Earth System Science Panorama

(Recent Research, News and Events on Climate, Earth and Environmental Sciences)

The Earth System Science Panorama comprises recent advances and developments, research and events in the fields of earth, ocean, climate, and environmental sciences in consistency with the objectives of our journal. Climate change is happening now. Never before we have witnessed so many extreme weather events-severe droughts, powerful storms, and devastating floods which take lakhs of lives and put millions of people in hazardous and precarious conditions with great risk of shelter and food security. The unprecedented heat coupled with global warming, alarming plastic, air, land, and ocean pollution has intensified the environmental catastrophe and posed a threat to the survival of human kind. The global framework to avoid dangerous climate change by limiting global temperature to well below 2°C and pursuing efforts to limit it to 1.5°C may be prioritized by adopting ***zero-emission vehicles, carbon capture through a large-scale plantation, and underground carbon sequestration and gravity technique****. Our optimum technology should be oriented to pollution control, similar innovation of producing alternatives to single-use plastics at a cheaper price, and similar uses. The reduction of a billion tonnes of micro plastics from the ocean has posed a challenge to technological innovation. Mitigating climate change is about reducing the release of greenhouse gas emissions that are warming our planet. Mitigation strategies include retrofitting buildings to make them more energy efficient; adopting renewable energy sources like solar, wind, and small hydro; helping cities develop more sustainable transport such as bus rapid transit, electric vehicles, and biofuels; and promoting more sustainable uses of land and forests.*

1. Waste to Green Energy – largest Bio-CNG plant of Asia in Indore, India

HDFC Bank, under its ESG commitment, is proud to be associated with Indore Clean Energy Private Limited (ICEPL) for the development of a 550 tonnes /day of Municipal Solid Waste (MSW) to Compressed Biogas (CBG) plant – **the largest Bio-CNG plant in Asia**. Indore Clean Energy Pvt. Ltd (ICEPL) is promoted by the Green Growth Equity Fund (GGEF), which is India's largest climate impact fund with anchor investors like NIIF and the Government of the United Kingdom. Earlier, on February 19, 2021, Prime Minister Narendra Modi virtually inaugurated the municipal solid waste-based Gobar-Dhan plant and dedicated it to the citizens of Indore City, Madhya Pradesh. **The plant has the capacity to treat 550 tonnes/day of wet organic waste and produce 17,000 kg/day of CNG and 100 tones/day of organic compost**. This is the largest waste-to-energy project funded by HDFC Bank under its ESG commitments, and the plant is expected to treat 50 percent of municipal waste generated in Indore City and convert it to 100 percent green products (biogas and manure). Courtesy: (ANI/Business Wire India)

2. Environmentalist Sonam Wangchuk's message to save our earth for a better tomorrow includes the curbing of single-use plastics replaced with paper solutions, the provision of livelihood, and the development of social forestry

World Environment Day is a timely reminder that we need to act fast on the problems threatening our planet's ecosystem. We cannot turn a blind eye towards major environmental issues such as air, water, and plastic pollution that are causing noticeable harm to us and the forest and marine ecosystem. **As polar explorer Robert Swan rightly said–'The greatest threat to our planet is the belief that someone else will save it.**' Therefore, it should be every individual's responsibility to take care of the planet, which has been a selfless shelter for centuries. As the clock is ticking, we need to fix environmental problems **because there's only one planet for us, i.e., Mother Earth**. This year's Environment Day theme reiterates the same sentiment-'Only One Earth', which calls for systematic actions to restore the planet. So let's make it our responsibility to take care of the Earth by making sustainable choices in our everyday lives. If you're wondering how to help Mother Earth from your end, it's simple – reduce your carbon footprint by avoiding plastic. Today, plastic might seem unavoidable. We have it in our surroundings in some form or the other. India also has an ongoing battle with plastic. According to the Central Pollution Control Board report of 2020, India recycles around 60% of plastic waste. The remaining 40% is the cause of the concern as it lands unmanaged. It ends up on riverbanks, streets, and even in animal intestines, causing great harm to their health. Environmentalist Sonam Wangchuk has a message for us, in which he tells us to press the 'refresh' button for Mother Earth and #TurnThePage to a better tomorrow. Small steps such as making sustainable choices can prove to be

beneficial for the Earth's ecosystem. Sonam Wangchuk suggests that paper-based solutions can be an alternative to plastic as the paper is 100% recyclable and bio- degradable. Saying no to single-use plastics such as plastic cups, straws, and single-use plastic cutlery can be the first step in reducing plastic consumption. It's advisable to **switch to paper**- based sustainable alternatives such as paper straws, cups, carry bags, food wrapping paper, etc. JK Paper has always been at the forefront of producing these paper-based solutions that can curb the use of single-use plastics. JK Paper is renowned for its eco-friendly processes at its plant sites to produce pulp and paper. They combine modern technology with process innovations to deliver paper solutions that serve as tangible solutions. For this, **they do not cut a single natural forest tree to make paper**. **Social Farm Forestry**, a programme started by the company in 1991, has not only produced environment-friendly paper but also created employment and livelihood for over 74,000 farmers. JK Paper has planted over 4,65,000 acres of land through Social Farm Forestry. On the occasion of World Environment Day, let's join a movement with JK Paper and #Turn The Page to tackle the challenges of tomorrow by making sustainable choices that will benefit Mother Earth. After all, we have **'Only One Earth', and it's our responsibility to take care of our home; remember, there is no PLANET-B**.

3. The World's largest integrated renewable energy storage project coming up in Kurnool, Andhra Pradesh

This is the first of its kind and single location of energy storage project with wind and solar capacities. This project is being implemented with an investment of over USD 3 billion, comprising of pumped storage (10,800 MWh of daily storage), solar (3000 MW) and wind (550 MW). Andhra Pradesh Chief Minister Y.S.Jagan Mohan Reddy performed the first concrete pour ceremony of the **world's largest Integrated Renewable Energy Storage Project (IRESP)** being implemented by Greenko Group at Kurnool District in Andhra Pradesh on **17th May 2022**. According to a press release, the 5,230 MW Integrated Renewable Energy Storage Project will play a pivotal role in India's attaining energy security and enabling a global energy transition. This is the first of its kind and single-location energy storage project with wind and solar capacities. This project is being implemented with an investment of over USD 3 billion, comprising of pumped storage (10,800 MWh of daily storage), solar (3000 MW) and wind (550 MW). With this project, Greenko has pioneered the concept of storage contracts with central utilities and large industries. The project is scheduled to be commissioned by the last quarter of 2023, the release said Greenko Group is the world's largest renewable energy storage and leading energy transition and decarbonization solutions company. Greenko with an installed renewable energy capacity of 7.5 GW across the wind, solar and hydro capacities has 10 GW of projects under development.

Recent Research in Plastic Recycling

4. A Unique Catalyst for Plastic Degradation Paves the Way for Plastic Upcycling

Plastic upcycling technologies are being advanced by a recently developed catalyst for breaking down plastics. A team of scientists led by Ames Laboratory scientists discovered **the first processive inorganic catalyst in 2020 to deconstruct polyolefin plastics into molecules that can be used to create more valuable products**. The team has now developed and validated a strategy to speed up the transformation without sacrificing desirable products. The catalyst was originally designed by Wenyu Huang, a scientist at Ames Laboratory. It consists of platinum particles supported on a solid silica core and surrounded by a silica shell with uniform pores that provide access to catalytic sites. The total amount of platinum needed is quite small, which is important because of platinum's high cost and limited supply. During deconstruction experiments, the long polymer chains thread into the pores and contact the catalytic sites, and then the chains are broken into smaller -sized pieces that are no longer plastic material. According to Aaron Sadow, a scientist at Ames Lab and director of the **Institute for Cooperative Upcycling of Plastics (ICOUP)**, the team crafted three variations of the catalyst. Each variation had identically sized cores and porous shells but varying diameters of platinum particles, from 1.7 to 2.9 to 5.0 nm. Instead, the rate at which the chains were broken into smaller molecules was different for the three catalysts. The larger platinum particles reacted with the long polymer chain more slowly, while the smaller ones reacted more quickly. This increased rate could result from the higher percentage of edge and corner platinum sites on the surfaces of the smaller nanoparticles. These sites are more active in cleaving the polymer chain than the platinum located on the faces of the particles. According to Sadow, the results are important because they show that activity can be adjusted

independently of selectivity in these reactions. “Now, we are confident that we can make a more active catalyst that would chew up the polymer even faster while using catalyst structural parameters to dial in specific product chain lengths,” he said. Huang explained that this type of larger molecule reactivity in porous catalysts in general is not widely studied. So, the research is important for understanding the fundamental science as well as how it performs for upcycling plastics. “We really need to further understand the system because we’re still learning new things every day. We are exploring other parameters that we can tune to further increase the production rate and shift the product distribution” said Huang.
Courtesy: Ames Laboratory Catalysts DOE Plastic Popular, MAY 27, 2022

5. Environment-friendly based Gravity technology can be used to solve renewable energy storage problems with economic and employment feasibility
The reliance on renewable for consistent power is, therefore, impossible without energy storage. through gravity.

Fossil fuels are bad for the planet’s health. Every child knows this and every adult is bearing the brunt of their lifestyle choices that have led us to the climate crisis. The solution lies in renewable energy. However, the biggest problem with switching to renewable is the inconsistency. Unlike thermal plants powered by fossil fuels that can operate night and day, renewable sources like wind and the sun are intermittent- the power generation drops or worse stops on a cloudy or wind-lull day. **The reliance on renewables for consistent power is, therefore, impossible without energy storage. Therefore, gravitational potential energy is one of the only viable grid-scale energy storage solutions. Yet the widespread use of renewables is challenged by the intermittency of solar and wind, and we’re not yet at a place where we can store enough energy to avoid these problems. Renewables are projected to increase from their current 12% of the global energy supply to 90% in 2050.**

