- People are exposed to natural sources of ionizing radiation, such as in soil, water, and vegetation, as well as in human-made sources, such as x-rays in medical devices.
- Ionizing radiation has many beneficial applications, including uses in medicine, industry, agriculture and research.
- As the use of ionizing radiation increases, so does the potential for health hazards if not properly used or contained.
- Acute health effects such as skin burns or acute radiation syndrome can occur when doses of radiation exceed very high levels.
- Low doses of ionizing radiation can increase the risk of longer term effects such as cancer

Chemical Disaster

Chemical, being at the core of modern industrial systems, has attained a very serious concern for disaster management within government, private sector and community at large. Chemical disasters may be traumatic in their impacts on human beings and have resulted in the casualties and also damages nature and property. The elements which are at highest risks due to chemical disaster primarily include the industrial plant, its employees & workers, hazardous chemicals vehicles, the residents of nearby settlements, adjacent buildings, occupants and surrounding community. Chemical disasters may arise in number of ways, such as:-

Process and safety systems failures

- Human errors
- Technical errors
- Management errors
- Induced effect of natural calamities
- Accidents during the transportation
- Hazardous waste processing/ disposal
- Terrorist attack/ unrest leading to sabotage

Following are the relevant provisions on chemical disaster management, prevailing in country:-

- **Explosives Act 1884 - Petroleum Act 1934**
- **Factories Act 1948 - Insecticides Act 1968**
- **Environment Protection Act 1986 - Motor Vehicles Act 1988**
- **Public Liability Insurance Act 1991 - Disaster Management Act 2005**

The **National Disaster Management Authority** (NDMA) is India's top body for disaster management, chaired by the Prime Minister, and is responsible for creating policies, plans, and guidelines for disaster mitigation, preparedness, and response. Established by the Disaster Management Act, 2005

Key functions and responsibilities

- Policy and planning: Lays down policies, approves the National Plan, and issues guidelines for disaster management at all government levels.
- Coordination: Coordinates the enforcement and implementation of disaster management policies and plans across different government ministries and departments.
- Resource allocation: Recommends the provision of funds for disaster mitigation activities.
- Capacity building: Works on capacity building to deal with threatening disaster situations.
- External assistance: Provides support to other countries affected by major disasters, as determined by the Central Government.
- Implementation: Guides the implementation of plans at the state and district levels through State and District Disaster Management Authorities (SDMAs and DDMAs).

The NDMA Coordinates response with the help of several Nodal agencies from different ministries.

Disaster	Agency	Ministry
Cyclone	IMD	M/o ES
Heat & Cold waves	IMD	M/o ES
Tsunami	Indian Tsunami Early Warning Centre (ITEWC), under Indian National Centre for Oceanic Information Services (NCOIS)	M/o ES
Flood	CWC	M/o WR
Landslides	Geological Survey of India	M/o Mines
Avalanches	Snow & Avalanche study establishment, DRDO	M/o Defence
Epidemics	Central Disease Surveillance Unit & State Disease Surveillance Unit	M/o Health and Family Welfare