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Earth System Science Panorama: An Overview

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Prologue

Addressing the critical challenges posed by global warming and climate change is a pressing concern for the survival of the human race. Recent research and events in Earth, climate, and environmental sciences highlight the urgency of this issue. **Key findings indicate a worrying trend of rising global temperatures, leading to severe weather events, melting polar ice caps, rising sea levels, and disruptions in ecosystems worldwide. These changes threaten not only biodiversity but also the livelihoods and well-being of human populations. Recent studies underscore the human impact on the environment, particularly through greenhouse gas emissions from industrial activities, deforestation, and unsustainable practices**. This anthropogenic influence significantly contributes to the acceleration of climate change. Furthermore, the need for immediate and effective remedial measures is evident. Strategies such as transitioning to renewable energy sources, implementing sustainable land-use practices, enhancing biodiversity conservation efforts, and adopting climate-resilient infrastructure are crucial steps toward mitigating the impacts of global warming. The compilation and revamphification of research findings, news, and events in the fields of Earth, Climate, planetary and Environmental sciences have been done by us in this section of this issue for the greater interest of the student-teacher community and wider public in simple language viewing their understanding limits. **These recent findings are not available in their prescribed textbooks. To spread global awareness on these sciences and follow up action plans to save our planet-earth is our prime objective. We have tried to present some important aspects of these themes in this column for critical reading, analysis, and feedback by our readers**.

Recent Research Findings and News on Earth Science

1. Uttarakhand tunnel collapse: Revisit safety guidelines, say experts.

The incident occurred at the Silkyara Bend–Barkot tunnel in Uttarakhand on November 12, 2023, where a section collapsed, trapping 41 construction workers inside for a period of two weeks. **Despite a multi-agency rescue effort involving government and international experts employing a five-pronged approach, they were unable to reach the workers due to the complex debris structure within the tunnel**. The collapse raised concerns about the fragile geological nature of the Himalayas, posing significant challenges to rescue operations and highlighting the necessity for extreme caution during projects like the Char Dham Pariyojana. Geologist Dr.S.P Sati from the Uttarakhand University of Horticulture and Forestry suggested that the use of explosives in tunnel construction might have contributed to the collapse. **He also noted the absence of an escape route, despite regulations mandating its construction for such tunnels. Dr. Sati emphasized the need for comprehensive geophysical and geotechnical surveys for all projects in ecologically sensitive areas. "There is a need for a comprehensive overhaul of the safety regulations for tunnel construction**. Regarding the Char Dham project (Badrinath, Kedarnath, Gangotri, and Jamunetri) typically requiring an Environmental Impact Assessment (EIA), the project was divided into multiple segments, each under 100 kilometres, which exempted it from a comprehensive EIA. This exemption has been criticized by experts like Dr.Sati and Mr.Ravi Chopra, the former chairperson of the committee appointed by the Supreme Court for the Char Dham project. Mr. Chopra deemed the bypassing of the EIA (Environmental Impact Assessment) as criminal neglect, stressing the essential nature of such assessments, especially in ecologically sensitive areas. The committee had urged the Centre to conduct an EIA, emphasizing its significance in ensuring the project's environmental safety. The incident highlighted the necessity for comprehensive safety regulations in tunnel construction and the importance of forming specialized oversight committees to monitor such projects. **Mr. Chopra's remarks and the concerns raised by experts like Sati indicate the need for a more stringent approach to safety regulations and environmental assessments in large-scale projects like the Char Dham Pariyojana to prevent such catastrophic incidents and preserve ecological balance**.

Courtesy: Nitin Kumar Dhruvaksh Saha, Business Standard, December 26, 2023.

2. Tectonic Tales of Life: How Geology Has Influenced Evolution for the Past 500 million Years

The recent research published in Nature reveals an intriguing connection between geological processes

and Earth's biodiversity over a timescale of 500 million years. It suggests that the movements of rivers, mountains, oceans, and sediment nutrients have significantly influenced the evolution and diversity of life on our planet. This research delves into the intricate relationships among physical, chemical, and biological systems across geological ages. The study focuses on the period after the Cambrian explosion, which established major modern life species types. It emphasizes the role of rivers as Earth's circulatory system, not only shaping landscapes but also acting as primary conduits for nutrient and sediment transfer from mountain sources to ocean sinks. Utilizing a model that spans half a billion years in five-million-year increments at a resolution of five kilometres, the research provides unprecedented insights into the factors driving species diversity, sediment flux to oceans, and the diversity of marine animal families over this extensive timeframe. The strong positive correlation, indicated by the Pearson coefficient of 0.88, emphasizes the relationship between these geological variables and biodiversity. The study integrates findings from significant evolutionary events such as the Cambrian explosion, the Great Ordovician Biodiversification Event (GOBE), and the major mass extinction events, demonstrating how geological occurrences have impacted biodiversity over time. Moreover, it highlights the discovery of the ancient Wollemi pine species in a secluded valley of the Blue Mountains, underlining the interconnectedness of geology, hydrology, climate, and genetics in influencing biodiversity and species survival. The research builds upon the work of renowned naturalists like Alexander von Humboldt, **whose observations inspired Charles Darwin and Alfred Wallace. It links landscape features to boundaries between animal species, indicating the critical role landscapes play in shaping Earth's biodiversity**. The groundbreaking unified theory proposed by a team of scientists from various institutions aims to connect the evolution of life in marine and terrestrial realms to sediment pulses controlled by past landscapes. By considering the cumulative interactions between the geosphere and atmosphere, they suggest that Earth's surface evolution provides the context for biodiversity to evolve. The team's model combines various environmental factors, providing a comprehensive simulation that accounts for the compounding effects of geological, climatic, and biological forces. By calibrating this simulation with genetic, fossil, climate, hydrology, and tectonics data, they aim to better understand the complex relationships driving biodiversity evolution. Their analysis demonstrates significant correlations between predicted sediment flux into oceans and marine biodiversity, as well as between landscape features and plant diversification on land. This suggests a profound interconnection between geological processes and the evolution of life on both land and marine environments over millions of years.

