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ACTING TOGETHER FOR A BETTER FUTURE

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General Information

Green Horizon is a peer reviewed e-newsletter published in English by the Centre for Environmental Studies, Yenepoya (Deemed to be University), Mangalore in two issues per year during June and December. This newsletter publishes manuscript of different categories like original articles, short communications, opinions, research communications, case study etc. We invite original contributions significantly advancing fundamental understanding and that focus on the interconnection of multiple environmental spheres of environment and nature (biodiversity, plants, animals, microbes, conservation, soil, air, water, climate, pollution, waste management, compost, environmental protection, environmental management and ecofriendly approaches). The authors, editors and reviewers need to adhere to the research and publication ethics to enhance the quality of the newsletter.

Aim and Scope

Green Horizon intends to project and share the knowledge on our environment and its protection for the benefit of society. It brings out quality and original materials exclusively on the environment and welfare of the biodiversity. Emphasis should be given to biodiversity, ecology, conservation, waste disposal, prevention of pollution and innovative ideas to protect and nurture our environment towards prolife.

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EDITORIAL

Embracing Change for a Sustainable Future

Welcome to the latest edition of our newsletter, where we delve into the most pressing environmental issues and explore innovative solutions for protecting the environment. In this edition, we shine a spotlight on the recent 2023 UN Climate Change Conference and its potential to usher in a new era of climate-friendly policies. The 28th United Nations Climate Change Conference, held in Dubai, marked a pivotal moment for global collaboration in the fight against climate change. With representatives from nearly every nation, COP28 aimed to forge agreements to limit global temperature rises and adapt to the challenges posed by climate change. This gathering offers hope for a collective effort towards building a sustainable future for generations to come.

To effectively address climate change, we must first understand its complexities and implications. Climate change, primarily driven by human activities such as the burning of fossil fuels, poses a significant threat to our planet's health and stability. It is imperative that we recognise the urgency of the situation and take meaningful action to mitigate its impacts. India, as a global leader, has demonstrated its commitment to combating climate change. Despite facing challenges in resource allocation, India has remained among the highest performers in addressing climate issues. By aligning policies with global standards and prioritising environmental conservation, India continues to play a crucial role in the collective effort to address climate change.

Achieving net-zero emissions is essential in the fight against climate change. This ambitious goal requires credible action and commitment from all nations. Through initiatives like carbon farming and urban forestry, we can make significant strides towards a sustainable future and mitigate the impact of climate change. Carbon farming, for instance, not only helps sequester carbon dioxide but also enhances soil health and agricultural resilience. Likewise, urban forests provide numerous benefits to cities and their inhabitants, from improving air quality to fostering community well-being.

We have also focused on the importance of biodiversity, particularly in coastal ecosystems. Coastal sand dunes, despite their harsh conditions, are home to a diverse array of plant species with ecological, economic, and industrial significance. Understanding and protecting these ecosystems is essential for maintaining the health of our planet. Our articles highlight sea urchins, one of the oldest species inhabiting the earth, and lichens, which play a vital role in nutrient cycling. They also act as pollution indicators and are crucial for environmental health.

As we navigate the challenges of climate change, let us remember that each action we take, no matter how small, contributes to a larger collective effort. Together, we can build a sustainable future for all. In closing, I am excited to announce the theme for our next issue: eco-friendly activities carried out by Yenepoya Medical College during their Silver Jubilee celebrations. Stay tuned for more insights, updates, and solutions in our upcoming newsletters. Together, let's make a difference....

With warm regards,
Dr. Bhagya B. Sharma
Editor-in-Chief
Green Horizon

The 2023 UN Climate Change Conference

Offering hope for a new climate-friendly world order

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The 28th United Nations Climate Change Conference, or Conference of the Parties of the UNFCCC, more commonly known as COP28, took place from 30th November to 13th December at Expo City, Dubai, United Arab Emirates. The COP conference has been held annually since the first UN climate agreement, the UN Framework Convention on Climate Change (UNFCCC), in 1992. The event aims for governments to agree on policies to limit global temperature rises and adapt to impacts associated with climate change, bringing together the 198 countries that have ratified the UNFCCC, representing almost every country in the world. The conference has now become the largest annual meeting convened by the United Nations. India was among the participating countries, and Prime Minister Narendra Modi personally attended the meet. Over 70,000 people were accredited for the summit, with an additional 400,000 granted access to the surrounding "blue zone." Business leaders, young people, climate scientists, indigenous peoples, journalists, and various other experts and stakeholders were also participants.

2023 United Nations Climate Change Conference, Dubai

Delivering the opening address to delegates at the World Climate Action Summit, a part of COP28, King Charles III of the UK expressed alarm at rising levels of pollution, stating that the world was "dreadfully far off track" from its climate targets. The British monarch warned, "We are carrying out a vast, frightening experiment of changing every ecological condition, all at once, at a pace that far outstrips nature's ability to cope. In 2050, our grandchildren won't be asking what we said; they will be living with the consequences of what we did or didn't do. The Earth does not belong to us; we belong to the Earth."

On the starting day of the summit on 30th

November 2023, a "loss and damage" fund to compensate poor states for the effects of climate change was agreed upon. The fund aims to distribute funds to poor states harmed by climate change and is to be administered by the World Bank. Initial promises were made by the host (UAE) to donate $100 million to the fund, and by the United Kingdom ($75 million), United States ($24.5 million), Japan ($10 million) and Germany ($100 million).