As renewable energy supply increases around the world, so too is the demand for grid-scale energy storage. It has been projected that the combined global stationary and transportation annual energy storage market will increase from today’s baseline of around 600 GWh by a factor of four by 2030 to more than 2,500 GWh. Today, global energy storage capacity is dominated by gravity-based pumped hydro (90%), followed by lithium, lead, and zinc batteries (5%), with the remaining capacity allotted to thermal and flow batteries, compressed air, flywheels, and other gravity-based mechanical systems. Within the framework of large-scale, grid-level energy storage, gravity-based solutions currently dominate the commercial space. Pumped hydro, for example, is a reliable technology with a rapid response time and proven longevity. It suffers nevertheless from the availability, scalability, and cost of suitable mountainous and water-rich land, low round-trip energy efficiency (70%), carbon-intense construction, and the challenge of co-locating solar and wind. Geoff Ozin and AthanTountas wrote two ASN articles in 2019 about some exciting new developments in storing renewable energy as gravitational potential energy by lifting and lowering heavy objects (Gigawatt Electricity Storage Using Water and Rocks and Climate Change Will Require Heavy Lifting). At the time, a Swiss private company founded in 2017 that caught their attention was Energy Vault. In a demonstration project built and showcased in Switzerland, they showed the first use of cranes to lift and lower heavy composite blocks into massive architectures to respectively store and release significant amounts of renewable electricity. Importantly, the composite blocks enable the use of alternative materials to replace environmentally unfriendly substances like concrete, which accounts for 7-8% of greenhouse gas emissions. In addition, the technology can accommodate the recycling of various pre-existing waste materials, which inturn helps large utility and industrial companies transform financial and environmental liabilities into infrastructure assets to support their transition to a fully circular economic approach. **For example, coal bottom ash waste and retired wind turbine blades can be re-directed from landfills into the company’s custom-made composite blocks that anchor the gravity-powered systems. By maximizing the use of locally sourced soil, sand, and waste materials-including outputs from fossil fuel Production-Energy Vault’s supply chain design reduces the impact of greenhouse gases from the transport sector while increasing jobs for the local economy. The result is an end-of-life solution for materials that are difficult to break down and can have negative environmental consequences. This beneficial reuse eliminates waste and enables the continual use of local resources within the framework of a circular economy. During lifting, electricity is stored as gravitational potential energy in the blocks, and on lowering, the stored**

potential energy drives a motor generator to regenerate electricity with as little loss as possible to maximize the efficiency of the process. As of April 2022, Energy Vault became listed on the New York Stock Exchange, and with the breath-taking news of its latest gravitational energy storage system. **In just three years, it has established an impressive global reach with its advanced gravity storage system on five continents, with more than US$32B earmarked for projects over the next five years. They have simplified their gravity storage system by integrating the lifting-and-lowering of heavy weights into a familiar "elevator" style building design that is compatible with all international building codes. Plus, they have perfected the manufacturing process of their eco-friendly and fully recyclable composite materials. This is one of the most promising sustainable solutions to global grid-scale renewable energy storage. It almost certainly will prove to be an indispensable piece of the circular economy puzzle, having a positive ripple effect on creating new clean technology industries and jobs, avoiding environmental liability, ameliorating climate change, and mitigating global warming.**
Courtesy: Geoff Ozin and AthanTountas

6. (A) World Environment Day 2022: 7 best ways to reduce pollution in Indian cities
Pollution has become one of the most pressing challenges that we face today is not an over statement as the dubious distinction of hosting 35 of the 50 global cities with the worst air. The important questions are, even as pollution is a country-wide menace, how can we contain and reduce pollution, at least in Indian cities and urban locations? More specifically, since transport-related emissions are some of the biggest contributors to city pollution, what are some of the ways to reduce pollution and its related effects in Indian cities? Suyash Gupta revealed the seven best ways to reduce pollution in Indian cities.

a. Not just aspirational, but a pragmatic decarbonization of the transport sector, both passenger and freight
Pragmatic decarbonization of the transport sector, through the use of much lower carbon fuels, should become a top and immediate priority for the authorities. We must be mindful of the fact that India's transport sector is responsible for 13.5 percent of the country's energy-related CO2 emissions, with road transport accounting for 90 percent of the sector's final energy consumption. Furthermore, it has been estimated that transportation sources are responsible for approximately a third of PM pollution, perhaps the most harmful pollutant to human health, which also contributes to high nitrogen oxide emissions in the country. Nonetheless, the scope of the decarburization programme must be extended to both personal/private vehicles and heavy-duty vehicles (HDVs). For private vehicles, relaxing policy norms for the uptake of alternative fuels such as auto LPG as compared to traditional carbon-based and heavily polluting petrol and diesel must drive the decarbonization programme. Notably, auto LPG has a global warming potential (GWP) of zero as opposed to methane's 25 and carbon dioxide's 1. Moreover, not only does it produce a lower amount of carbon dioxide per unit of heat produced, with a low carbon-hydrogen ratio, it lets off negligible amounts of nitrogen oxides and particulate matter. Similarly, since India has seen rapid growth in freight road transport in recent decades on the back of rising demand for heavy-duty vehicles, especially the ICE-based HDVs, there has been a spill-over effect in the form of higher demand for fossil fuels and thereby higher pollution. We need to contain this demand for HDVs, especially long-range trucks and the resultant use of fossil fuels. (Gabriela Palai).

b. Strive for full-fledged electrification of railways.
We need to achieve full-fledged electrification of our railways. This would release the pressure and load on the freight roads transport in the country. While 54% of conventional passenger demand and 65% of freight demands are carried out today on electrified railways, we need to invest more to increase this electrification footprint. (J.J Jordan).

c. Incorporate transit-oriented development models into urban planning
With transportation increasingly constituting the fulcrum around which city life today operates and evolves, we must contemplate and develop urban planning strategies predicated on transit-oriented development models. This means designing or redesigning (existing urban units) our urban spaces in a way that concentrates housing, jobs, and services around public transport hubs while facilitating the

easy and safe movement of pedestrians and non-motorized modes of mobility such as bicycles. Copenhagen, with its five-finger plan, and Brazil's Curitiba are exemplary models for transit-oriented urban development. (Francesco Ungaro)

d. Disincentivise high carbon liquid fuelled private transport through policy
Simultaneously, we must disincentivise, through policies–such as increased taxes and new regulations – the use of private transport vehicles. For instance, there could be more road taxes and parking charges for the usage of private vehicles, particularly those which run on high-carbon liquid fossil fuels, with an eye on restricting the presence of personal vehicles on roads. Also, people should be encouraged to undertake the pooling of their personal vehicles. (Inline Media)

e. Expand railway's Roll-on Roll-off (RO-RO) service to Delhi and other cities
We could consider replicating the RO-RO service offered to Delhi by the Indian Railways to the other major cities in the country. Given that traffic congestion stemming from stop-and-go traffic flow increases emissions, taking the heavily loaded trucks and lorries onto railway wagons under the RO-RO service and off the roads would go a long way in addressing city emissions. While questions have been raised over the financial feasibility of this exercise, it is not impossible to find a way out. In addition, we should deploy and operate smart traffic systems in our cities.

f. Implementation of an emissions trading system
We should widely encourage market-based emissions trading mechanisms in which the government sets a cap for emissions and allows companies to buy and sell permits to stay below the cap, thereby keeping pollution under control. This involves emitting firms obtaining and surrendering a permit for each unit of emissions. Those lacking enough permits either reduction of emissions or to buy permits from another firm. Gujarat has introduced the world's first emissions trading system for particulate pollution. This must be replicated across the country. (Tima Miroshnichenko)

g. Afforestation and foster green habits and practices
We must make our cities greener through planting more trees and enough vegetation in order to provide a filter and sink for city pollutants. Also, green buildings should be encouraged in terms of their design and material of construction while employing renewables such as solar power and green appliances within. At the same time, city people should use green and recyclable materials in their daily lives. (Leiliane Dutra)
Courtesy: Suyash Gupta, Hindustan Times

6. (B) 5th June2022–WORLD ENVIRONMENT DAY
(An Introspection of 50 Years of Celebration.)
The UN General Assembly, in its Stockholm Conference on "Human Environment "held in 1972, proposed 5th. June, to celebrate as World Environment Day (WED). The purpose of the celebration was to arouse awareness among various levels, the alarming rate of environmental stress that earth is facing due to population explosion, resource depletion and industrialization. Each year a Theme is selected and the celebration flagged off in the capital city of a country and carried on world over by way of seminars, meetings and projects. During the last 5 decades of celebration, since it started in 1972, there has been a series of Themes of global importance, most concerned with Earth, such as:
1974: Only One Earth (The Slogan of 1972 Stockholm Conference).
1994: One Earth, One Family. (Vasudeba Kutumbakam).
1999: Our Earth, Our Future, Just save it.
2001: Connect with the World Wide Web of life.
2002: Give Earth a chance.
2003: Water - 2 billion people are dying for it.
2004: Wanted Seas and Oceans – Dead or alive.
2005: Green Cities – Plan for the Planet.
2008: Kick the Habit towards a low carbon economy.
2009: Your Planet needs you – Unite to combat Global Warming.
2010: Many Species, One Planet, One Future/ Biodiversity.

2022: Only One Earth.

The first and the latest WED Themes show 50 years since we started, the truth still holds that this Planet is our only home but poorly husbanded. Worse of all the driver on the steering wheel of our Space van is technoholic.

No doubt, the thematic celebrations have generated a tremendous volume of awareness among people at all levels, there has been little relief of environmental stress in the domain of any of the themes mentioned above. For example, the Berlin wall has been demolished, but States and Nations have been further fragmented and riddled with religious, social, and economic conflicts and terrorism. Even the Family is atomized. "The earth has been flattened", levelled through Science and Technology, but the gap between rich and poor has widened. Forest cover has shrunk further, developmental projects like the establishment of industries, power plants, SEZs and the building of dams have encroached on human habitats, violated human rights, produced millions of ecological refugees and urban migration has crippled city infrastructures in most developing countries – India is a living example. Carbon emission continues to increase, "Climatic change" remains a mere debate and lost in commercialized Carbon Trading in world Carbon Bazaar, water pollution in land and ocean (oil spill) have increased and water conflicts (water share/ water wars) have spread over mountain glaciers, rivers, lakes, dams and trickled down to municipal districts and public taps. Of late, the Globalization of "Man, Microbe and Materials" has brought the fatal Corona pandemic.