Courtesy: SciTech Daily, December 2023.

3. Thailand's Hidden Treasure: New Trilobite Species Reveal Secrets of Ancient Supercontinent Gondwanaland

The discovery of ten new trilobite species in Thailand, dating back 490 million years, offers significant insights into Earth's geological history and its connection to the ancient supercontinent Gondwanaland. Trilobites, extinct marine creatures with distinctive half-moon-shaped heads, provide clues about the geography and environments of ancient times. These newly discovered trilobite species, found in a less explored area of Thailand, shed light on the complex puzzle of ancient world geography. The trilobite fossils were preserved between layers of petrified ash in sandstone, formed from volcanic eruptions settling on the sea floor, creating a green layer known as a tuff. A 100-page monograph published in a British journal provides detailed information about the newly identified species, including one named in honor of Thai Royal Princess Maha Chakri Sirindhorn. The fossils were dated using radioisotope techniques on zircon crystals found within the tuff layers. Zircon, known for its chemical stability and resistance to heat and weathering, allowed scientists to determine the age of the volcanic eruption, subsequently dating the fossils to around 490 million years ago, during the late Cambrian period. Discovering tuffs from this specific period is rare, and their presence will aid in dating similar fossils found in regions like China, Australia, and North America, where comparable fossils exist in rocks that lack reliable dating methods. The fossils were excavated from Ko Tarutao, an island about 40 minutes southwest of the Thai mainland, recognized as a UNESCO geopark site that has attracted international scientific teams. One of the most intriguing aspects of the discovery is the identification of 12 trilobite types previously unseen in Thailand but found elsewhere globally. This finding suggests connections between Thailand and other regions, notably Australia, during the late Cambrian era when this part of the world was situated on the outer edges of Gondwanaland. During the trilobites' lifetime, this region was on the outer margins of Gondwanaland, an ancient supercontinent that included Africa, India, Australia, South America, and Antarctica. "Because continents shift over time, part of our job has been to work out where this region of Thailand was in relation to the rest of Gondwanaland," Dr.Hughes said. This process involves piecing together a dynamic, ever-changing 3D puzzle of ancient geography. The naming of a species in tribute to Princess Maha Chakri Sirindhorn recognizes her commitment to advancing scientific endeavours in Thailand. Overall, the fossils discovered offer invaluable information about ancient environments and

geographical connections, contributing significantly to our understanding of Earth's past.
Courtesy: Sci Tech Daily, December 19, 2023.

4. 2023 Nepal earthquake

A moment magnitude 5.7 earthquake struck Jajarkot District, Karnali Province, Nepal, on 3 November 2023, killing 153 people and injuring at least 375. The earthquake was widely felt in western Nepal and northern India and is the deadliest to strike the country since 2015. Nepal lies in the Himalayas, where earthquake activity is associated with ongoing continental collision between the Indian and Eurasian plates. These plates converge at a rate of 40–50 mm (1.6–2.0 in) per year. **The Indian Plate is thrusted beneath the continental crust of the Eurasian Plate, forming thrust faults along the collision zone. The Main Frontal Thrust predominantly accommodates this motion. Earthquakes along these thrust faults have been devastating in historic times**. Based on a study published in 2014, of the Main Frontal Thrust, on average a magnitude 8 or larger earthquake occurs every 750 ± 140 and 870 ± 350 years in the east Nepal region. A study from 2015 found a 700-year delay between earthquakes in the region. The study also suggests that because of tectonic stress buildup, large earthquakes such as the 1934 and 2015 events in Nepal may be connected, following a historic earthquake pattern. A 2016 study on historical great ($M \geq 8$) earthquake pairs and cycles found that associated great earthquakes are likely to occur in the West China region through the 2020s. Nepal's National Earthquake Monitoring and Research Centre recorded the earthquake at 6.4 on the local magnitude scale. The epicentre was estimated to be in Ramidanda, in Jajarkot District. A magnitude 5.3 aftershock occurred on 6 November. Another 375 people were injured. **Despite the earthquake's relatively low magnitude, the high levels of damage and casualties were attributed to substandard construction in the region and because it occurred at night when people were asleep. Many of the collapsed houses were made of stacked logs and rocks. About 62,039 houses were affected across thirteen districts of Nepal, of which 26,550 collapsed,** mostly in Rukum West District.
Courtesy: Wikipedia.