On 13th December, the conference president, Sultan Al Jaber, announced that a final compromise agreement between the countries involved had been reached. The deal commits all signatory countries to move away from carbon energy sources "in a just, orderly and equitable manner" to mitigate the worst effects of climate change and reach net zero by 2050. The global pact was the first in the history of COP summits to explicitly mention the need to shift away from every type of fossil fuel.

Final Agreements and Pledges

The participants of the conference pledged $85 billion to different climate issues and made 10 pledges:

1. Coalition for High Ambition Multilevel Partnerships (CHAMP) for Climate Action Pledge was signed by 71 countries, including the United States, Brazil, France and Germany. It includes commitments to promote international and sub-national climate action, make new, more ambitious nationally determined contributions by 2025, increase efforts for climate change adaptation and preserve biodiversity to limit warming to 1.5 degrees.

2. UAE Leaders' Declaration on a Global Climate Finance Framework was signed by 13 countries, including the United States, India, the United Kingdom and Germany. It includes targets of mobilizing $100 billion by 2025 and $5-7 trillion by 2030 for climate action, making debt reforms, implementing an emissions pricing mechanism, and mobilizing concession and private capital.

3. COP28 UAE Declaration on Climate and Health was endorsed by 143 countries, including the European Union, China and the United States. It includes commitments to reduce negative health impacts from climate change in collaboration with indigenous peoples, women, local communities and health workers and prevent zoonotic spillover.

4. COP28 Declaration on Climate, Relief, Recovery and Peace was adopted by 82 countries, including Canada, China, Ukraine, the United States and Rwanda. The declaration includes commitments to promote peace, implement environmental policies that support peace, prevent climate change from increasing conflict, and help and empower people affected by environmental degradation and conflict.

5. Global Renewables and Energy Efficiency Pledge was signed by 130 countries, including Bhutan, Brazil, the European Union, Angola, Bangladesh, Burkina Faso and Chad. The countries pledge to refer to energy efficiency as “first fuel” and double the rate of energy efficiency increase from around 2% to over 4% every year until 2030. They also pledged to triple the capacity of renewable energy by 2030, ensuring a just transition, and increase renewable energy use and energy efficiency in an environmentally responsible manner.

6. COP28 UAE Declaration on Sustainable Agriculture, Resilient Food Systems, and Climate Action was adopted by 159 countries, including Australia, Belarus, Brazil, China and the United States. It includes commitments to make the global food system more sustainable and climate resilient, promote food security by helping vulnerable people, transition to sustainable water management, include food systems in climate action strategies, and protect and restore nature.

7. COP28 Gender-responsive Just Transitions and Climate Action Partnership includes 76 countries, including Canada, China, Sweden, the Democratic Republic of the Congo, Israel and the United Arab Emirates. Its declaration includes a pledge to ensure a just transition, considering the effects on women, especially indigenous, rural, and with disabilities.

8. Global Cooling Pledge for COP28 was endorsed by 61 countries, including Denmark, Japan, Canada, the United States and Spain. The declaration mentions the effects of increasing heat waves on health and the economy (including food waste) and the contribution of the cooling industry to climate change. The signers pledged, among other things, to cut GHG emissions from the cooling industry by 68% by 2050, increase the efficiency rate of air conditioning equipment by half by the year 2030, make a national plan for cooling, increase green spaces and blue spaces in cities, and promote passive cooling (that can reduce a building's cooling load by more than 25%).

9. COP28 Declaration of Intent was endorsed by 37 countries and includes different pledges to advance hydrogen engines, including derivatives of hydrogen, as a climate solution.

10. COP28 Joint Statement on Climate, Nature and People was endorsed by 18 countries, including China, the United States, Canada, France, Germany and the United Kingdom. The statement recognizes that the problems of climate change, biodiversity loss, land degradation, ocean degradation and social inequality are interconnected and cannot be solved separately. Therefore, the signers pledge to unify the plans to solve the problems into one integrated strategy.

Understanding Climate Change

Climate change is a crucial subject of concern in modern times and it can adversely affect the future of our planet. Understanding its various facets holds the key to mitigating it.

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What is climate change?

Climate change refers to prolonged alterations in temperatures and weather patterns. These changes can be natural, stemming from variations in the sun's activity or significant volcanic eruptions. However, since the 1800s, human activities have emerged as the primary catalyst for climate change, primarily attributable to the combustion of fossil fuels such as coal, oil and gas. The burning of fossil fuels produces emissions of greenhouse gases, functioning like a cover enveloping the Earth, trapping the sun's warmth and elevating temperatures. The primary contributors to climate change among greenhouse gases include carbon dioxide and methane, originating from activities like using gasoline for driving or coal for heating. Deforestation and land clearing can also release carbon dioxide into the atmosphere. Notably, methane emissions derive from sources such as agriculture as well as oil and gas operations. The principal sectors responsible for greenhouse gas emissions encompass energy, industry, transportation, buildings, agriculture and land use.

Humans are responsible for global warming.

Human activities have been identified by climate scientists as the primary cause of virtually all global warming over the past 200 years. The emission of greenhouse gases resulting from these human-induced activities is causing the Earth to warm at an unprecedented rate, surpassing any period in the last two millennia. Compared to the late 1800s, prior to the industrial revolution, the Earth's surface temperature has risen by approximately 1.1°C. This warming trend exceeds any recorded temperature over the last 100,000 years. The recently concluded decade (2011–2020) stands as the warmest on record, with each of the last four decades surpassing the warmth of any preceding decade since 1850.