Increased environmental stress and global environmental deterioration, in spite of increased awareness, is considered to be due to:
(1) Our limit in levels of environmental awakening and
(2) Our anthropocentric approach to the environment which presupposes "Nature for service of man" and undermines Nature and natural elements.
Even if globally aware, our perception of Nature is determined by our experience to immediate surroundings. Environmental factors such as hot, cold, humid, smelly, acidic, dusty, noisy, bright, crowded, suffocating, and even subjective feelings like violence, and unethical (corruption) have variations in geographic space and time and when sensed, their perception depends on our level of awakening (like Sensitivity, when instruments are used). Therefore, keeping our living room or factory floor clean, our city green, demand for "Sons of the Soil", "Amar Sonar Bangla", "My country, My people, My nation", "Asia for Asiatic"- that was Hiro Hitto's slogan in 2nd. World war, "Keep Australia White", "Deutschland, Deutschland, Uber Ales" – that was Hitler's sermon; are but various scales and levels of consciousness.
Courtesy: K. C. Sahu Prof. (Retd.), IIT Bombay, email: sahukc_kc@yahoo.com

7. The UK's largest carbon capture project will turn CO2 into Sodium Bicarbonate (baking soda)
Tata Chemicals Europe's plant at Northwich will eventually capture 40,000 tonnes of carbon dioxide a year for use in making sodium bicarbonate. **The UK's biggest carbon capture project was opened on June 24, 2022, with carbon dioxide being used to make sodium bicarbonate for dialysis machines, pharmaceutical tablets, and baking soda**. Carbon capture and storage (CCS) is seen by the UK's climate change advisers as a "crucial" technology for reaching net-zero emissions but has had a chequered history with several major projects being cancelled. The new Tata Chemicals Europe (TCE) plant at Northwich in north-west England is currently on track to capture about 36,000 tonnes of CO2 a year. Eventually, this will rise to 40,000 tonnes, about 11 percent of the facility's emissions, and more than 100 times the amount captured in power station pilots by energy firm Drax. Martin Ashcroft at TCE says the £16.7 million demonstration project, helped by a £4.2 million government grant, shows net zero doesn't mean outsourcing manufacturing overseas. "What we can't have is effectively decarbonization of the UK by deindustrialization," he says. **The CO2 is captured from a gas-fired power plant at the facility and isn't stored, but purified and turned into liquefied CO2 to make sodium bicarbonate**. "Effectively, we are making our own raw material," says Ashcroft. TCE previously bought most of its CO2 from two of the UK's biggest fertilizer plants, one of which is closed. The company had been concerned that the CO2 captured from flue gas wouldn't be a sufficiently high grade for the pharmaceutical industry, but the sodium bicarbonate made with it has been shown to be good enough for use in haemodialysis for people with kidney disease, and as an ingredient to control

the pH in tablets. Some of the product, better known as baking soda, is also sold to the food industry. Stuart Haszeldine at the University of Edinburgh, UK, welcomes the project, which he notes is similar to a coal plant in India that is using CO2 to make sodium bicarbonate. However, he says, because there is no permanent storage of the CO2 at the Northwich site, it will eventually be released to the atmosphere. "This is an emissions decrease, not a permanent and durable removal of the fossil carbon released from burning the methane gas," he says. Ashcroft is considering a second carbon capture project either at the facility or at a nearby salt plant, and says it is vital that the UK government puts money behind two "CCS clusters" it has backed for the north-west and north-east of England.
Courtesy: Adam Vaughan, 24 June 2022

8. Scientists accidentally create a mutant enzyme that eats plastic bottles(PET)
The breakthrough, spurred by the discovery of plastic-eating bugs at a Japanese dump, could help solve the global plastic pollution crisis. Scientists have created a mutant enzyme that breaks down plastic drinks bottles– by accident. The breakthrough could help to solve the global plastic pollution crisis by enabling, for the first time, the full recycling of bottles. The new research was spurred by the discovery in 2016 of the first bacterium that had naturally evolved to eat plastic, at a waste dump in Japan. Scientists have now revealed the detailed structure of the crucial enzyme produced by the bug. The international team then tweaked the enzyme to see how it had evolved, but tests showed they had inadvertently made the molecule even better at breaking down the PET (polyethylene terephthalate) plastic used for soft drink bottles. "What actually turned out was we improved the enzyme, which was a bit of a shock," said Prof John McGeehan, at the University of Portsmouth, UK, who led the research. "It's great and a real finding." The mutant enzyme takes a few days to start breaking down the plastic – far faster than the centuries it takes in the oceans. But the researchers are optimistic this can be speeded up even further and become a viable large-scale process. "What we are hoping to do is use this enzyme to turn this plastic back into its original components, so we can literally recycle it back to plastic," said McGeehan. "It means we won't need to dig up any more oil and, fundamentally, it should reduce the amount of plastic in the environment." About 1m plastic bottles are sold each minute around the globe and, with just 14% recycled, many end up in the oceans where they have polluted even the remotest parts, harming marine life and potentially people who eat seafood. "It is incredibly resistant to degradation. Some of those images are horrific," said McGeehan. "It is one of these wonder materials that has been made a little bit too well." However, currently, even those bottles that are recycled can only be turned into opaque fibres for clothing or carpets. The new enzyme indicates a way to recycle clear plastic bottles back, which could slash the need to produce new plastic. Industrial enzymes are widely used in, for example, washing powders and biofuel production, They have been made to work up to 1,000 times faster in a few years, the same timescale McGeehan envisages for the plastic-eating enzyme. A patent has been filed on the specific mutant enzyme by the Portsmouth researchers and those from the US National Renewable Energy Laboratory in Colorado **One possible improvement being explored is to transplant the mutant enzyme into an "extremophile bacteria" that can survive temperatures above 70C, at which point PET changes from a glassy to a viscous state, making it likely to degrade 10-100 times faster**. "Enzymes are non-toxic, biodegradable, and can be produced in large amounts by microorganisms," he said. "There is still a way to go before you could recycle large amounts of plastic with enzymes, and reducing the amount of plastic produced in the first place might, perhaps, be preferable. But, this is certainly a step in a positive direction." Morgan Vague also isolated three bacteria-eating plastic when she was a senior in biology at Reed College in Oregon. Specifically, they ate a plastic called polyethylene terephhatlates, or PET for short. The bacteria broke PET down into by-products that are harmless. Ideonellasakaiensis is a bacterium from the genus Ideonella and family Comamonadaceae capable of breaking down and consuming the plastic polyethylene terephthalate (PET) using it as both a carbon and energy source.
Courtesy: The Guardian, 22nd May 2022

9. 196 nations, including India join hands to fight drought
Restoration of one billion hectares of degraded land globally by 2030
Pledging to accelerate **the restoration of one billion hectares of degraded land globally by 2030**, 196 countries, including India, adopted 38 decisions to step up drought preparedness and give new political and financial impetus to help nations deal with devastating impacts of land/soil degradation on

20th May 2022 Strengthening land tenure for gender equity, involving women in land management and mobilisation of $2.5 billion **to help future supply chains while tackling deforestation and climate change are also part of those decisions**, taken by these countries after two weeks of deliberations at the 15th session (CO) of the United Nations Convention to Combat Desertification (UNCCD) at Abidjan, Côte d'Ivoire, a west African country. Addressing the problem of sand and dust storms and other escalating disaster risks; building robust monitoring mechanism to track progress against land restoration commitments and promoting decent land-based jobs for youth as part of land-based entrepreneurship are other decisions that will see multiple efforts in many countries across the globe to restore degraded land, build drought resilience and save soil to ensure food security and protect biodiversity. The latest UN findings show that 40% of ice-free land globally is degraded, and the world has already seen a 29% rise in droughts since 2000. It is projected that three- quarters of the world's population will be affected by drought by 2050 unless urgent action is taken. "Meeting against the backdrop of multiple global challenges, including the worst-in-40-years drought in eastern Africa, as well as food and economic crises fuelled by the ongoing Covid-19 pandemic, countries have sent a united call about the importance of healthy and productive land for securing future prosperity for all," said Ibrahim Thiaw, UNCCD executive secretary. The countries have decided to establish an inter-governmental working group on drought for the 2022-24 period to look into possible options, including global policy instruments and regional policy frameworks, to support a shift from reactive to proactive drought management. India, on its part, has pledged to restore 26 million hectares of its degraded land by 2030 as part of ongoing efforts to achieve its 'land degradation neutrality' (LDN) targets. The LDN is a stage where the amount and quality of land resources remains stable or increase within specified temporal and spatial scales and ecosystems, factoring in degradation and restoration. Simply put, any country will not have net loss in terms of land degradation if it achieves LDN through restoration efforts. The previous conference (COP14) was held in India in September 2019, when the country had raised its target of restoring degraded land from 21 million hectares to 26 million hectares by 203. Restoration of degraded agricultural land is achieved through several agronomic and biological techniques. **Crop rotations, agro-forestry, reduced tillage, cover crops, vegetative filter strips, residue, canopy cover management and no - till** are important among these practices.
Courtesy: The Times of India May 22, 2022

10. New material can capture toxic pollutants from the air–A new finding in combating climate change

Professor Michael Zaworotko, Bernal Chair of Crystal Engineering and Science Foundation of Ireland Research Professor at the University of Limerick's Bernal Institute. Below, Dr Xiang-Jing Kong from the Department of Chemical Sciences at UL and the material that has been created, named BUT -55. Credit: University of Limerick. Researchers at the University of Limerick have developed a new material that has the ability to capture toxic chemicals from the air. The material is capable of capturing trace amounts of benzene, a toxic pollutant, from the air and crucially uses less energy than existing materials to do so, according to the researchers. The sponge-like porous material could revolutionize the search for clean air and have a significant impact in the battle against climate change, the researchers believe. Professor Michael Zaworotko, Bernal Chair of Crystal Engineering and Science Foundation of Ireland Research Professor at the University of Limerick's Bernal Institute, and colleagues developed the new material, with findings reported in Nature Materials. **Volatile organic compounds (VOCs) including benzene are a class of toxic pollutants that cause severe environmental and health issues. Developing technologies to remove benzene from air at trace concentrations and doing it with a low energy footprint are both challenges that have not been overcome until now.A family of porous materials—like a sponge—have been developed to capture benzene vapor from polluted air and produce a clean air stream for a long working time," explained Professor Zaworotko. "These materials could be regenerated easily under mild heating, making them candidates for air purification and environmental remediation**. "Our materials can do much better in both sensitivity and working time than traditional materials." Professor Zaworotko and Dr. Xiang-Jing Kong from the Department of Chemical Sciences at UL, along with colleagues from leading universities in China, developed a new porous material that has a such strong affinity for benzene that it captures the toxic chemical even when present at just 1 part in 100,000. Earlier work from Professor Zaworotko's lab resulted in leading materials for carbon capture and water harvesting. The water harvesting material has

favorable properties for capturing and releasing water from the atmosphere that is already being used in dehumidification systems. This research opened up possibilities to design porous materials for efficient separation of these chemicals with low energy input as well as the removal of other trace pollutants from the air."
Courtesy: Nature Materials, 2022