5. The recent discovery of vast phosphate reserves in southwest Norway

The recent discovery of vast phosphate reserves in southwest Norway, announced by Norge Mining, has far-reaching implications for global resource dynamics. **Estimated at approximately 70 billion metric tons, this discovery has the potential to meet worldwide demands for fertilizers, solar panels, and electric vehicle batteries for at least a century, as reported by EURACTIV based on Norge Mining's announcement**. Phosphate, a critical material for fertilizer production, holds strategic importance according to the European Commission's considerations outlined in their Critical Raw Materials Act. Approximately 90 percent of mined phosphate rock is used for phosphorous production, a crucial component in fertilizers that is currently irreplaceable. The global food supply chain heavily depends on fertilizers, making it susceptible to price fluctuations, especially during geopolitical tensions such as those observed in the Russia-Ukraine conflict. **Beyond fertilizer production, phosphorous plays a vital role in the manufacturing of solar panels and advanced lithium batteries used in electric vehicles, semiconductors, and computer chips**. Europe, recognizing the strategic significance of these products in its transition towards green and digital advancements, has prioritized them for production. Historically, phosphate rock reserves were concentrated in regions like the Western Sahara in Morocco, China, Egypt, and Algeria. **However, the discovery in Norway, considered the world's largest, has shifted this paradigm. The newly found deposit, with an estimated 4,500 meters underground extension, surpasses initial expectations. Norge Mining is committed to environmentally sustainable operations, planning to capture carbon emissions and implement greener mining processes**. The strategic significance of the discovered phosphate deposit has garnered interest from both the Norwegian government and global stakeholders. This discovery is pivotal for Europe as it helps to reduce dependence on external suppliers for critical raw materials. **Additionally, the presence of vanadium and titanium within the phosphate deposit has attracted attention from the aerospace and defense industries. The combination of Norway's phosphate discovery and neighboring Sweden's recent rare-earth metal discovery is seen as a significant strategic advantage in the geopolitical landscape, particularly in competition with Moscow and Beijing. In conclusion, the massive phosphate discovery in Norway has the potential to reshape global resource dynamics, reinforcing Europe's position in strategic industries and contributing to the transition towards sustainable and advanced technologies**.

Courtesy: Moneycontrol news, July 2023.

6. On mitigation of earthquake and landslide hazards in the eastern Himalayan region

The detailed research conducted by Dr. Brijesh K. Bansal and associated geoscientists offers valuable insights into earthquakes and landslides, particularly in the eastern Himalayan region. This compilation, aimed at the student and teacher community, serves to disseminate recent research findings that are not commonly available in standard textbooks. The objective is to foster awareness and facilitate the development of strategic plans to mitigate geological hazards through scientific and engineering applications, significantly reducing their impact on human life and local infrastructure. Mitigation efforts encompass various crucial steps, including precise hazard mapping, potential assessment, continuous monitoring, early warning systems, geotechnical treatment, and the design of resilient infrastructure. Several government initiatives have been instrumental in identifying vulnerable areas, enhancing understanding of crustal structure, geodynamics, tectonics, seismogenesis, and soil properties, among other factors, aiding in better mitigation strategies. Mass awareness, education, and community participation are integral aspects of the overall strategy to minimize losses and destruction from future earthquakes and landslides. Government-led programs, such as the School Earthquake Laboratory Programme (SELP), have successfully engaged students and teachers in earthquake-related data collection, analysis, and awareness building. These initiatives, particularly in the eastern Himalayan states like Assam, Nagaland, Sikkim, and Arunachal Pradesh, have been beneficial in creating earthquake awareness among students and inspiring interest in further studies in this field. Continuous monitoring and the implementation of various initiatives have significantly improved the ability to detect and locate earthquakes promptly. For instance, the expansion of the seismological network has facilitated rapid estimation and dissemination of earthquake information, aiding stakeholders within a short timeframe. Additionally, GPS observations along the plate boundary and within the Indian plate have provided critical data for estimating convergence rates and Indian plate motion in different regions. Studies encompassing crustal conductivity imaging, palaeo seismological investigations, earthquake source characteristics, crustal structure, and numerical modelling have provided essential insights for earthquake-resistant structural designs, urban planning, and disaster management. Similarly, efforts directed toward landslide mapping, monitoring, and early warning systems have contributed to a better understanding of landslide causes and effects, aiding in the development of effective mitigation techniques. The research outlined in this paper not only enhances understanding and management of geological hazards but also highlights areas for further study and improvement, such as identifying hidden faults, mapping active faults, and enhancing science communication. Bridging the gap between research and practice through effective science communication and reducing this gap is vital. Several proposed initiatives, including strengthening landslide monitoring, expanding GPS measurements across major structural features, conducting locale-specific geological and geophysical studies, developing earthquake scenarios, and promoting awareness through regular training and campaigns, aim to enhance preparedness and mitigation efforts. Ongoing collaborative efforts with countries like Italy, the UK, and Norway to strengthen the national seismological network and develop landslide early warning systems hold promise for minimizing future earthquake and landslide-related losses and damages. The comprehensive research findings and proposed initiatives provide a roadmap for better mitigation strategies and preparedness in the face of geological hazards, offering significant potential for reducing the impact of earthquakes and landslides on communities and infrastructure in the eastern Himalayan region.

Courtesy: Bansal et al. Natural Hazards, 2022.

7. Not just Earth, scientists have now discovered volcanic activity on Mars

The recent identification of volcanic activity on Mars has sparked significant interest among scientists due to its intriguing parallels with Earth's geological history. Despite the apparent calmness of the Martian surface, investigations have unveiled a turbulent volcanic past that draws striking similarities to Earth's own volcanic activity. Research focused on the Martian plain known as Elizabeth Planitia suggests that volcanic eruptions might have occurred within the last 120 million years. Evidence of past volcanic activity is visible on the Martian surface, resembling a face with numerous features resembling volcanic eruptions. These eruptions, however, are considered to have taken place in the distant past. Although Mars seems relatively stable, its interior reveals a history of magma and lava activity. The study concentrated on Elysium Planitia, identified as Mars's youngest volcanic terrain, shedding light on both historical and current volcanic phenomena on the planet. Considering the vast cosmic timeline, volcanic activity initiation on Mars dates back a mere million years, a comparatively recent occurrence in the age of the universe. Scientists note the novelty of this discovery, emphasizing that such