While many associate climate change primarily with elevated temperatures, the consequences go beyond temperature fluctuations. As the Earth operates as a complex, interconnected system, changes in one aspect can trigger cascading effects in others. The current impacts of climate change encompass intensified droughts, water scarcity, widespread fires, rising sea levels, floods, polar ice melting, severe storms, and a decline in biodiversity, among other consequences.

People are experiencing climate change in diverse ways.

The impacts of climate change extend beyond environmental concerns and encompass various aspects of human life, including health, agricultural productivity, housing, safety, and employment. Certain populations are particularly susceptible to the impacts of climate change, notably those residing in small island nations and other developing countries. Already, conditions like rising sea levels and saltwater intrusion have progressed to a stage where entire communities are compelled to relocate. Prolonged droughts pose a significant threat, placing people at risk of famine. Looking ahead, the projected increase in the frequency and severity of weather-related events is expected to lead to a growing number of individuals being displaced from their homes due to climate-related factors. This highlights the wide-ranging and escalating challenges that climate change poses to diverse aspects of human well-being and societal stability.

Every increase in global warming matters.
In a series of United Nations reports, a consensus among thousands of scientists and government reviewers emerged, emphasizing that restricting the global temperature increase to no more than 1.5°C is crucial to avoiding the most severe climate impacts and preserving a habitable climate. However, prevailing policies suggest a trajectory towards a 3°C temperature rise by the close of the century.

The emissions responsible for climate change emanate from all corners of the globe and impact everyone, although certain nations contribute significantly more than others. The seven largest emitters-China, the United States of America, India, the European Union, Indonesia, the Russian Federation and Brazil-accounted for approximately half of the total global greenhouse gas emissions in 2020. While collective action on climate is imperative for all, there exists a heightened responsibility for those countries and individuals that contribute more substantially to the problem. This underscores the need for proactive measures from major emitters to address the climate crisis.

Source: https://chemtrust.org/climate/

We face a huge challenge, but we already know many solutions.
Numerous solutions to address climate change not only promise economic advantages but also enhance our quality of life while safeguarding the environment. Global frameworks and agreements, such as the Sustainable Development Goals, the UN Framework Convention on Climate Change and the Paris Agreement, provide guidance for collective progress. Three overarching categories of action include reducing emissions, adapting to climate impacts, and securing the necessary funding for adjustments.

Shifting from fossil fuels to renewable energy sources like solar or wind is a key strategy to curtail the emissions fueling climate change. Urgent action is imperative, even as an increasing number of countries commit to achieving net-zero emissions by 2050. To keep global warming below 1.5°C, emissions must be halved by 2030. This necessitates substantial reductions in the use of coal, oil and gas, with more than two-thirds of existing proven reserves of fossil fuels needing to remain untapped by 2050 to avert catastrophic levels of climate change. Acting swiftly and decisively is critical to achieving these goals.

Taking measures to adapt to the consequences of climate change is essential for safeguarding individuals, residences, businesses, livelihoods, infrastructure and natural ecosystems. This adaptation encompasses both existing impacts and those anticipated in the future. While adaptation efforts are necessary globally, immediate attention and prioritization are crucial for the most vulnerable individuals with limited resources to struggle with climate-related hazards. Investing in adaptation can yield substantial returns, with early warning systems for disasters serving as a notable example. These systems not only save lives and protect property but can also generate benefits up to 10 times the initial cost, underscoring the value of proactive adaptation strategies.

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Climate Change - Where Does India Stand?

India ranked 7th in this year's Climate Change Performance Index and also remained among the highest performers.

Climate change is the most pressing issue dominating today's environmental discourse. India has traditionally aspired to be a model global citizen. The country has readily embraced global initiatives aimed at fostering a better world, spanning gender equality, human rights, and democratic values. Similarly, our state policies regarding environmental conservation, habitat protection and wildlife preservation are aligned with global standards. If we are lagging behind in these, it is because we have faced limitations in resources and infrastructure to the implement the official policies, but our political will has seldom wavered.

So, where does India stand on the critical issue of climate change? Chronologically, this is a relatively new concern, catching many off guard. Policies in this realm carry significant implications for a nation's economy and way of life. Merely espousing ideals is insufficient; tangible action is imperative. The 28th United Nations Climate Change Conference (COP28) in Dubai provided insights into India's stance on climate change.

Prime Minister Narendra Modi interacted with multiple world leaders at the COP28 climate change summit in Dubai. Image source: https://www.hindustantimes.com/environment/from-gaza-war-to-paris-agreement-key-takeaways-from-climate-summit-cop28-in-dubai-environment-israel-hamas-101701479271644.html

At this esteemed global summit, India positioned itself as a leader of the global south, highlighting the shared challenges faced by developing nations. During his opening address, Indian Prime Minister Narendra Modi delivered a pointed critique of wealthy nations: “A small section of mankind has exploited nature indiscriminately. But the whole of humanity is paying its price, especially the residents of the global south.” His statement underscores the responsibility of developed nations to lead climate initiatives with greater commitment.

However, facts speak volumes. It's worth examining our country's track record and the obstacles hindering our efforts. According to a report released during COP28 in Dubai, India climbed to 7th place in this year's Climate Change Performance Index, up from the previous ranking, remaining among the top performers. Assessing climate mitigation efforts of 63 countries plus the EU – covering over 90% of Global Greenhouse Gas Emissions, India received high rankings in the categories of Greenhouse Gas Emissions and Energy Use, but a medium ranking in Climate Policy and Renewable Energy, consistent with the previous year.