11. Urban affairs ministry programme aims to upskill 5000 professionals to lead climate action
LCCM (Leaders in Climate Change Management) envisions capacitating professionals, including mid- to junior-level government officials and frontline workers, and preparing them to champion climate change adaptation and mitigation solutions in a coordinated effort to achieve India's climate commitments. The National Institute of Urban Affairs (NIUA) and World Resources Institute (WRI) India have announced Leaders in Climate Change Management (LCCM), a practice-based learning programme that aims at building capacity among urban professionals to lead climate action across sectors and geographies in India. The online learning will be hosted on the National Urban Learning Platform, the capacity-building arm of the NIUA. It will also be hosted and supported by ATI, Mysuru. The programme aims to sign similar deals with ATIs across India over the next few months. Mr.Kunal Kumar, joint secretary at the housing and urban affairs ministry, said, "To achieve these goals, we need to have innovation, participation, technology, integration and capacity optimisation. We have already started this journey through various missions of the government of India, including the Smart Cities Mission. The ministry, in collaboration with the French Development Agency (AFD), European Union and the NIUA, launched the initiative– **City Investments to Innovate, Integrate and Sustain (CITIIS) as an urban innovation mechanism. The programme has developed project management tools and frameworks across the urban sector, including environmental and social safeguards. Leaders in Climate Change Management (LCCM)** is connected to the CITIIS programme. The first cohort of the LCCM programme will have participants from the 12 cities getting assistance under the CITIIS programme. LCCM will become an integral part of CITIIS 2.0, as it will act as a capacity-building arm." Dr OP Agarwal, chief executive of WRI India, presenting the LCCM programme, its structure and aim to upskill urban climate leadership in India, said, "The key challenge in building capacity for mid-career professionals is using the right kind of pedagogy – a teaching style that encourages learning by doing, rather than by just listening to lectures. LCCM has fully recognised this and adopted this kind of teaching style. Hitesh Vaidya, director of the NIUA, said, **"Given the rate of investments towards urban sectors in India, for example, $30 billion for the smart cities programme, the need for incorporating climate action within existing and future investments towards physical, social, and environmental services is paramount to ensure sustainable development. Through LCCM, the National Institute of Urban Affairs will be working towards its goal of building capacities and knowledge dissemination on the dynamic discourse of urban issues with reference to climate change issues".**

12. Recent Research on Micro Plastic Pollution in the ocean
Scientists unveil tiny self-propelled bionic robot fish which can swim and collect microplastics in the ocean. Scientists have designed a tiny robot-fish that is programmed to remove microplastics from the seas and oceans by swimming around and adsorbing them on its soft, flexible, self-healing body. Microplastics are the billions of tiny plastic particles which fragment from the bigger plastic things used every day, such as water bottles, car tyres, and synthetic T-shirts. They are one of the 21st century's biggest environmental problems because once they are dispersed into the environment through the breakdown of larger plastics, they are very hard to get rid of, making their way into drinking water and food, harming the environment and animal and human health. Researchers at Sichuan University have revealed an innovative solution to track down these pollutants when it comes to water contamination: designing a tiny self-propelled robo-fish that can swim around, latch on to free-floating microplastics, and fix itself if it gets cut or damaged while on its expedition. The robo-fish is just 13mm long, and thanks to a light laser system in its tail, it swims and flaps around at almost 30mm per second, similar to the speed at which plankton drift around in moving water. Her team's novel invention is described in a research paper in the journal Nano Letters. "To the best of our knowledge, this is the first example of such soft robots.
Courtesy: Sofia Quaglia,22nd Jun 2022, Nano Letters, The Guardian

13. Climate change is linked to heatwave as mercury breaches 49-degree mark in north India

Climate change is not only raising temperatures and making India's heatwaves more intense, it is also changing weather patterns that, in turn, are driving dangerous heat extremes. **The United Nations Intergovernmental Panel on Climate Change warns that heat waves and humidity- related heat stress will intensify in South Asia, and scientists who study climate change say Indians can expect more of the same hot temperatures in the coming years. India has been reeling under what experts say is the worst heatwave in its history, with scorching day temperatures being reported in many states in the past two weeks**. **Climate change** is not only raising temperatures and making India's heatwaves more intense, but it is also changing weather patterns that, in turn, are driving dangerous heat extremes, say experts. This is resulting in the cooling western disturbance being disrupted, anticyclones becoming more dominant, and Arctic waves breaking records, among other things. March was recorded as the hottest in **122 years** from 1901-2022, according to reports. April brought no respite either, with Northwest and Central India being the hottest. Overall, it was the **fourth hottest April** the country has witnessed ever since records were kept. Several places recorded maximum day temperatures in the range of 44-46°C for several consecutive days, while a few places even touched the 47°C mark. Worse, on May 15, some parts of Delhi and Uttar Pradesh recorded a high of **49 degrees Celsius**. The mercury, however, dipped **slightly** on May 16. There have been studies that said that **March and April are warming much faster** than the core summer months of May and June in India. The persistent heatwave has highlighted global warming's cascading effect on the temperature, according to inputs share by Climate Trends, India, a climate communications initiative.

Courtesy: Gulam Jeelani, 16th May 2022

14. New global study identifies opportunities for increasing carbon storage on land to mitigate climate change

A new study, "*The Global Potential for Increased Storage of Carbon on Land," published in the Proceedings of the National Academy of Sciences (PNAS),* provides a series of geospatial maps that improve our understanding of the global gap between current and potential carbon storage on land and **offers a framework for action to realize the full potential of land-based carbon storage as a natural climate solution**. The study is timely, coming on the heels of the Intergovernmental Panel on Climate Change (IPCC)'s Working Group III's latest report, which **focuses on the urgent need to reduce carbon emissions in order to limit future warming and highlights the significant mitigation potential of natural and managed ecosystems given the opportunity to remove additional carbon from the atmosphere**." From forests to soils, terrestrial ecosystems store enormous amounts of carbon globally, and are capable of storing even more," said Dr. Wayne Walker, Carbon Program Director at Woodwell Climate Research Center. "But realizing the untapped potential of land to aid in addressing the climate crisis means understanding how much storage space is available, and what actions can be taken in those places to take advantage of the opportunity they offer as rapidly as possible. This study provides the data and conceptual framework for action. **Using the new global maps, researchers quantified the unrealized potential carbon storage of both above and below-ground woody biomass and soil organic carbon and found 287 petagrams of untapped carbon storage, with 78% available in woody biomass and the remaining 22% in soils, across tropical, temperate, and boreal climate zones. These findings reveal the significant potential for expanding land-based carbon capture globally through the restoration, improved management, and maintenance of forests and other woody systems. Improved management of existing forests alone may offer more than 75% of the untapped potential, with the majority (71%) of it concentrated in tropical ecosystems**. Forest stewardship represents the greatest opportunity for realizing carbon removal and storage in the near term, and the urgency of the clima te crisis demands that we prioritize these efforts," said Peter Ellis, Director of natural climate solutions science at The Nature Conservancy and study co-author. **This research shows that after safeguarding lands required for food production and human habitation, improved management of forests and other woody systems particularly degraded forests across the global tropics offers tremendous climate mitigation potential**." Both the IPCC report and the new study identify land-based, natural climate solutions as important for driving large-scale greenhouse gas emissions reductions and enhanced removals (IPCC WGIII, 2022). These efforts including maintenance, management, and restoration of terrestrial systems require globally consistent

frameworks in order to accurately address current gaps and explain landscape-level planning and targeted mitigation solutions. This study introduces a critical dataset for achieving these efforts. *Courtesy: Woodwell Climate Research Center*

15. Global warming: 361 million tonnes of CO2 and 39 million tonnes of methane pumped into the atmosphere a year from this source

The world is blind to Gas flared at oil and gas facilities is greater than the EU's total import from Russia and is a key source of methane emissions.

Something that has not changed over 160 years of oil production is the deliberate **burning of gas associated with it, called gas flaring. It is turning out to be a major source of methane emission, a greenhouse gas (GHG) "over 80 times more powerful than carbon dioxide as a warming gas in a 20-year time frame**". Since 1996, the Bank's Global Gas Flaring Reduction Partnership — "a multi-donor trust fund composed of governments, oil companies, and multilateral organizations committed to ending routine gas flaring at oil production sites across the world" — has been tracking gas flaring using satellite technology. **According to the latest data released on May 5,2021saw the world burn 144 billion cubic metres (bcm) of greenhouse gas at oil and gas facilities**. This gas flaring resulted in approximately **400 million tonnes of carbon dioxide emissions globally last year**" wrote Zubin Bamji, the Program Manager of the Global Gas Flaring Reduction Partnership. **Of this, 361 MMtCO2e was in the form of CO2 and 39 MMtCO2e was in the form of methane. Gas flaring is considered both an energy waste and a global-warming activity. The flared gas in 2021 is more than the European Union's 27 member states' gas imports from Russia. To make sense of its energy potential, the wasted 144 bcm of natural gas would have generated 1,800 terawatt hours of energy or nearly two-thirds of the European Union's net domestic electricity generation**. On the other hand, gas flaring is a direct source of methane. Methane has more warming potential than CO2, but its atmospheric life is much less. Thus, its control can lead to a fast reduction in the emission of GHGs, thus controlling climate change. **In 2015, countries and companies committed to ending flaring by 2030 under the World Bank-initiated Zero Routine Flaring initiative. The latest assessment shows that efforts are matching the commitment made. "Global gas flaring volumes have remained largely static over the last 10 years, plateauing at around 144 bcm."**

Courtesy: M. Maskey, H. Alemohammad, K. J. Murphy and R. Ramachandran6 November 2020 Down to Earth, 06 May 2022

16. Important Findings of the Intergovernmental Panel on Climate Change(IPCC)2022 Report on Climate Impacts, Adaptation and Vulnerability

The recent report from the Intergovernmental Panel on Climate Change (IPCC) paints a troubling picture: climate change is already impacting every corner of the world, and **much more severe impacts are in store if we fail to halve greenhouse gas emissions this decade** and immediately scale up adaptation. Following the first installment of the IPCC's Sixth Assessment Report, Working Group II's contribution, released on February 28, 2022, draws from 34,000 studies and involves 270 authors from 67 countries. It provides one of the most comprehensive examinations of the intensifying impacts of climate change and future risks, particularly for resource-poor countries and marginalized communities. The 2022 IPCC report also details which climate adaptation approaches are most effective and feasible, as well as which groups of people and ecosystems are most vulnerable, an additional 350 million people will experience water scarcity by 2030; and as much as 14% of terrestrial species will face high risks of UN Secretary-General Antonio Guterres called the report "**an atlas of human suffering and a damning indictment of failed climate leadership**." Six important points of the Report

A. Climate impacts are already more widespread and severe than expected

Climate change is already causing widespread disruption **in every region in the world with just 1-degree C (2 degrees F) of warming**.

Withering droughts, extreme heat, and record floods already threaten food security and livelihoods for millions of people. Since 2008, devastating floods and storms have forced more than 20 million people from their homes each year. The crop productivity growth in Africa hasshrunk by a third due to climate change. Today, half the global population faces water insecurity forat least one month per year. Wildfires are scorching larger areas than ever before

in many regions, leading to irreversible changes to the landscape. Higher temperatures are also enabling the spread of vector-borne diseases, such as West Nile virus, Lyme disease, and malaria, as well as water-borne diseases like cholera. Climate change is also harming species and whole ecosystems. Animals such as the golden toad and Bramble Cays Melomys (a small rodent) are now extinct due to the warming world. Other animals, such as the flying fox, seabirds, and corals, are experiencing mass die-offs, while thousands more have moved to higher latitudes and elevations. Wildfire in Lowell, Oregon. Even with just 1.1 degrees Celsius of warming, the world is already experiencing withering droughts, extreme heat waves and severe floods.