signs were not observed previously. While pinpointing the exact timing of these eruptions remains challenging, scientists estimate their occurrence around the era when dinosaurs roamed Earth. Joana Voigt and Christopher Hamilton from the University of Arizona highlight Elysium Planitia as a region exhibiting more significant volcanic activity than previously believed, possibly indicating ongoing volcanic processes. The discovery of lava flow spots on Mars's surface has piqued scientific curiosity. Voigt emphasizes Elysium Planitia's significance in understanding the dynamic relationship between the planet's surface and its inner dynamics, manifested through volcanic eruptions. NASA's InSight lander, deployed in 2018 and 2022, has played a pivotal role in recording Mars's internal disturbances through vibrations and constant ringing, providing crucial data for understanding the planet's geological processes. The timeframe of volcanic activity on Mars aligns intriguingly with the existence of dinosaurs on Earth, approximately 120 million years ago. This revelation challenges previous assumptions about Mars's geological activity and significantly contributes to our evolving comprehension of the planet's evolution. The discovery of volcanic activity on Mars not only provides insight into the planet's geological past but also raises questions about its present and future geological dynamics, fostering further exploration and study of our neighbouring celestial body.
Courtesy: Times of india.com, Dec 2023, Source: NASA.

8. Initiatives towards Net Zero pollution

Minister of State for Environment, Forest and Climate Change, Shri Ashwini Kumar Choubey in a written reply to a question in Lok Sabha informed that India has submitted **its long-term low carbon development strategy which lays out India's vision and approaches towards reaching net zero by 2070**. India's commitment to combatting climate change and pollution through a combination of regulatory measures, innovative programs, and collaborative efforts at both the national and state levels are highly appreciated by the CEHESH FRATERNITY. The focus on sustainability, green initiatives, and inclusive development is evident throughout these initiatives.

A summary of the key points:

1. Nationally Determined Contribution (NDC) and Low Carbon Development Strategy:
    - India has submitted an updated NDC for 2021-2030 and a long-term low-carbon development strategy aiming for net zero emissions by 2070.
    - Foundational principles of equity have been considered in the preparation of these documents.
2. Government Initiatives for Pollution Prevention and Control:
    - Enactment of environmental laws, guidelines, and standards.
    - Notification of National Ambient Air Quality and effluent discharge standards.
    - Introduction of cleaner/alternate fuels, ethanol blending program, and leapfrogging to BS VI fuel norms.
    - Promotion of cleaner production processes and incentives for hybrid and electric vehicles.
3. Waste Management and Pollution Control Measures:
    - Notification of rules for environmentally sound management of various types of waste.
    - Ban on single-use plastic and open burning of leaves, biomass, and waste.
4. National Clean Air Programme (NCAP):
    - A national strategy to reduce air pollution, including city-specific Clean Air Action Plans for 131 cities.
5. Plantation and Greening Initiatives:
    - Multi-departmental and multi-agency plantation activities under various programs and funding sources.
    - Specific action points under NCAP for extensive plantation drives, agro-forestry schemes, and city-specific plans.
6. Ethanol Blending Program:
    - Target to achieve 20% blending of ethanol in petrol by ESY 2025-26.
7. Revised Environmental Standards for Brick Kilns:
    - Issuance of revised environmental standards, emphasizing the use of approved fuels and monitoring emissions.
8. Climate Targets and NDCs:
    - India's NDC for 2021-2030 includes targets for reducing emission intensity, increasing non-fossil fuel sources in electric capacity, and creating a carbon sink.
9. National Action Plan on Climate Change (NAPCC):

- Comprehensive programs and schemes covering areas like solar energy, energy efficiency, water, sustainable agriculture, health, Himalayan ecosystem, sustainable habitat, green India, and strategic knowledge for climate change.

10. State Action Plans on Climate Change (SAPCC):
    - Thirty-four States/Union Territories, including Bihar, have prepared SAPCCs aligned with NAPCC, addressing state-specific climate change issues.

Courtesy: Press Information Bureau, March 20, 2023.

9. Indore declared India's first "water plus" city

After being declared India's cleanest city for the last four years, Indore is now **the country's first "water plus" city**. Water Plus is a new evaluation category introduced by the Ministry of Housing and Urban Affairs in its Swachh Survekshan (survey) for 2021. The parameter explains the city's preparedness in terms of recycling wastewater and conserving water bodies. **As per the guidelines, a city will get Water Plus tag only after all the wastewater released from households and commercial establishments is treated to a satisfactory level before releasing into the environment**. According to the Indore Municipal Corporation, the city is reusing close to 110 million liters of wastewater each day by installing seven sewerage treatment plants. The municipality also succeeded in closing more than 7000 private and commercial sewerage systems that dumped its waste water directly into the city's water bodies.

10. A despairing handwriting of a film shows the effects of environmental crisis on India's capital – with images as nightmarish as sci-fi

The documentary "Invisible Demons" by Rahul Jain provides a stark and haunting portrayal of the severe environmental degradation and its disproportionate impact on the marginalized communities in India. The film captures distressing scenes of pollution in Delhi, presenting a bleak picture of a looming environmental apocalypse. Jain's admission of his own privilege, growing up in a sheltered environment, sets the tone for the exploration of environmental injustice in India. **The film highlights the harsh reality that the economically disadvantaged bear the greatest burden of the country's rapid economic growth. It showcases how pollution-related health issues, exacerbated by extreme temperatures and toxic air, are ravaging the population. The documentary effectively uses visuals, such as patients in hospitals struggling for breath, streets engulfed in thick smog, and rivers contaminated with industrial waste and plastic, to paint a distressing picture of the environmental crisis**. The absence of any uplifting or hopeful resolution further emphasizes the gravity of the situation. The lack of political action or intervention adds to the despair, indicating a disheartening reality where those in power turn a blind eye to these critical issues. **"Invisible Demons" sheds light on the urgent need for action, drawing attention to the devastating consequences of environmental degradation and the pressing need for policies and interventions to address these issues. The film serves as a wake-up call, urging society to confront the environmental crisis before it escalates further**.