While India boasts the world's largest population, its per capita emissions remain relatively low, the index notes. “Our data indicates that in the per capita GHG category, the country is on track to meet a benchmark of well below 2 degrees Celsius. However, progress in renewable energy adoption is sluggish,” the report states.

Experts reported that India is striving to fulfill its Nationally Determined Contributions (NDCs) with clear long-term policies focusing on promoting renewable energy and supporting domestic manufacturing of renewable energy components. Despite these efforts, India's growing energy demands are still predominantly met by coal, alongside oil and gas, contributing significantly to greenhouse gas emissions and severe urban air pollution, the report highlights.

India maintains relatively high taxes on petrol and diesel, aimed at acting as carbon taxes, although the impact on consumption remains debated. “While some experts view them as effective tools to reduce consumption, others note the government's dependence on tax revenues from these sources,” the report explains.

“At the last COP, India, along with China, altered the language of the cover decision to 'phase down' rather than 'phase out' fossil fuels, which was perceived as a setback for global commitments to end the fossil fuel era,” the report adds. Additionally, large-scale renewable energy projects have reportedly negatively impacted local communities through land acquisitions and unequal distribution.

Furthermore, the report emphasizes the need for policies to be transformative and adaptive, focusing on ecosystem-based solutions, equity, and effective bottom-up implementation. Experts advocate for a faster phase-out of coal, reduced reliance on gas and accelerated adoption of renewable energy. They call for India to achieve Net Zero emissions no later than 2050 and to develop people-friendly, climate-friendly, sustainable infrastructure, considering cultural and social contexts.

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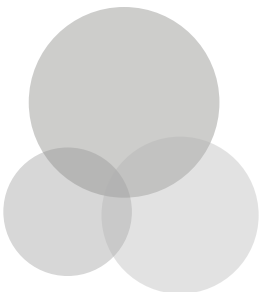

Lichens as Bioindicators

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Introduction

Lichens are multifaceted creatures resulting from a symbiotic relationship between two distinct organisms, that is algae and fungus. The fungus is the lichen's predominant partner and is responsible for most of its features, including its fruiting bodies and thallus form. Lichens play a significant role in the cycling of nutrients and serve as producers for a variety of higher trophic feeders, including mites, nematodes, reindeer and gastropods. The characteristics of lichens differ from those of the constituent organisms. They are not actually plants, but they do come in a variety of hues, shapes and sizes. They can have flat leaf-like structures that grow crust-like and stick to surfaces like a thick layer of paint, or they can have small, leafless branches or other growth forms (Baker, *et.al*., 2003).

Lichen on tree bark

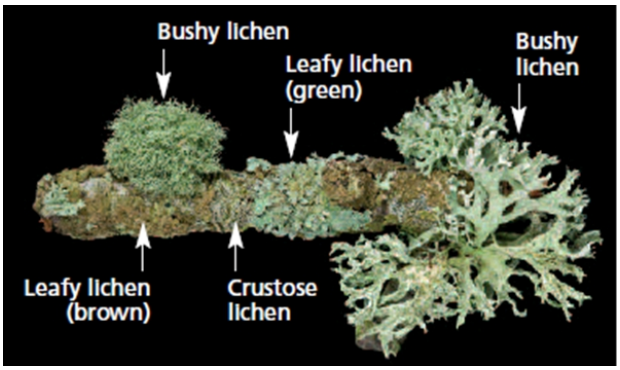
Lichen is a composite creature that develops from algae or cyanobacteria that coexist in symbiotic, mutually beneficial relationships with the filaments of fungi. Through photosynthesis, the cyanobacteria or algae create carbohydrates that the fungi consume for their own advantage. The fungus' filaments shield the algae or cyanobacteria from the environment while simultaneously attracting moisture and nutrients and acting as an anchor for them. The majority of descriptions of lichen associations characterize them as symbiotic, even though some photosynthetic partners in lichen can survive outside the lichen. The lichen symbiotic interaction expands the ecological range of both partners.Through dust and rain, the atmosphere provides both partners with their primary sources of water and mineral nutrients.

In addition to acting as a larger area for the algae to absorb mineral nutrients and, in certain situations, supplying minerals from the substrate, the fungal partner shields the algae by holding onto water. In certain tripartite lichens, cyanobacteria can fix atmospheric nitrogen, enhancing the activities of the green alga. This can occur when cyanobacterium is present as a primary partner or as an additional symbiont. Other plants and animals also depend on lichens. Other organisms can grow in the organic material that lichens leave behind when they decompose because of their capacity to grow in certain arid areas, such as the surface of a rock. Numerous animals, such as reindeer, squirrels, snails, and insects, eat them as well.

Lichens as Pollution Indicators

Due to the fact that lichens get all of their water and nutrients from wet and dry atmospheric deposition, they are susceptible to air pollution,

including nitrogen (N). Increased nutrient load can result from nitrogen deposition. The chlorophyll in algae is used to make carbohydrates that feed both the algae and the fungi, but too much nitrogen can damage or even kill it. Some lichen species can tolerate nitrogen better than others (Riedel, *et. al*., 2021). A rise in atmospheric N deposition may be indicated if there is a rise in N-tolerant species and a decrease in N-sensitive species. Lichens are the "canaries in the coal mine" of N deposition. A change in the species composition and/or health of these organisms represents the possible onset of the decline in ecosystems brought on by N deposition.