B. We are locked into even worse impacts from climate change in the near-term

Even if the world rapidly decarbonizes, greenhouse gases are already in the atmosphere, and current emissions trends will make some very significant climate impacts unavoidable through 2040. The IPCC estimates that in the next decade alone, climate change will drive 32-132 million more people into extreme poverty. Global warming will jeopardize food security, as well as increase the incidence of heat-related mortality, heart disease, and mental health challenges. For example, under a high emissions scenario, increased flood risk could lead to an additional 48,000 deaths of children under 15 years old in 2030, due to diarrhea. Species and ecosystems will face dramatic changes as well, such as mangroves failing to counteract sea level rise, declines in sea-ice-dependent species and large-scale tree death.

C. Risks will escalate quickly with higher temperatures, often causing irreversible impacts of climate change

The report finds that every tenth of a degree of additional warming will escalate threats to people, species, and ecosystems. Even limiting global warming to 1.5 degrees C (2.7 degrees F) a global target in the Paris Climate Agreement, is not safe for all For instance, with just 1.5 degrees C of global warming, many glaciers around the world will either disappear completely or lose most of their extinction. Similarly, if warming exceeds 1.5 degrees C, even temporarily, much more severe, often irreversible effects of climate change will occur, such as stronger storms, longer heat waves and droughts, more extreme precipitation, rapid sea-level rise, loss of Arctic sea ice and ice sheets, thawing permafrost and more. Overshooting 1.5 degrees C also increases the probability of high- impact events, such as mass forest dieback, which would turn critical carbon sinks into carbon sources. The IPCC projects that these risks will compound one another as multiple hazards occur at the same time and in the same regions. For example, in tropical regions, the combined effects of heat and drought may trigger sudden and significant losses in agricultural yields. At the same time, heat-related mortality will increase while labour productivity decreases, so people will not be able to work harder to overcome drought-related losses. Together, these impacts will lower families' incomes while raising food prices, a devastating combination that jeopardizes food security and exacerbates health risks like malnutrition.

D. Inequity, conflict and development challenges heighten vulnerability to climate risks

Right now, 3.3 billion-3.6 billion people live in countries highly vulnerable to climate impacts, with global hotspots concentrated in small island developing states, the Arctic, South Asia, Central and South America, and much of sub-Saharan Africa. **Inequity, conflict, and development challenges such as poverty, weak governance, and limited access to basic services like healthcare not only heighten sensitivity to hazards but also constrain communities' ability to adapt to climatic changes. In highly vulnerable nations, for example, mortality from droughts, storms, and floods in 2010-2020 was 15 times greater than in countries with very low vulnerability**. Exposure to climate impacts rose dramatically in cities since the publication of the IPCC's Fifth Assessment Report in 2014. The fastest increases in urban vulnerability occurred across informal settlements, where precarious housing, inadequate access to basic services, and limited resources impede resilience efforts. This challenge is especially acute in sub-Saharan Africa, where 60% of the urban population lives in informal settlements, and in Asia, where 529 million people reside in these vulnerable areas. Many rural communities also face increasing climate risks, particularly Indigenous People and those whose livelihoods depend on sectors directly exposed to climate risks, such as agriculture, fishing and tourism. As climate impacts intensify, some households may have little choice but to move to urban centers. The IPCC projects that by 2030, extreme droughts across the Amazon will spur rural migration to cities, where indigenous peoples and traditional communities will likely be forced to live on the margins. Not only do these

urban and rural development patterns shape such unequal experiences of climate hazards, they also make ecosystems themselves more vulnerable to climate change. Land-use change, habitat fragmentation, pollution, and species exploitation are weakening ecological resilience. And ecosystem loss, in turn, amplifies people's vulnerability. Cities expanding across coastal wetlands, for example, degrade ecosystems that otherwise would have helped protect shoreline neighborhoods from sea level rise, storm surges, and coastal flooding. These climate hazards can have cascading and compounding effects on residents' health, food security, access to clean water, and livelihoods. **Mangrove restoration is a form of ecosystem-based adaptation, that can reduce climate risks while delivering co-benefits for livelihoods, ecosystems, and human health**.

E. Adaptation is crucial. Feasible solutions already exist, but more support must reach vulnerable communities

At least 170 countries' climate policies now include adaptation, but many have yet to move beyond planning into implementation. The IPCC finds that efforts today are still largely incremental, reactive, and small-scale, with most focusing only on current impacts or near-term risks. A gap between current adaptation levels and those needed persists, driven in large part by limited financial support. The IPCC estimates that adaptation needs will reach $127 billion and $295 billion per year for developing countries alone by 2030 and 2050, respectively. At the moment, adaptation accounts for just 4-8% of tracked climate finance, which totaled $579 billion in 2017-18. The good news is that existing adaptation options can reduce climate risks if they're sufficiently funded and implemented more quickly. The 2022 IPCC report breaks new ground by analyzing various climate adaptation measures' feasibility, effectiveness, and potential to deliver co-benefits like improved health outcomes or poverty reduction Three assessed climate change adaptation approaches include:

F. Social programs that improve equity and justice

Reconfiguring social protection programs (such as cash transfers, public works programs, and social safety nets) to include adaptation can lower urban and rural communities' vulnerability to a wide range of climate risks. These measures are especially effective when coupled with efforts to improve access to infrastructure and basic services, such as clean water, sanitation, and healthcare. Partnerships between governments, civil society organizations, and the private sector, as well as inclusive, locally-led decision-making processes, can help ensure that the provision of these services improves vulnerable communities' climate resilience.

- *Ecosystem-based adaptation:* This approach encompasses a wide range of strategies, from the protection, restoration, and sustainable management of ecosystems to more sustainable agricultural practices like integrating trees into farms, increasing crop diversity and planting trees in pastures. Ecosystem-based adaptation can reduce climate risks that many people already face including droughts, extreme heat, floods, and fires, while also delivering co- benefits for biodiversity, livelihoods, health, food security, and carbon sequestration. Meaningful collaboration with indigenous peoples and local communities is integral to the success of these measures.
- *New technologies and infrastructure*: Emerging evidence suggests that coupling nature- based solutions with engineered options like flood control channels may help reduce water- related and coastal risks, particularly in cities. Access to better technologies, such as more resilient crop varieties, improved livestock breeding, or solar and wind power, can also help strengthen resilience. Some of these climate adaptation responses, however, can be harmful if poorly designed or implemented inappropriately. Expanding irrigation systems, for example, can address short-term climate risks but can also drain scarce groundwater reserves.

G. Some impacts of climate change are already too severe to adapt to. The world needs urgent action now to address losses and damages

With the 1.1 degrees C of global warming the world is already experiencing, some highly vulnerable people and ecosystems are beginning to reach the limits of what they can adapt to. In some regions, these limits are "soft" — effective adaptation measures exist, but political, economic, and social challenges hinder implementation, such as limited access to finance. But in others, people and ecosystems already face or are fast approaching "hard" limits to adaptation, where climate impacts are so severe that no existing adaptation measures can effectively prevent losses and damages. For instance,

some coastal communities in the tropics have lost entire coral reef ecosystems that once helped sustain their food security and livelihoods. Others have had to abandon low-lying neighborhoods and cultural sites as sea levels rise. Whether facing the soft or hard limits of climate adaptation, the result for communities is devastating and oftentimes irreversible. These losses and damages will only increase as global temperatures rise. For instance, if the world warms beyond 1.5 degrees C, communities that depend on glacial and snowmelt will face water shortages to which they cannot adapt. At 2 degrees C (3.6 degrees F), the risk of simultaneous failures in maize production across key growing regions will increase significantly. And, if the temperature rises above 3 degrees C (5.4 degrees F), parts of southern Europe will experience dangerously high summer heat.

H. Rapidly Closing Window of Opportunity for Climate Action

The science is unequivocal: climate change endangers the well-being of people and the planet. Delayed action risks triggering impacts of climate change so catastrophic our world will become unrecognizable. The next few years offer a narrow window to realize a sustainable, livable future for all. Changing course will require immediate, ambitious, and concerted efforts to slash emissions, build resilience, conserve ecosystems, and dramatically increase finance for adaptation and addressing loss and damage. The COP27 summit, held in Egypt in November 2022, is a crucial opportunity for governments to make progress on all these fronts, and for developed countries to demonstrate their solidarity with vulnerable nations. Coming to grips with the climate crisis will not be easy. Governments, civil society, and the private sector must all step up. As the IPCC report makes clear, there is no alternative.
Courtesy: Kelly Levin, Sophie Boehm and Rebecca Carter, Feb 2022

17. Hydrogen to play key role in decarbonization

Hydrogen is set to play a key role in the utilities sector as the world starts to actively pursue decarbonization strategies.

The path to net-zero has picked up momentum recently, since targets have been set by the UAE, Saudi Arabia, Bahrain, Japan, South Korea, and Canada with the aim of becoming carbon neutral by 2050. China has also set a target to decarbonize by 2060 and the Biden administration has recommitted to the Paris agreement. While global demand for hydrogen currently sits at 8-10 exajoules (EJ), this is set to grow significantly. The EU published its plans for renewable energy last summer and is aiming for hydrogen to make up six gigawatts (GW) of capacity by 2024 and reaching 40 GW by 2030. The Hydrogen Council has estimated that hydrogen could make up a fifth of energy demand by mid- century and is the lowest-cost solution to decarbonization. Currently, approximately 95% of worldwide hydrogen is produced through fossil fuels, according to the International Renewable Energy Agency (IRENA). However, hydrogen from renewable sources has the potential to transform the energy industry which is facing key challenges Despite the opportunities and a drive in decarbonization, the International Energy Agency (IEA) says demand for low-carbon hydrogen remains low, with interest mainly coming from the transport industry. It says that more efforts are needed to create demand and encourage industries to make the switch to low-carbon hydrogen. Ferdinand Varga, Managing Director and Senior Partner of Boston Consulting Group, the Strategic Insights Partner of the World Utility Congress said: 'One of the most forward-looking energy supplies for industries is low-carbon fuels, specifically hydrogen. Meeting the future demand for hydrogen will not be easy, as production and supply of it might require subsidisation of its production to close the gap with other forms of low–carbon fuels, and most importantly, an adequate supply of cheap renewable power. Discussion on how hydrogen will play a key role in the decarbonization of the utility sector will help to provide a path forward on when, where, and how players should participate in it'.The cost of green hydrogen is beginning to drop, as solar and wind power become cheaper and electrolyzer capacity improves. But the scaling up of hydrogen faces challenges, as renewable capacity is slow to increase, limited funds have been allocated to hydrogen production projects, and carbon-intensive sectors, such as transport, are slow to pick up the fuel.