Courtesy: Cath Clarke, The Guardian, October 2, 2022.

11. Lucid explanation of Climate change terms

From net-zero to regenerative agriculture (RA), ESG (Environmental, social, and corporate governance), Wet bulb temperature (WBT), Distributed Renewable Energy (DRE), etc. are some terms that have been explained in a lucid manner.

a. *Anthropogenic climate change*

The term 'anthropogenic' is derived from the Greek words anthropos, meaning human, and 'genesis', meaning origin. It is used to describe something that is of human origin, caused by human activity, or related to human influence. In the context of climate change, it refers to the climate crisis that is primarily driven by human activities, such as the burning of fossil fuels for energy generation or the reduction of forest cover that stores carbon. These actions have led to the increase of greenhouse gas emissions in the atmosphere, causing the warming of the planet. While the earth has its own natural cycles of warming and cooling, temperatures have been rising at an unprecedented rate since the mid-1800s. Data shows that the planet's average surface temperature has increased by approximately 1.1°C since the start of the Industrial Revolution in 1850, highlighting how human activity has been pushing the rate of greenhouse gas emission. The sixth assessment

report by the Intergovernmental Panel on Climate Change (IPCC) also states that human-caused emissions of greenhouse gases "have led to an increased frequency and/or intensity of some weather and climate extremes".

b. *Just transition*

A just transition refers to minimizing the adverse impacts of the energy transition—**from fossil fuel to renewable energy sources**—on vulnerable groups and communities. It seeks to address the socio-economic consequences of climate policies so that marginalized communities don't bear the brunt of the shift. For example, as economies move away from fossil fuel to renewable energy sources, a just transition framework can ensure workers and communities dependent on these industries find alternative sources of income and aren't left behind in the transition. The concept of a just transition has its roots in the labour and environmental movements of the 20th century. It gained prominence when it was introduced at the United Nations Earth Summit in Rio de Janeiro in 1992, and then included in the preamble of the Paris Agreement in 2015. This recognition highlighted the need for a just transition lens in global policies to address the unique challenges of the Global South. In India, coal continues to be a stable source of power. With a growing population, and growing energy demands, the country's coal usage is stated to peak between 2030 and 2035. With a majority of its population and economy dependent on coal, India has kept away from international treaties such as the Just Energy Transition Partnerships that demand ambitious coal phase-out targets from recipient countries in exchange for financial support.

c. *Climate intersectionality*

Intersectionality acknowledges the different aspects of a person's identity—such as race, gender, sexuality, and class—and how they interact with one another. In the context of climate change, an intersectional lens recognizes that the climate emergency and its solutions impact individuals and communities differently on the basis of these various socio-economic factors. For example, globally, 80 percent of the population displaced by climate change is female. Women also face a higher rate of mortality during extreme weather events, according to studies by WHO. This sheds light on how the climate crisis can worsen existing inequalities, reinforcing the need for more inclusive and equitable solutions.

d. *common but differentiated responsibilities*

Common but differentiated responsibilities (CBDR) is a key principle recognized in the United Nations Framework Convention on Climate Change (UNFCCC), guiding global climate change negotiations. CBDR points to the importance of a fair and equitable distribution of efforts and resources in addressing environmental issues. The principle of CBDR acknowledges that the crisis is a universal issue.

e. *Regenerative agriculture*

Regenerative agriculture is a farming system that focuses on soil health and involves a set of practices that minimizes the ploughing of the land and the use of artificial chemicals and pesticides. It includes methods such as planting different types of crops in rotation and using animal manure and compost to replenish soil nutrients. This in turn improves the soil's ability to retain water, resulting in less water wastage in farming while simultaneously enhancing the nutrient quality of crops. Additionally, due to improved soil health, farmers have to spend less on inputs such as fertilizers and pesticides. This can help in significantly reducing greenhouse gas emissions from farming while also increasing the soil's capacity to absorb more carbon from the atmosphere. However, it also highlights that historically, developed countries have contributed more to greenhouse gas emissions and therefore must bear a greater responsibility when it comes to climate action. Additionally, developed nations—with more advanced technology and financial resources—are better equipped to address the climate crisis, while developing countries—facing greater vulnerability—are still pursuing crucial developmental goals. Under this principle, countries have been divided into Annex I and non-Annex I. The former countries are generally developed countries and have a greater mitigation responsibility than non-Annex I countries.

f. *Nature-based solutions*

Nature-based solutions or NbS are strategies to address environmental and societal challenges using natural resources. They aim at mitigating climate change while also providing co-benefits such as biodiversity conservation and improved livelihoods for communities. For example, in coastal Gujarat, mangrove restoration is a prime example of NbS, as it offers local communities livelihood opportunities and a buffer against erosion

and hurricanes. Additionally, mangroves have a unique capacity to capture and store large amounts of carbon from the atmosphere. In India, NbS are currently implemented under different schemes and programmes including the Mahatma Gandhi National Rural Employment Scheme, as a part of which approximately 60 percent of the activities are related to natural resource management, and the National Action Plan on Climate Change (NAPCC). Additionally, they are a crucial part of India's climate mitigation strategy as found in the country's Nationally Determined Contributions.