Branch showing the three different types of lichen (leafy, bushy and crustose).
Image source: https://www.apis.ac.uk/nitrogen-lichen-field-manual

Lichens are especially useful as bioindicators. Living things that represent the state and quality of the environment are called bioindicators. The use of canaries by early coal miners to identify acceptable underground air quality is a typical illustration of a bioindicator. The study in Nash, 1976 says that, miners were informed that the air quality was safe and did not contain any lethal amounts of methane, even though a canary in a cage displayed signs of activity. A miner should always leave the area as soon as a canary dies because small birds like canaries are much less tolerant of harmful gases. In contrast to canaries, lichens are found all over the world, have long lifespan, and have the ability to hold onto heavy metals and certain environmental contaminants.
Numerous bioindicators have the benefits of long-term monitors and can thus cross temporal or spatial boundaries that would otherwise present significant challenges, in contrast to other protocols that utilize mechanical or chemical indicators with a single sampling event. Lichens are bioindicators of ammonia, fluoride and sulfur dioxide (SO_2). You can see how these pollutants are affecting the variety and distribution of lichens in your area (Jeran, *et.al.*, 2002). The patterns of lichen damage, like many other bioindicators, do not prove a direct causal relationship between them and atmospheric quality.

Air Pollution Indicated by Lichens

Lichens obtain their nutrients from the air in order to grow. Lichens cannot filter what they absorb because they lack protective surfaces or roots, so anything in the air is immediately absorbed inside (Rodriguez, *et.al*., 2011). Pollutants have the ability to build up in lichen and quickly turn toxic. Although lichens are simpler to study and react to environmental change more quickly than butterflies, nematodes, frogs and toads, they are still very good indicators of environmental pollutants (Crespo, *et.al*., 2005). In general, an area's level of pollution increases with the size and variety of lichens present. Nitrogen and sulfur dioxide are the two primary air pollutants that have an impact on lichen growth.

Nitrogen sensitive oakmoss lichen
Image source:
https://www.nhm.ac.uk/discover/nature-and-pollution-what-lichens-tell-us-about-toxic-air.html

In the presence of nitrogen, certain lichens will perish while others will flourish (Delves, *et.al*.,2023). Emissions of sulfur dioxide are caused by industry and the burning of coal. This contaminant has killed a lot of lichen. Other plants and animals also depend on lichens. Other organisms can grow in the organic material that

lichens leave behind when they decompose because of their capacity to grow in certain arid areas, such as the surface of a rock. Numerous animals, such as reindeer, squirrels, snails and insects eat them as well.

Conclusion

It feels good to breathe in clean, fresh air. Fresh air is healthy for our lungs because it doesn't pose any health risks. Lichens are sensitive to air pollution, so they are excellent indicators of air quality. As bioindicators of pollution in the environment, climate change and ecological continuity, lichens are valuable. While a great deal of work has been done in temperate regions, the techniques have rarely been used in tropical regions. Not just the quantity of pollutants in the air, but also the impact of air pollution on ecosystems can be inferred from lichens. This is useful information if you want to understand how ecological communities are being altered by air pollution and what that implies for the people who depend on them. In studies it's evident that lichens are more found in place where pollution is less, especially in high-range region it's easy to find lichens than in cities.

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Urban Forests: Nurturing Nature in Concrete Jungles

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In the midst of bustling cities and concrete landscapes, urban forests stand as green reserves, providing a host of ecological, social and economic benefits to urban dwellers. These green havens, comprising trees, shrubs and other vegetation, play a crucial role in enhancing urban livability, mitigating environmental challenges and fostering community well-being. This article focuses on the importance of urban forests and the numerous benefits they offer to cities and their inhabitants.

Urban forest as a part of smart city development
Image source:
https://www.daijiworld.com/news/newsDisplay?newsID=953533

Urban forests act as natural air purifiers, absorbing pollutants such as carbon dioxide, nitrogen oxides and particulate matter, and releasing oxygen through the process of photosynthesis. By filtering and trapping airborne pollutants, trees help improve air quality, reduce respiratory illnesses and mitigate the urban heat island effect, thereby enhancing public health and well-being. Trees sequester carbon dioxide from the atmosphere, helping to mitigate climate change by storing carbon in their biomass and in urban soils. Urban forests play a vital role in offsetting carbon emissions from human activities, contributing to global efforts to reduce greenhouse gas concentrations and combat the impacts of climate change.

Despite their urban setting, urban forests support a surprising array of plant and animal species, providing essential habitat, food and shelter for wildlife. By preserving and enhancing green spaces within cities, urban forests contribute to biodiversity conservation, promoting ecological resilience and supporting urban wildlife populations. The dense infrastructure and heat-retaining materials prevalent in urban areas contribute to the urban heat island effect, leading to higher temperatures compared to surrounding rural areas. Urban forests help mitigate this effect by providing shade, evaporative cooling and reducing surface temperatures through transpiration, thereby creating more comfortable and livable urban environments.

Trees and vegetation in urban forests play a crucial role in managing storm-water runoff by absorbing and slowing down rainwater, reducing the risk of flooding, soil erosion and water pollution. The root systems of trees help to stabilize soils, increase infiltration rates and prevent sedimentation in water bodies, contributing to improved water quality and aquatic habitat conservation.

Today the need of hour is to encourage, develop and create awareness among the residents of colony; the importance and benefits of having Urban forests. The soaring heat is unbearable and people residing in the flats have faced the wrath of the changing weather conditions. Everyone is aware of the coolness provided by a green cover in our surrounding. The resident association in every area should take initiative, involve more

members to encourage plantation in and around their residential area. Every housing colony should have a committee working towards the establishment of Urban forests. It is high time we realize our existence is dependent on the greenery around us. The committee should assign the duty to care of these saviour of environment to the residents of the society on rotation basis so that each one fulfills their responsibility towards a greener, cooler and soothing surrounding. The people residing in independent houses should also be encouraged to develop a greener surroundings. The waste water from kitchen sinks can be used to water these plants and also the wet waste can be used to make compost thereby nourishing and helping in the flourishing of an urban forest set up in their housing premises.