18. Larger variability in sea level due to warming of the Earth

A team of researchers from the University of Hawaii (UH) at Mānoa School of Ocean and Earth Science and Technology (SOEST) identified a global tendency for future sea levels to become more variable as oceans warm this century due to increasing greenhouse gas emissions. **Sea level variability alters tidal**

cycles and enhances the risks of coastal flooding and erosion beyond changes associated with sea level rise. Sea level rise is occurring as the Earth warms due to two main factors: **melting of land-based ice such as glaciers and ice sheets, and the expansion of seawater as it warms, termed thermal expansion**. Previously unknown was whether the rate of thermal expansion, which accelerates with warming, will also affect the variability of sea level. In a study published this week in *Communications Earth & Environment*, the team led by Matthew Widlansky, associate director of the UH Sea Level Center, assessed future sea level projections from global climate models. The team found that while future sea level variability changes are uncertain in many locations, nearly all of the 29 models they analyzed agreed on an overall tendency for the variability to increase on seasonal-to-interannual timescales. "Whereas it is well understood that the rate of global mean sea level rise will accelerate with future warming, in part due to the oceans expanding faster at higher temperatures, it was previously unexplored how this nonlinear thermal expansion property of seawater will affect future sea level variability," said Widlansky. Future projections of changing sea level annual ranges with increasing greenhouse gas concentrations during the 21st century. The global tendency for increasing sea level variability is explained by the yearly range of seawater buoyancy becoming larger as the oceans warm. Climate models disagree about the future change in some regions (stippling) because of other contributing processes, such as changes in ocean temperature variability, which are more uncertain. Credit: Widlansky, et al. (2020). "Following thermodynamic laws, sea level variability increases in a warmer climate because the same temperature variations, for example, related to the seasonal cycle, cause larger buoyancy and sea level fluctuations," added Fabian Schloesser, a researcher at the UH Sea Level Center who collaborated on the study. In places where changes due to ocean thermodynamics and other climate variability processes align, the team found the largest increases in future sea level variability. Coastal flooding occurs increasingly often due to a combination of slowly rising sea levels and ocean variability. The new findings, therefore, further emphasize the importance of sea level monitoring and forecasting. "Forecasting can potentially provide alerts months in advance if sea levels are likely to cause tides to be more extreme than otherwise expected," said Widlansky. While the science team explores how to develop better forecast outlooks, the UH Sea Level Center is actively monitoring extremes through a global network of tide gauge observations, including in Honolulu, Hawai'i.
Courtesy: Communications Earth &Environment, University of Hawaii, Manoa

19. Climate Mitigation Strategy
Mitigating climate change is about reducing the release of greenhouse gas emissions that are warming our planet. Mitigation strategies include retrofitting buildings to make them more energy efficient; adopting renewable energy sources like solar, wind and small hydro; helping cities develop more sustainable transport such as bus rapid transit, electric vehicles, and biofuels; and promoting more sustainable uses of land and forests. **About 1.4 billion people around the world rely on traditional fuels like coal and wood to meet their basic energy needs. This is not only harmful to the environment; it can also lead to premature deaths for millions of people, especially women and children. By 2035, global energy demand is projected to grow by more than 50 percent, and even faster in developing countries. All these new consumers need clean energy that will not hurt them or the environment**. The 2018 Intergovernmental Panel on Climate Change (IPCC) Special Report on 1.5 Degrees of Warming highlights the urgency of the needed climate actions: global emissions will need to peak by 2030 and rapidly decrease to net -zero by 2050 if we are to be able to stay within the safety limits established by the Paris Agreement. **Climate change affects virtually all natural and economic systems. This interaction between climate change and biodiversity, land degradation, forests, chemicals and waste, and waters points to the importance of recognizing climate change implications in everything we do**. The Global Environment Facility (GEF), established on the eve of the 1992 Rio Earth Summit, is a catalyst for action on the environment. Through its strategic investments, the GEF works with partners to tackle the planet's biggest environmental issues. **The GEF is the largest multilateral trust fund focused on enabling developing countries to invest in nature and supports the implementation of major international environmental conventions including on biodiversity, climate change, chemicals, and desertification**. The GEF-7 climate change mitigation strategy aims to support developing countries to make transformational shifts toward low-emission development pathways compatible with the objectives of the United Nations Framework Convention

on Climate Change (UNFCCC) and the Paris Agreement. Within the evolving landscape of climate finance, the strategy is designed to be as complementary as possible to other sources of climate finance, such as the Green Climate Fund. GEF support for climate change mitigation with three overarching objectives:

- **Promote innovation and technology transfer for sustainable energy breakthroughs: Technology is one of the key means to reduce or slow the growth of and stabilize the concentration of greenhouse gas emissions (GHG).** To that end, technology innovation, especially when promoted in partnership with the private sector, can help create or expand markets for green products and services, generating jobs, and supporting economic growth, while contributing to the reduction of GHG emissions. Resources from the GEF play a key role in piloting emerging and innovative solutions, including clean technologies, business models, supportive policies and strategies, and financial tools which foster private sector engagement for climate-friendly technologies and innovations. Four entry points have been prioritized for GEF-7 support in the climate mitigation area, in consideration of their innovative nature and complementary to other financial mechanisms: de-centralized renewable power with energy storage; electric drive technologies and electric mobility; accelerating energy efficiency adoption; and cleantech innovation.
- **Demonstrate mitigation options with systemic impacts**: Climate change affects virtually all natural and economic systems. The interaction between climate change and all areas of the GEF's work points to the importance of recognizing climate change implications in other focal areas by harnessing mitigation options and integrating climate resilience measures while promoting multiple global environmental benefits in a holistic and integrated fashion. This will be done via the three GEF-7 cross-cutting Impact Programs: Sustainable Cities; Food Systems, Land Use and Restoration; and Sustainable Forest Management.
- **Mainstreaming mitigation concerns into sustainable development strategies**: The GEF continues to address the need for enabling conditions to mainstream climate change concerns into the national planning and development agenda through sound data, analysis, and policy frameworks. This is exemplified by the GEF support for National Communications, Biennial Update Reports, Technology Needs Assessments, Nationally Determined Contributions and the Capacity-building Initiative for Transparency.

Results

In GEF's first 25 years, we have provided support for 940 climate change mitigation projects expected to contribute 8.4 billion tonnes of direct and indirect greenhouse gas emission reductions over time. The GEF has provided at least US$4.2 billion and leveraged $38.3 billion from other sources for more than 1,000 mitigation projects, and programs in 160 countries. A wide variety of mitigation strategies are supported, but production and consumption of energy is the single largest contributor to greenhouse gas emissions. GEF investments are geared to mitigate these emissions through specific projects. For example:

- *Energy efficiency*: introducing standards for consumer appliances and equipment, such as lighting, air conditioners and motors, and stronger building codes.
- *Renewable energy*: commercializing and scaling technologies like solar, wind, small hydro, bio power and geothermal energy.
- Policy: introducing feed-in tariffs, reverse auctions and other market-based mechanisms and financial instruments to speed up investments in clean energy.

Looking Ahead The GEF-7 climate change mitigation strategy aims to support developing countries to make transformational shifts toward low-emission development pathways compatible with the objectives of the UNFCCC and the Paris Agreement. Within the evolving landscape of climate finance, the strategy is designed to be as complementary as possible to other sources of climate finance, such as the Green Climate Fund. Building on the GEF's long-standing track record of driving innovation and fostering enabling conditions, the strategy also aims at promoting private sector engagement and increased investment in low-carbon technologies. With these objectives in mind, the GEF-7 mitigation strategy looks to harness and maximize synergies with the other GEF focal areas, **including integrated programmes focusing on sustainable cities, sustainable forest management, and food commodity value chains**. To achieve the ambitious goal of reducing (or avoiding) emissions of greenhouse gases

equivalent to at least 1.5 billion tons of CO2, the mitigation strategy hinges upon **three fundamental pillars**: **The promotion of innovation and technology transfer for sustainable energy breakthroughs. Technology is one of the keys to reducing or slowing the growth in greenhouse gas emissions, and stabilising their concentrations. GEF will focus its efforts on four areas: (i) de-centralized renewable power with energy storage; (ii) electric drive technologies and electric mobility; (iii) accelerating energy efficiency adoption; (iv) and cleantech innovation**. **Demonstration of mitigation options with systemic impacts**. GEF will conduct holistic and integrated migration efforts through its Impact Programs for Sustainable Cities, Food Systems, Land, and Restoration, and Sustainable Forest Management. The Sustainable Cities Impact Program, for example, targets urban interventions with significant climate change mitigation potential to help cities shift towards low-emission and resilient urban development in an integrated manner. **Foster enabling conditions for mainstreaming mitigation concerns into sustainable development strategies**. The GEF continues to address the need for enabling conditions to mainstream climate change concerns into the national planning and development agenda through its support for enabling activities, including Convention obligations and the Capacity-building Initiative for Transparency through sound data analysis and policy frameworks.