g. *Net zero emissions*

Net zero emissions refers to achieving a balance between the release of greenhouse gases into the atmosphere and their removal from it. This involves counteracting the various sources of these gases, such as the burning of fossil fuels, with sinks that help absorb the gases from the atmosphere. Forests and the ocean are examples of two natural sinks in our environment. While carbon dioxide (CO2) is the most commonly discussed greenhouse gas in this context, achieving net zero also involves cutting down emissions of methane (CH4) and nitrous oxide (N2O). Achieving net zero emissions is central to the global agenda of addressing climate change. At COP26, India committed to attaining this goal by 2070. Other countries too have committed to reaching net zero—Sweden by 2045, the UK by 2050, and China by 2060. However, climate scientists have warned that net zero promotes the idea of 'burn now, pay later'. It focuses on reducing carbon emissions in the near future, which may lead to delayed action in reducing emissions today. This may create more emissions than absorption in sinks, whether natural or artificial,

h. *Decarbonisation*

Decarbonisation is the process of moving away from practices that would add more carbon to the environment, and instead moving towards carbon-capturing practices or those practices that would absorb carbon from the atmosphere. Current transportation, agriculture, and land use practices, for instance, are some of the leading sources of carbon emissions globally. Decarbonisation will require a shift from these practices, while simultaneously adopting practices such as afforestation and regenerative agriculture that will facilitate in removing carbon from the atmosphere in the long run. The modern economy is heavily reliant on fossil fuel usage, which is one of the largest sources of CO2 in the atmosphere and decarbonisation will entail a complete economic overhaul and finding alternative ways of living and working conditions.

i. *Heat action plans*

July 2023 was the hottest month on record. The temperatures were 1.5°C higher than pre-industrial times. As temperatures rise, many countries such as India that are highly vulnerable to heatwaves are facing severe repercussions. According to the National Disaster Management Authority, the number of people who have died due to heatwaves in India has been increasing for a few decades. This is where heat action plans (HAPs) come in. HAPs are measures that the state- or local-level administration takes to protect those communities that are at the greatest risk from heatwaves. The people working in the unorganized sector, such as daily wage workers at construction sites and street vendors, and gig workers such as delivery executives mostly suffer. The HAP explains the preparation required to deal with a heatwave through the adoption of certain methods. **This could include sending regular text alerts when temperatures cross a certain mark; directing resources such as healthcare, financial support, and infrastructural facilities such as shelters and water coolers on streets; organizing public awareness campaigns on how to minimize the effects of and protect oneself from a heatwave**. India's first HAP was introduced in Ahmedabad, Gujarat, in 2013. Other municipalities in India have also implemented HAPs. However, a study by the Centre for Policy Research on all 37 HAPs identified significant shortcomings in these plans, revealing further consideration for improvement.

j. *Wet bulb temperature*

The wet bulb temperature and its relationship to climate change is a typical phenomenon. **Wet bulb temperature is indeed a crucial metric for understanding the combined effects of heat and humidity on human comfort and health. The ability of the human body to cool itself through sweating relies on the evaporation of sweat from the skin. When the air is already saturated with moisture, as indicated by a high wet bulb temperature, this cooling mechanism becomes less effective, leading to increased risks of heat-related illnesses and even fatalities**. **Climate change contributes to the intensification of wet bulb temperatures due to rising global temperatures and increased humidity levels. The impact is particularly significant in regions like northwestern India and coastal areas in eastern India, where high wet bulb**

temperatures pose a severe threat to public health. It's important for policymakers and public health agencies to consider wet bulb temperature when developing heat action plans (HAPs) and strategies to mitigate the health risks associated with extreme heat events. Adaptation measures may include improved heat warnings, increased access to cooling centres, and public awareness campaigns on heat-related precautions. A 2020 study highlighting the lethality of wet bulb temperatures exceeding 35°C emphasizes the urgency of addressing this issue. **As climate change continues, understanding and addressing the risks associated with high wet bulb temperatures will be crucial for safeguarding vulnerable populations in affected regions**.

k. *Distributed renewable energy*

Distributed renewable energy (DRE) refers to generating electricity from renewable sources such as solar panels or wind turbines in a way that it's produced close to where it's needed. Instead of relying on a central power plant that's far away, distributed renewable energy systems are often installed on rooftops, in community centres, or even at individual homes. It helps to reduce the need for long-distance power transmission and can be more reliable and sustainable. **In India, DRE also serves the goal of providing energy access to remote and rural areas where connections to a centralized power grid do not exist. Mini-grids are currently being used to meet household and commercial energy needs in Uttar Pradesh, Bihar, and Odisha. According to a report by the Climate Policy Initiative, India will require an annual DRE investment of INR 1.3 lakh crore to meet its sustainable energy targets**.