Conclusion

Urban forests play a vital role in enhancing the sustainability, resilience and livability of cities worldwide. From improving air quality and mitigating climate change to supporting biodiversity conservation and enhancing urban aesthetics, urban forests offer a multitude of benefits to urban residents and ecosystems. To maximize the potential of urban forests, policymakers, urban planners and community stakeholders must prioritize the preservation, expansion and sustainable management of green spaces within cities. Through collective efforts, urban forests can continue to thrive as essential components of healthy, vibrant and sustainable urban environments for generations to come.

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Diversity and Bioprospect Potential of Coastal Sand-dune Vegetation

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Abstract
The coastal sand dunes (CSD) are unstable or partially stable ecosystems that house a wide variety of herb, shrub, and tree species. Studies on vegetation in the CSD of tropical regions have relatively received less attention compared to temperate regions. Plant communities in CSD experience several environmental perturbations, such as high temperatures, alkaline pH, low moisture, salt spray, sand burial, inundation, sand accretion, and sand erosion. The stability of CSD depends on the nature of plant species, the associated microbiota, and the availability of organic matter. Being adapted to extreme habitats, CSD vegetation possesses ecological, economic, and industrial significance. The associated microbiota provide strength to vegetation to withstand coastal conditions (e.g., bacteria, fungi, lichens, algae, and others). Besides, free-living and vegetation-associated microorganisms help organic matter turnover, establish mutualism, support dune stability, and participate in biogeochemical cycles.

Keywords Coastal ecosystem, Ecosystem services, Human interference, Mutualism, Plant communities

Introduction

Coastal sand dunes (CSD) have been considered one of the maritime ecosystems that is in a dynamic state owing to substrate mobility and other environmental factors. In spite of harsh and extreme conditions, CSD harbours a variety of dune vegetation as well as microbiota. The physical phenomena of sand burial, alkaline pH, sand accretion, sand erosion, inundation, and salt spray eliminate the abundance of less-tolerant plant species as well as microbes (Maun, 1998). Organic matter input to the CSD will be the major energy source, and other nutrient inputs come from precipitation and salt spray. Deficiency of freshwater and several minerals (e.g., nitrogen, phosphorus, and potassium) affect the development of vegetation on CSD (van der Valk, 1974; Maun, 1994). In addition to vegetation, CSD supports many bacteria, fungi, mycorrhizas, mushrooms, lichens, algae, and diatoms (Beena *et al*., 2000; Sridhar, 2009; Ghate and Sridhar, 2016). Many such microbiota have a mutualistic association with vegetation, which helps their adaptation to harsh conditions. This article briefly discusses the occurrence of vegetation in the CSD of the Indian coasts and the significance of wild legumes.

Vegetation

Among the vegetation, members of Asteraceae, Convolvulaceae, Fabaceae, and Poaceae dominate the tropical CSD (Moreno-Casasola, 1986; Arun *et al*., 1999; Kulkarni *et al*., 1997). Stoloniferous *Ipomoea pes-caprae* governs in tropical regions owing to its tolerance to dune perturbation. *Canavalia cathartica* as well as *C. maritima* grow along with *I. pes-caprae*. Some plant species, in addition to *I. pes-caprae*, are capable of harvesting nutrients from rain or salt spray and allocating more root biomass than aerial parts to overcome the unfavourable conditions of CSD (e.g., *C. maritima*, *Chamaecrista chamaecristoides, Palafoxia lindenii, Schizachyrium scoparium*, and *Trachypogon gouini*).

The CSD of the Indian subcontinent has been divided into eight subdivisions: 1) Pakistan, Kutch, and northwest Kathiawar; 2) Southern Kathiawar-Gujrat; 3) Konkan; 4) Malabar; 5) Coromandel-Circar; 6) islands between India and Sri Lanka; 7) Utkal and Bengal; 8) Andaman

and Nicobar Islands (Rao and Meher-Homji, 1985). The strand vegetation in these regions consists of 41 families (Table 1). Four major families (>10 spp.) found in CSD in decreasing order include Fabaceae (24 spp.), Poaceae (22 spp.), Asteraceae (15 spp.), and Cyperaceae (13 spp.). The rest of the 37 families ranged from 1 to 7 spp.

Table 1. Plant families in coastal sand dunes of the Indian subcontinent (modified from: Arun *et al*., 1999; Rao and Sherieff, 2002).

Family	Number of species	Family	Number of species
Fabaceae	24	Anacardiaceae	1
Poaceae	22	Cactaceae	1
Asteraceae	15	Capparaceae	1
Cyperaeae	13	Caryophyllaceae	1
Rubiaceae	7	Casuarinaceae	1
Scropulariaceae	5	Clusiaceae	1
Verbenaceae	5	Lauraceae	1
Acanthaceae	4	Liliaceae	1
Amaranthaceae	4	Lythraceae	1
Convolvulaceae	4	Molluginaceae	1
Euphorbiaceae	4	Nyctaginaceae	1
Lamiaceae	4	Onagraceae	1
Solanaceae	3	Pandanaceae	1
Malvaceae	2	Pedaliaceae	1
Asclepiadaceae	2	Portulaceae	1
Boraginaceae	2	Rhamnaceae	1
Commelinaceae	2	Salvadoraceae	1
Goodeniaceae	2	Sapindaceae	1
Palmae	2	Sterculiaceae	1
Tiliaceae	1	Violaceae	1
Aizoaceae	1		

The Indian subcontinent consists of 54 plant species belonging to six types of strand vegetation: mat-forming creepers (12 spp.), prostrate or erect herbs and sedges (15 spp.), climbers (5 spp.), plants with perennating organs (3 spp.), scrubs (8 spp.), and trees (12 spp.) (Table 2). Besides stabilizing the CSD, this vegetation possesses many applications useful to wild life, livestock, and humans.