20. Call for global strategy to monitor effect of airborne plastic pollution on oceans

An international team of experts have called for the creation of an observation network to monitor the effect of airborne plastic pollution on oceans. Plastic particles have now been detected in all investigated areas of the environment including in water bodies, the soil and air. **The global study estimates that by 2040 the level of plastic pollution could reach 80 million metric tonnes per year. The expert team, led by Dr. Deonie Allen from the University of Strathclyde and Dr Steve Allen of Dalhousie University, estimate that potentially up to 25 million metric tonnes of micro and nano plastic are transported every year and form part of the atmospheric flux between the air and marine environment. Microplastics are plastic fragments generally considered to be smaller than five millimetres in length while Nano plastics are smaller than one-millionth of a metre. Global research into plastic pollution has highlighted that the wind can carry the particles to some of the most remote corners of the earth even faster than by ocean currents or rivers. The new paper presents a global strategy to create a cohesive, comparable dataset that will enable atmospheric micro and nano plastic activity to be monitored. The proposed strategy will enable not only the quantification of the ocean-atmosphere micro and nano plastic flux but also their effects and influence on our ecosystem and human health. It shall also illustrate more effective prevention and management of plastic pollution**. *Courtesy: University of Strathclyde, Glasgow*

21. Discoveries in the field of Earth System Science

Each year, the Earth Science Division's Research and Analysis Program combines space, airborne, and ground-based observations with data processing from high-tech computer models and algorithms to uncover new things about the Earth.

a. Measuring a large oceanic migration from space

Each night, marine organisms around the world migrate hundreds of meters to the surface to feed, only to return once day breaks. **This cycle, known as Diel Vertical Migration (DVM), is thought primarily to be an adaptation to avoid predators near the sunlit surface and is responsible for transporting large amounts of nutrients and carbon throughout the ocean. Scientists analyzed ten years of data from NASA's Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) sensor to reveal a global picture of DVM for the first time**. They found that some areas, such as subtropical gyres, contained significantly more migrators than others and that variations in the number of organisms were correlated to surface productivity. **These results provide important insight into ocean biological and biogeochemical activities, as well as a path forward for improving our understanding of the ocean as a whole system.**

b. Causes of mangrove loss

Mangroves are small trees or shrubs that grow along coastal shorelines. They prevent erosion and serve as an important habitat for many species. Human activities, such as shoreline development, have

historically been responsible for global declines in mangrove ecosystems. However, new research has shown that human-driven mangrove loss is beginning to decline. Scientists analyzed more than one million images from NASA's Landsat satellite from 2000-2016 to capture natural and human-induced sources of global mangrove deforestation. They found that direct human-driven mangrove loss dropped by 73% during the study period, and they created the first-ever high-resolution global mangrove loss map. This research demonstrates that future mangrove resilience will depend primarily on sea level rise and extreme events, such as hurricanes.

c. Understanding the period of strengthening of hurricanes

Hurricane damage accounts for more than half the cost of all U.S.-based natural disasters combined together. Although scientists can predict where hurricanes will strike with good accuracy, they are less successful at predicting when and how they will strengthen. The probability that a hurricane will suddenly increase in strength depends on many factors, including the internal structure of the storm. NASA Earth-observing satellites can peek inside storms to assess storm structures. **Scientists combined NASA observations with IBM Watson Studio to develop a novel machine-learning model to study the hurricane lifecycle. The study showed that inner-core precipitation, ice water content, and outflow temperature correlate well with storm intensification.**

d. Determining the effect of dust on clouds

When it comes to cloud formation, global climate models typically struggle to differentiate between the effects of aerosol interactions and normal meteorology. **New research is shedding light on how aerosols like dust affect cloud formation, especially deep convective clouds (DCCs). DCCs are commonly associated with severe weather near the equator and play a large role in Earth's climate**. By combining cloud observations from NASA's CloudSat satellite with MERRA-2 reanalysis products, scientists were able to isolate dust's effects on DCC formation. They found the presence of dust led to a 54% increase in DCCs when compared to dust-free conditions. Further, marine, sulphate, and combustion aerosols are associated with even more prevalent DCCs. **A better understanding of DCC formation will help improve global climate projections**.

e. Characterizing landslides movement

Landslides destroy property and contribute to the loss of life. Understanding how landslides respond to ongoing climate shifts, such as increased precipitation, is essential for predicting when they will occur. Although commonly associated with fast-moving, catastrophic events, most landslides are relatively slow. Scientists studied the Slumgullion landslide in Colorado (a large, slow-moving landslide) from 2011-2018 to better characterize landslide behaviour. **Combined measurements from airborne uninhabited aerial vehicle synthetic aperture radar (UAVSAR) and ground-based instruments confirmed mobility rates at the edges of landslides and how fluid from snowmelt and rainwater can trigger movement. These results shed new light on landslide boundaries and subsurface flow. This research will help communities better prepare for landslide events**.

f. Ranking mountains' ability to store water

Mountains are the water towers of the world, storing and supplying a significant portion of water to meet natural and societal needs. However, how much water they store and how vulnerable they are to climate change is still unknown – especially on a global scale. Scientists leveraged NASA data and models to develop a new global system to help ranking mountains, based on their storage capacity and dependent groups, such as communities and ecosystems. **Using this Water Tower Index (WTI), scientists found the highest-ranked WTI mountains were also the most vulnerable to climatic or socioeconomic shifts**.

g. Constraining Earth's climate sensitivity

NASA scientists have more closely constrained Earth's "climate sensitivity," or the amount of global temperature rise associated with a doubling of pre-industrial atmospheric carbon dioxide (CO2). Previous studies identified the temperature range to be between 1.5°C and 4.5°C. NASA participated in research that re-examined these findings, along with new lines of evidence and advanced computer modelling, to determine with more confidence that Earth's climate sensitivity is closer to the middle or

upper part of this range. This means society is unlikely to avoid substantial climate change (more than 2°C) under a high-emission future, and global temperatures could rise by as much as 4.5°C by about 2060.

h. Examining the causes of ice sheet melt

Melting ice sheets account for almost a third of the current global sea level rise. As the climate continues to change, NASA scientists are trying to better understand which processes-atmospheric or oceanic-contribute most to ice sheet melt. S**urface height measurements from NASA's ICESat (2003-2009) and ICESat-2 (2018-current) satellites revealed that enhanced ice melt driven by atmospheric and oceanic warming in Greenland and by oceanic warming in Antarctica contributed nearly 1 millimeter per year to sea level rise from 2003-2019. Greenland, where both oceanic and atmospheric processes worked together to thin the ice sheet, contributed nearly double the amount of sea level rise as Antarctica, where slow but widespread thickening due to atmospheric processes partially offset dramatic losses due to oceanic warming**.

i. Consolidating NASA's understanding of sea level rise

NASA released a comprehensive review of its current understanding of both natural and human-induced regional sea level variation. These include changes in ocean thermodynamics, vertical land motion near the coasts, changes in the ice sheet and glacier mass, and variability in land-based water storage and distribution. The study also takes into account high-frequency sea level variability associated with things like tides and storm surge. The study presents updated estimates for the major components of sea level rise. For example, **the study refines our understanding of the average global sea level rise of 3.3 ± 0.4 mm/year over the past three decades and explains why some coastal seas are rising faster than others in response to different physical processes**.

j. Understanding shark hunting patterns

Scientists combined satellite tracking with ocean remote sensing and numerical models to better understand pelagic blue shark movements and migration in the Atlantic Ocean. The pelagic zone is a region within the ocean that encompasses about 333 million cubic miles. Scientists found the sharks used warm swirling water masses called eddies to hunt beyond the pelagic zone into the twilight zone-a region of the deep ocean that lies beyond the reach of sunlight about 650-3,300 feet below the surface. Large eddies in the ocean serve as an internal weather system, mixing the water column and occasionally trapping and transporting smaller prey species, including plankton, for hundreds of miles. **This research helps to reveal the connection between predators and deep ocean prey resources**.

k. Discovering degradation exceeds deforestation in the Brazilian Amazon

Forest degradation is a common form of human disturbance, including activities like selective logging and extraction. While forest degradation falls short of total deforestation, it can still lead to biomass loss and fragmentation. Although deforestation rates in the Brazilian Amazon are well known, but the extent of forest degradation is not known. **Scientists analyzed the extent of forest degradation across the entire Brazilian Amazon over an approximately 22-year period up until 2014 using high-resolution remote sensing data from NASA's Landsat satellite. They found that the extent and rate of forest degradation were equal to or greater than deforestation, which has important implications for carbon storage, biodiversity, and energy balance**.

l. Mapping a new component of global air quality

NASA scientists have developed a new method to measure isoprene (C5H8), a chemical compound associated with ozone (O3) formation and poor air quality, using satellite observations. Isoprene is naturally emitted from trees and is difficult to measure from space. This is because once emitted, isoprene reacts rapidly with the surrounding environment to form formaldehyde (HCHO) – a toxic chemical linked to carcinogenic effects. NASA's new detection method combines machine-learning technology, airborne measurements, and advanced computer modelling to create and validate near-global maps of seasonal isoprene concentrations around the world. These new datasets could help communities in forested regions improve local air quality predictions.

Courtesy: Earth Science Division, NASA

22. Massive Hunga Volcano Eruption Created an Atmospheric Pulse That Caused an Unusual Tsunami-Like Disturbance

This looping video shows a series of GOES-17 satellite images that caught an umbrella cloud generated by the underwater eruption of the Hunga Tonga-HungaHa'apai volcano on January 15,
2022. Crescent-shaped bow shock waves and numerous lighting strikes are also visible. Credit: NASA Earth Observatory image by Joshua Stevens using GOES imagery courtesy of NOAA and NESDIS.

Hunga Volcano Eruption Provides an Explosion of Data

The gigantic January 15, 2022, eruption of the **Hunga submarine volcano** in the South Pacific Ocean devastated the island nation of Tonga and created a **variety of atmospheric wave** types, including booms heard 6,200 miles (10,000 km) away in Alaska. It also created an atmospheric pulse that caused an unusual tsunami-like disturbance that arrived at Pacific shores sooner than the actual tsunami. Those are among the many observations reported by a team of 76 scientists from 17 nations who conducted the research on the eruption's atmospheric waves, the **largest known** from a volcano since the 1883 **Krakatoa eruption**. The team's work, compiled in an unusually short amount of time due to significant scientific interest in the eruption, was published on May 12, 2022, in the journal Science. David Fee, director of the Wilson Alaska Technical Center at the University of Alaska Fairbanks Geophysical Institute, is a leading author of the research paper and is among four of the center's scientists involved in the research.

Courtesy: University Of Alaska Fairbanks May 2022

23. Huge Subglacial Lake Discovered in East Antarctica

Lake Snow Eagle, the newly-discovered subglacial lake is approximately 42 km in length and 370 km^2 in area, making it one of the largest subglacial lakes in Antarctica.

Revealed by heavily instrumented polar research aircraft, Lake Snow Eagle lies in a km-deep canyon in the highlands of Princess Elizabeth Land, a few hundred km from the coast. It lies relatively close to the coast, researchers think that this lake might contain information about how the East Antarctic Ice Sheet first began and the part played by the Antarctic Circumpolar Current, a ring of cold water circling the continent that keeps it cool. "This lake is likely to have a record of the entire history of the East Antarctic Ice Sheet, its initiation over 34 million years ago, as well as its growth and evolution across glacial cycles since then," said Dr. Don Blankenship, a senior research scientist in the Institute for Geophysics at the University of Texas at Austin. "Our observations also suggest that the ice sheet changed significantly about 10,000 years ago. The existence of Lake Snow Eagle and its host canyon emerged when Dr. Blankenship and colleagues spotted a smooth depression on satellite images of the ice sheet. To confirm it was there, they carried out systematic areal surveys over the site with ice-penetrating radar and sensors that measure minute changes in Earth's gravity and magnetic field. Along with the gravity and magnetic surveys, which lit up the underlying geology of the region and the depth of water and sediments, Yan constructed a detailed picture of a jagged, highland topography with Lake Snow Eagle nestled at the base of a canyon. According to the team, the lake is about 42 km long, 14.5 km wide, and 198 m deep. The sediments at the bottom of the lake are 305 m deep and might include river sediments older than the ice sheet itself. "This lake's been accumulating sediment over a very long time, potentially taking us through the period when Antarctica had no ice at all, later it went into a deep freeze," said Dr. Martin Siegert, a glaciologist at Imperial College, London.