l. *Loss and damage*

The description provides a clear overview of the concept of loss and damage in the context of climate change, particularly its implications for countries like India. **Loss and damage indeed refer to the adverse consequences of climate change on both the environment and society, encompassing disruptions to agriculture, property damage, and loss of life due to extreme weather events. India's vulnerability to climate change, as highlighted by its ranking and the high level of displacement due to disasters, underscores the urgency of addressing these issues. Developing countries, often categorized as non-Annex 1 nations, face unique challenges such as flooding, rising sea levels, droughts, and heat waves. Adaptation measures, including population relocation, rehabilitation, and resilient infrastructure development, are crucial for these nations. The financial burden associated with climate adaptation is significant, as evidenced by the estimated costs mentioned in the UNEP's 2022 Adaptation Gap Report. This underscores the importance of diverse climate finance options to support developing countries in their efforts to adapt to and mitigate the impacts of climate change. The discussions around loss and damage at COP27 reflect the ongoing global dialogue on climate responsibility. The concept of historical responsibility, where developed countries are seen as having contributed more to climate change, has led to calls for compensation to help developing nations to address current and future loss and damage. The establishment of a loss and damage fund by developed or Annex 1 nations demonstrates a recognition of the need to support vulnerable countries in building resilience against climate disasters. This fund aims to provide financial assistance for adaptation efforts and help address the impacts of climate change in the most affected regions**.

m. *Circular economy*

This description provides a comprehensive overview of the key principles and benefits of a circular economy, as well as examples of how different countries, such as China and India, are incorporating circularity into their approaches to resource management. **The emphasis on prolonging product life, recycling, and reusing aligns with the broader goals of sustainability and mitigating environmental impact. Designing products for durability and ease of recycling is crucial in minimizing the ecological stress associated with resource extraction and production since approximately half of all global greenhouse gas emissions are linked with resource extraction. This highlights the environmental benefits of a circular economy**. By reducing the need for extracting new raw materials and encouraging the use of recycled materials, circularity plays a role in lowering carbon emissions and mitigating climate change. The specific focus areas identified in India for adopting a circular economy, such as plastic products, e-waste, scrap metal, rubber, and solar panels, demonstrate a targeted and strategic approach to address the challenges associated with different waste streams. Additionally, the mention of communities in India engaging in upcycling practices, such as the pheriwalis who upcycle clothes, showcases the potential for grassroots initiatives to contribute to a circular economy. It's encouraging to see countries and communities recognizing the importance of circularity in resource

management and waste reduction, as these practices are crucial for creating a more sustainable and resilient future. If you have any specific questions or if there's anything else you'd like to explore on this topic, feel free to let me know!

n. *Environmental, social, and corporate governance*

Economic, social, and corporate governance (ESG) is a framework used to evaluate a business's governance mechanisms and its ability to effectively manage its environmental and social impacts. This includes looking at a company's carbon emissions, water consumption, or customer privacy breaches. It is a critical regulatory measure designed to promote sustainable and responsible business practices. Institutional investors, stock exchanges, and boards of directors are increasingly using a company's management of ESG-related risks to assess its overall business performance. In essence, it's about understanding how a company's ethical and responsible practices affect its success in both financial and societal terms. **India's efforts to scale back its carbon footprint also focus on reducing emissions from businesses and corporations. This is why the Securities and Exchange Board of India (SEBI), the regulatory authority that oversees the securities market in the country, made it mandatory for India's top 1,000 listed companies to submit a Business Responsibility and Sustainability Report (BRSR) in 2021. These companies are expected to supply information in the BRSR about any ESG initiatives undertaken, along with information on their performance against nine key principles**.

Courtesy: Jasmine Bal and Shreya Adhikari, India Development Review India Development Review (IDR).

12. Cause of flood in Delhi. Experts explain Yamuna's fury

On 13 July morning, the water level of the Yamuna River at the Old Railway Bridge in Delhi NCR experienced an unprecedented and staggering rise reaching an alarming height of 208.48 metres. The Central Water Commission, acknowledging the severity of the situation, has classified it as an "extreme situation" and predicts a further rise in the water level. Here are some of the reasons experts point out for the situation in the national capital.

Extreme rainfall in a short duration

According to Manu Bhatnagar, principal director of the Natural Heritage Division at the Indian National Trust for Art and Cultural Heritage, **the principal cause behind the raging Yamuna River in Delhi can be attributed to the occurrence of intense rainfall within a relatively short period**. "The same amount of water falling over a longer period of time would not lead to such a situation as it allows time for the water to pass through. Even a lesser amount of precipitation can result in a higher level downstream if it falls in a shorter period of time," he explained.

Water release from the Hathnikund barrage

A senior official at the CWC said the water released from the Hathnikund barrage took less time to reach Delhi compared to previous years. **The main reason could be encroachment and siltation**. Earlier, the water would have had more space to flow. Now, it passes through a constricted cross-section. "The water from the barrage at Yamuna Nagar in Haryana, around 180km from the national capital, takes around two to three days to reach Delhi.

Encroachment of the floodplains

The country representative of the International Union for Conservation of Nature, Yashveer Bhatnagar, attributed the record water level in the Yamuna to intense rainfall in the entire upper catchment area is mainly due to the encroachment of the floodplains which have an incremental effect."

Silt accumulation

Bhim Singh Rawat, associate coordinator of the South Asia Network on Dams, Rivers, People (SANDRP), said that a **major factor contributing to the unprecedented rise in the water level of the Yamuna River is the elevated river bed caused by substantial silt accumulation**.

Floodwater flow obstruction

"More than 20 bridges within the 22-kilometre river stretch from Wazirabad to Okhla obstruct the flow, leading to the deposition of silt in the riverbed and the formation of numerous mid-stream sandbars,"

said Rawat while talking to news agency PTI. The locations of these sandbars include beneath the Signature Bridge, between the ITO barrage and Yamunabank, between ISBT Kashmiri Gate and the Old Railway Bridge, and between the Old Railway Bridge and the Geeta Colony Bridge.