Table 2. Nature of strand vegetation in coastal sand dunes of the Indian subcontinent (modified from: Rao and Meher-Homji, 1985).

Nature of strand vegetation	Plant species
Mat-forming creepers	*Aeluropus lagopoides, Canavalia maritima, Canavalia cathartica, Indigofera aspalathoides, Ipomoea pes-caprae, Launaea sarmentosa, Paspalum vaginatum, Perotis indica, Sesuvium portulacstrum, Sporobolous virginicus, Trachys muricata, and Zoysia matrella*
Prostrate/erect herbs and sedges	*Allmania nodiflora, Anotis carnosa, Atriplex repens, Atriplex stocksii, Borreria articularis, Borreria stricta, Crotalaria nana, Enicostema hyssopifolium, Euphorbia atoto, Euphorbia rosea, Geniosporum tenuiflorum, Hydrophylax maritima, Polycarpaea corymbosa, Polycarpaea spicata, and Scaevola plumieri*
Climbers	*Dalbergia spinosa, Derris triflorum, Flagellaria indica, Ipomoea macrantha, and Parsonsia helicandra*
Plants with perennating organs	*Asparagus dumosus, Scilla hyacinthina, and Urginea indica*
Scrubs	*Acrostichium aureum, Clerodendrum inerme, Dimorphocalyx glabellus, Halopyrum mucronatum, Myriostachya wightiana, Scaevola taccada, Syzygium ruscifolium, and Tamarix articulata*
Trees	*Acacia planifrons, Ardisia littoralis, Copparis cartilaginea, Calophyllum inophyllum, Euphorbia caducifolia, Hyphaene dichotoma, Messerschmidia argentea, Morinda citrifolia, Pandanus tectorius, Pemphis acidula, Premna serratifolia, and Salvadora persica*

Seeds of *Canavalia* spp. adapted to CSD possess nutritional value, and their pasture is useful as fodder for livestock (Sridhar and Seena, 2006; Sridhar and Bhagya, 2007; Abhisheka *et al*., 2022). Fruits of *Pandanus tectorius* trees in CSD possess many bioactive compounds, including 11 vitamins (thiamine, riboflavin, nicotinic acid, vitamin B6, vitamin B12, folic acid, calcium-D-pantothenate, vitamin C, vitamin D3, vitamin E, and vitamin K1) (Englberger *et al*., 2009). Leaves of *P. tectorius* are traditionally used to bake starch-based foods (Bhagya *et al*., 2013). The fruit of *Morinda citrifolia*, commercially known as Noni, has several therapeutically valuable, industrially-valued compounds (Assi *et al*., 2017). The toothbrush tree, *Salvadora persica*, has several medicinal and industrial applications (Farag *et al*., 2021). Besides possessing bioactive compounds, *Asparagus dumosus* and *Scaevola plumieri* are suitable as ornamental plants. These facts are a few examples of the benefits of CSD vegetation.

Economic significance

Up to 24 CSD legumes possessing economic value have been identified in southwest India (Table 3). Many of them fix atmospheric nitrogen in association with bacteria, cyanobacteria, and actinobacteria. They serve as agriculturally valued cover crops, green manure, mulch, fodder, and pasture. Many legumes are used ethnically by coastal dwellers as vegetables, and several of them also produce edible seeds. Some plants are oil-yielding, dye-yielding, and produce value-added metabolites (e.g., canavanine, concanavalin A and hallucinogen L-betonicine). Some plants serve as piscicides, insecticides, biopesticides, cytotoxins, purgatives, antifeedants, antitumour agents and produce biodiesel. Recently, several edible, ectomycorrhizal, and medicinal mushrooms have been traced to the CSD of southwest India (e.g., *Amanita konajensis, Dacryopinax spathularia, Ganoderma lucidum, Lentinus squarrosulus, Macrolepiota rhacodes, Scleroderma citrinum*, *Termitomyces schimperi,* and *Xylaria hypoxylon*) (Ghate and Sridhar, 2016).

Table 3. Applications of coastal sand dune legumes of southwest India (Source: Bhagya and Sridhar, 2009; Sridhar, 2009).