Courtesy: The Journal Geology

24. Advancing Artificial Intelligence for Earth Science: A Data Systems Perspective

Tackling data challenges and incorporating physics into machine learning models will help unlock the potential of artificial intelligence to answer Earth science questions.

Artificial intelligence is **the simulation of human intelligence processes by machines, especially computer systems. Machine learning is a subfield of artificial intelligence, which is broadly defined as the capability of a machine to imitate intelligent human behaviour. Artificial intelligence systems are used to perform complex tasks in a way that is similar to how humans solve problems. Machine learning, applied to the wealth of Earth observation data, could produce answers for many pressing questions and problems in Earth science**. The Earth sciences present

uniquely challenging problems, from detecting and predicting changes in Earth's ecosystems in response to climate change to understanding interactions among the ocean, atmosphere, and land in the climate system. To address these problems, however, is a wealth of data sets—containing atmospheric, environmental, oceanographic, and other information—that are mostly open and publicly available. **This fortuitous combination of pressing challenges and plentiful data is leading to the increased use of data-driven approaches, including machine learning (ML) models, to solve Earth science problems. Machine learning, a type of artificial intelligence (AI) in which computers learn from data, has been applied in many domains of Earth science. Such applications include land cover and land use classification, precipitation and soil moisture estimation, cloud process representations in climate models, crop type detection and crop yield prediction, estimations of water, carbon, and energy fluxes between the land and atmosphere, spatial downscaling of satellite observations, ocean turbulence modelling, and tropical cyclone intensity estimation**.

Machine learning can discover patterns and trends buried within vast volumes of data that are not apparent to human analysts.

Machine learning uses a bottom-up approach in which algorithms learn relationships between input data and output results as part of the model-building effort, so it is not always easy to interpret the outputs of the resulting models. However, ML can discover patterns and trends buried within vast volumes of data that are not apparent to human analysts. In traditional Earth science modelling, researchers use a top-down approach based on their understanding of the physical world and the laws that govern it. This approach allows us to interpret model outputs, yet it can be limited by the sheer amount of computing power required to solve large problems and by the difficulty of finding patterns where we don't expect them. **Recent efforts by Earth scientists have focused on integrating the best aspects of physics-based modelling and machine learning, incorporating physical laws into ML model architectures to help building models that are easier for interpretation.**

Numerical Models, Real-World Constraints

Machine learning models can be combined with physical constraints to bridge the gap between data-driven methods and physical modelling and to increase the interpretability of ML models.

Interpreting ML model outputs and assessing why a model produces a specific output from a set of inputs can be difficult. However, the latest research shows that ML models can be combined with physical constraints to bridge the gap between data-driven methods and physical modeling and to increase the interpretability of ML model.

These advancements are encouraging; however, several challenges in adopting ML for the broader Earth science community. Specifically, high-priority challenges include

- a lack of publicly available benchmark training data sets across all science disciplines
- a lack of interoperability among data sources, types, and formats (e.g., standard data formats for computer vision algorithms may be different from the standard formats for commonly used Earth science models)
- limited availability of baseline pretrained models that can be customized for various types or modes of Earth observations
- label or target values that are not usually structured, such as oceanic measurements from drifting buoys that cannot be adapted easily to the grid systems commonly used in ML algorithms.

Priority areas for using machine learning in the Earth sciences were identified at a workshop hosted by NASA's Earth Science Data Systems Program and Radiant Earth Foundation. The Earth observation and ML communities would benefit from further collaborations to address these challenges and develop innovative solutions to geoscience problems. To promote such collaborations, NASA's Earth Science Data Systems (ESDS) Program and Radiant Earth Foundation hosted a workshop last January in Washington, D.C., that gathered 51 scientists, practitioners, and experts from government agencies, non-profit organizations, universities, and private industries. Workshop participants presented and discussed recent advances in ML techniques as well as their applications to Earth science problems. Three working group sessions reviewed existing gaps in knowledge and tools, and they provided recommendations to facilitate applications of ML to Earth observation data. In particular, participants created a set of recommendations to develop an ML "pipeline" involving training data generation,

model development and documentation, and sharing these models and data sets. The full report from the workshop is now available online.

Physically Aware Machine Learning Models

Because extreme weather events and impacts of climate change are rare or unseen in training data gathered from historical observations, machine learning models usually struggle to provide accurate predictions of scenarios involving such events or impacts. Because ML techniques explain patterns from data and do not incorporate physical laws (e.g., mass and energy balance), they typically cannot extrapolate beyond the range of parameters learned from the training dataset used. The inability to extrapolate is a challenge for expanding ML-based applications in the Earth sciences. For example, extreme weather events and impacts of climate change are rare or unseen in training data gathered from historical observations, ML models usually provide accurate predictions of scenarios involving such events or impacts. In recent years, several approaches have been implemented to embed physical constraints in either ML model architectures or the cost function (which helps the model make itself more accurate) during training. **These approaches have shown promising results in estimating atmospheric convection, sea surface temperature, and vegetation dynamic modelling. Further research is needed to build and expand physics-aware ML models in the Earth sciences**.

Courtesy: NASA ESDS with co-sponsorship from the IEEE Geoscience and Remote Sensing Society

25. New 3D geological model expected to help guide exploration of rare earth elements

The Baiyun Ebo mine in China's Inner Mongolia region is the site of almost half the world's rare earth production.

Scientists from the University of Exeter and the British Geological Survey (BGS), alongside a team of institutions across Europe, have developed a new 3D geological model designed to guide the exploration of rare earth elements. The model targets alkaline igneous systems, which host many of the world's REE deposits. In a paper published in the journal, Economic Geology, the researchers point out that despite the growing importance of these essential raw materials, exploration models for REE are comparatively less developed than those for major and precious metals such as iron, copper, and gold. To address this, the teams involved in the project decided to use both geophysical and geochemical approaches to create their model. In other words, their solution is based on a compilation of maps, geophysical and geochemical data, and petrological observations from alkaline igneous systems worldwide. According to the experts, groups of alkaline igneous rocks with a common geological history occur at many localities around the world and are common hosts of REE deposits. Our understanding of the geology of REE deposits was largely based on the details studies of individual occurrences, with a host of complex local nomenclature—a barrier to exploration, relative to more mature commodities such as copper or gold. Beard explained that the aim of this work was to generate a multistage REE exploration guidebook of alkaline-silicate systems, to allow geologists to locate prospective regions and REE deposits. **This was done by synthesizing diverse observations from maps, geophysical models and geochemical indicators to generate a workflow for explorers that are applicable from continental to deposit scale. The publication includes a schematic 3D model for alkaline-silicate systems showing the position of various types of critical mineral deposits**.

Courtesy: Staff Writer, Education Suppliers &Equipment, USA July 2022

Career opportunities in Climate Science

The Master of Advanced Studies in Climate Science and Policy (MAS-CSP)

The consequences of climate change on social systems are expected to vary in different regions of the world on account of several regional and other local factors. Therefore, different modelling studies, adaptation strategies and technology systems would be required in differing geographical and social contexts. Further, there are many uncertainties in disaggregating the effects of global warming on different agro-climatic regions due to still inadequate scientific understanding of the processes involved in climate change. This would require developing a strong capability in basic and applied research in climate science by strengthening observational and modelling tools and systems. India is too large a country to adopt strategies based on global averages of climate change. The current levels of uncertainties associated with the likely consequences of climate change in various regions of the country are significant and do not enable the development of strategic action plans for different regions within

the country. There are a number of constraints that limit at present the ability of the national knowledge system to deliver the required and expected outcomes for effective response. Addressing these constraints through strategic actions that include the development of appropriate institutional and human resource capacity for this purpose will form the main goal of the National Mission on Strategic Knowledge for Climate Change. Accordingly, the following objectives have been identified for the Mission.

- Formation of knowledge networks among the existing knowledge institutions engaged in research and development relating to climate science and facilitatesdata sharing and exchange through a suitable policy framework and institutional support.
- Establishment of global technology watch groups with institutional capacities to carry out research on risk minimized technology selection for developmental choices
- Development of national capacity for modelling the regional impact of climate change in various ecological zones within the country for different seasons and living standards.
- Establishing research networks and encouraging research in the areas of climate change impacts on important socio-economic sectors like agriculture, health, natural ecosystem, bio-diversity, coastal zones, etc.
- Providing an improved understanding and awareness of the key climate processes and the resultant climate risks and associated consequences.
- Building alliances and partnerships through global collaboration in research & technology development on climate change under International and bilateral S&T cooperation arrangements.

2. National Mission for Sustaining the Himalayan Ecosystem (NMSHE)
East Antarctica's Largest Subglacial Lake Has Been Discovered
Advancing Artificial Intelligence for Earth Science: A Data Systems Perspective
Numerical Models and Real-World Constraints.

The Himalayas assume great significance to the people of India-socially, culturally, and economically. The Himalayan ecosystem possesses nearly 51 million people who practice hill agriculture. Most of India's river systems in the north originate from glaciers in the Himalayan region. The Himalayas are therefore a major source of fresh water for the perennial rivers such as the Indus, the Ganga, and the Brahmaputra. Glacial melt may impact their long-term lean-season flows, with adverse impacts on the economy in terms of water availability and hydropower generation. For centuries, the Himalayan ecosystem has remained delicately balanced and has been responsible for the tremendous biodiversity of the region. The ecosystem has become increasingly vulnerable to the impacts of changes due to natural causes, anthropogenic emission-related causes, and also due to the developmental paradigms of modern society. The National Mission for Sustaining the Himalayan Ecosystem has been launched with the goal of addressing all such issues holistically and in a coordinated manner by involving all possible stakeholders. The most crucial and primary objective of the mission is to develop a sustainable national capacity to continuously assess the health status of the Himalayan ecosystem, enable policy bodies in their policy-formulation functions, and assist states in the Indian Himalayan Region with their implementation of actions selected for sustainable development. Accordingly, the following objectives have been identified for the mission. Building human and institutional capacities in different existing and new institutions in the Himalayan region. Identification of national knowledge institutions and development of a self-sustaining knowledge network, development, and adoption of new methods for assessing the health of the Himalayan ecosystem including those of glaciers, and create a database of the same.

- Assessment and quantification of the changes in the Himalayan ecosystem attributable to climate change as a result of global emissions and human activities in the region and model for future projections.
- Exploration of linking of traditional and formal knowledge systems through the strategic mechanism of formalization for mutual benefit and value for the sustainability of the Himalayan ecosystem.
- Identification of most-desirable Adaptation Policies to Improve Regional Sustainability.

Compilation and Revampification: DR. B. MISHRA