Narrowing of natural drainage system

The Energy Resources Institute has identified multiple factors contributing to the alarming increase in flood incidents within the NCR of Delhi. **These include the uneven distribution of rainfall, uncontrolled urbanization, and encroachment upon natural drainage channels and urban lakes**. Of particular concern is the unchecked filling of urban water bodies, which has become a widespread problem. **The proliferation of illegal colonies throughout the city, without adherence to proper planning measures, has resulted in the narrowing of natural drainage systems. This poses a significant threat to the overall well-being of the city and serves as an open invitation to urban flooding, as warned by The Energy Resources Institute**.
Courtesy: Times of India.com / July 13, 2023.

13. Japan's Mini Lunar Probe Transforms as It Moves

Inspired by a children's toy, LEV-2 uses shape-changing mechanics to propel itself across the Moon's sandy landscape. Japan launched its lunar lander in September 2023 and onboard is a little transforming robot called LEV-2. Short for Lunar Excursion Vehicle 2, the robot is designed to shapeshift its way across the Moon, gathering up close and personal information about the lunar surface. JAXA (Japan Aerospace Exploration Agency) has developed a Lunar Excursion Vehicle 2 (LEV-2) that is mounted on the Smart Lander for Investigating Moon (SLIM) jointly with TOMY COMPANY, LTD., Sony Group Corporation and Doshisha University. LEV-2, which is a ball-shaped vehicle with a diameter of approximately 8 cm and a mass of approximately 250 g, is equipped with two cameras and can change its shape to run on the lunar surface. The LEV-2 lunar probe is a fascinating combination of advanced technology and inspiration drawn from children's toys. Its design, reminiscent of a shape-changing toy, not only makes it compact and transportable but also serves as an engaging way to spark scientific interest in children. The collaboration with Tomy Company, a Japanese toy company, not only contributed to the playful appearance of LEV-2 but also had practical implications by reducing the number of components and enhancing reliability. Sony's involvement in developing the control board and camera duo for LEV-2 adds a layer of sophisticated technology to the probe. The energy-efficient components ensure that LEV-2 can operate effectively within the challenging lunar environment. This collaboration showcases the versatility of partnerships between space agencies and companies of different industries, bringing together expertise in robotics, aerospace, and consumer electronics.
Courtesy: Adrianna 09 September 13, 2023 Credit: JAXA/Tomy/Sony/Doshisha University.

14. International Ocean Satellite Monitors El Niño

All El Niño events are not created under equal conditions. Their impacts vary widely, and satellites like the U.S.-European Sentinel-6 Michael Freilich helped to anticipate those impacts on a global scale by tracking changes in sea surface height in the Pacific Ocean. These conditions can then propagate poleward along the western water that expands as it warms, so sea levels tend to be higher in places with warmer water. El Niños are characterized by higher-than-normal sea levels and warmer-than-average ocean temperatures along the equatorial Pacific coasts of the Americas. El Niños can bring wetter conditions to the U.S. Southwest and drought to regions in the western Pacific, including Indonesia. This year's El Niño is still developing, but researchers are looking to the recent past for clues as to how it is shaping up. There have been two extreme El Niño events in the past 30 years: the first from 1997 to 1998 and the second from 2015 to 2016. Both caused shifts in global air and ocean temperatures, atmospheric wind and rainfall patterns, and sea levels. Sentinel-6 Michael Freilich captured the 2023 data, the TOPEX/Poseidon satellite collected data for the 1997 image, and Jason-2 gathered data for the 2015 map.
Courtesy: tdanielson@v1-media.com / October 22, 2023.

Epilogue

The above-noted text covers a wide range of significant earth science-related events and news, showcasing the intersection of geology with various aspects of human life, natural disasters, and global geopolitics. The influence of geology on evolution of life for the past 500 million years, Uttarakhand tunnel collapse, revelation of secrets of Gondwanaland by new Trilobite species, mitigation of earthquake and landslide Hazards in the Eastern Himalayan Region, and huge Phosphate deposits in Norway and subsequent revolution in shaping

fertilizer and solar cell demand and supply: and creating a new geopolitical landscape, were some important and interesting facts of this section of this issue, **Further, they emphasize the importance of understanding Earth's geological processes for both scientific advancements and addressing challenges posed by natural disasters and resource management**.

In epilogic remarks on the description of pollution, global warming, climate change, and a people-centered approach, **it is essential to emphasize the interconnectedness of these issues and the critical role that individuals and communities play in addressing them. The pollution, stemming from various sources such as industrial emissions, deforestation, and improper waste disposal, continues to pose a significant threat to ecosystems and human health. Addressing pollution requires a multi-faceted approach, including stricter regulations, sustainable practices, and the promotion of clean technologies**. Global warming and climate change are closely linked to the accumulation of greenhouse gases in the atmosphere, primarily caused by human activities. The consequences, including rising temperatures, extreme weather events, and disruptions to ecosystems, demand urgent global action. **Mitigation efforts should focus on reducing emissions, transitioning to renewable energy sources, and enhancing climate resilience. A people-centered approach recognizes that individuals and communities are at the heart of sustainable development. Empowering people through education on earth, climate, and planetary sciences, awareness, and inclusive decision-making processes is crucial for fostering a collective commitment to environmental stewardship. Environmental policies should prioritize social equity, ensuring that vulnerable communities are not disproportionately affected and have access to resources for adaptation**. In conclusion, tackling pollution, global warming, and climate change necessitates a holistic and collaborative effort. Governments, businesses, and individuals must work together to implement sustainable practices, prioritize renewable energy, and promote environmental education. By embracing a people-centered approach, we can build a more resilient and sustainable future for all, where the well-being of both the planet and its inhabitants are safeguarded.

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