Legume	Economic value
Aeschynomene indica	Cover crop, green manure, and mulch
Alysicarpus rugosus	Fodder and seeds are edible
Alysicarpus vaginalis	Fodder and seeds are edible
Canavalia cathartica	Cover crop, green manure, pasture, and a source of canavanine and concanavalin A
Canavalia maritima	Cover crop, green manure, pasture, and a source of canavanine, concanavalin A, and hallucinogen (L-betonicine)
Caesalpinia mimosoides	Pasture
Cajanus scarabaeoides	Edible, green manure, and oil-yielding
Calopogonium mucunoides	Cover crop, and grow in sandy and laterite soils
Cassia mimosoides	Green manure
Cassia pumila	Purgative
Crotalaria nana	Cover crop and green manure
Crotalaria pallida	Cover crop and green manure
Crotalaria striata	Cover crop and green manure
Derris triflorum	Insecticide and piscicide
Indigofera hirsuta	Pasture and dye-yielding
Mimosa invisa	Cover crop
Pongamia pinnata	Medicinal and source of biodiesel
Mucuna pruriens	Cover crop and seeds are edible
Sesbania bispinosa	Cover crop and seeds are edible
Sesbania speciosa	Green manure and oil-yielding
Tamarindus indica	Pulps and seeds are edible, and leaves yield yellow dye
Tephrosia purpurea	Cover crop, green manure, vegetable, antifeedant, biopesticide, piscicide, cytotoxic and antitumor potential
Tephrosia villosa	Green manure
Vigna radiata	Green manure, pasture, and seeds are edible

Human interference

There is high pressure on the CSD biota due to human interference. One of the major hindrances to the CSD biota is granite wall construction to prevent erosion, which prevents organic matter input from the buffer zones onto the dunes, which are the major source of carbon to cater to the needs of dune vegetation and microbiota. Extraction of dune sand, extraction of shells, wood removal and seaweed harvest from the coastal zones pose major threats to the biota of CSD. The removal of woody debris from the CSD has also had major effects on the availability of organic matter in the coastal biota. Construction of roads and cultivation of monocrops (e.g., *Acacia* and *Casuarina*) affect the growth of typical natural dune vegetation. Extensive use of CSD for recreation, fishing

activities, burning organic matter, sewage input, and dumping synthetic waste further deteriorates natural vegetation. Another major problem is discarding the plastic debris on the CSD, which is detrimental not only to vegetation but also to the coast-dwelling fauna.

Outlook

A plethora of vegetation and microbiota exist on the coastal sand dunes (CSD). They are responsible for maintaining the delicate balance of marine and terrestrial ecosystems. Many natural saline-tolerant dune vegetations have agricultural, nutritional, and industrial applications that could be harnessed. Several microbes in CSD adapted to saline habitats (e.g., macrofungi, mycorrhizas, lichens and rhizobia) have biotechnological potential. Human interference (extensive granite wall construction, recreation sites, sewage input, plastic dumping, sand mining, and wood extraction) is detrimental to dune biota and severely changes the ecosystem services of CSD biota. The CSD dunes offer many plants and microbes adapted to extreme conditions (salinity, alkaline pH, sand abrasion, and sand burial), which are the natural source of adaptation for agriculture and industrial applications. Rehabilitation of coastal sand dunes is one of the major tasks that needs urgent attention to restore natural vegetation and microbiota. Protection of the coastal sand dune ecosystem will be achieved by a green wall approach with suitable economically valued mat-forming creepers, sedges, climbers, and fruit-yielding tree plantations to cater to the needs of CSD. However, the cultivation of wind-breaking timber-yielding trees is also detrimental owing to the eventual removal of timbers and poles.

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Sea Urchins: The Lawn Mowers of Coral Reefs

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Sea urchins are echinoderms which belong to class Echinoidea. These spiny globular species are symmetrical along five axes and have tube feet. More than 900 species of sea urchins have been identified worldwide. They inhabit a shallow intertidal zone and the deep sea with depths exceeding 16,000 feet. They are found in different colors, like pale orange, pink, yellow, red and purple (Fig. 1). Few species are known to be poisonous to humans but not deadly.

The egg mass or roe of some sea urchins is consumed in many European countries, Chile, North America and Asian countries, especially Japan. Due to excessive usage in Japanese delicacy, the consumption of sea urchin in Japan is around 90% of the global supply. Also, their attractive skeletons are transformed into souvenirs and sold worldwide.

Fig. 1 Red and purple sea urchins on the ocean floor of Southern California (Source: www.nationalgeographic.com)

Sea urchins have a rigid spherical internal skeleton called a 'test' which is formed by fusion of plates of calcium carbonate. An adult sea urchin body is covered with a large number of sharp spines which project from the test. Spines are mineralized appendages which constantly break and regenerate during the lifespan of sea urchins. These movable spines not only protect from predators, but also assist in locomotion and wedging their body into crevices. When the sea urchin dies, the skin layer covering the spines and test breaks down, eventually leaving a hollow test (Fig. 2). Despite the prickly spines, many organisms like crabs, fishes and birds feed on sea urchins.

Fig. 2 Dead sea urchin with bare test at Padubidri beach

The mouth of sea urchin is present at the base facing the ground and the anus on the top surface. The complex jaw structure is known as Aristotle's lantern, which consists of a circle of five calcium carbonate teeth or plates, with a fleshy, tongue-like structure within. Sea urchins also have tube feet which are small active tubular projections emerging from the base of body. The movement of tube feet is controlled by water vascular system, where the sea urchins can extend or contract the feet by changing the amount of water inside. The tube feet help in collecting food, chemoreception, respiration and

excretion of waste. Tiny jaw-like structures on stalks called pedicellariae can be seen in some species which keep the body free from debris and parasites.

The primary food source for sea urchins is algae, but they also feed on sea cucumbers, mussels, polychaetes, sponges, brittle stars and crinoids, making them omnivores. As they feed on algae growing on hard surfaces, their hollow bodies can create loud noises. This noise on reefs can attract baby fishes and crustaceans underwater, thus providing suitable habitat.

The core of a sea urchin is mostly empty, but it is filled with sperm or eggs during the mating phase. Sea urchins are dioecious with no difference in external features between male and females. Sea urchins release eggs and sperm simultaneously into the water, where females can drop millions of eggs. They reproduce through external fertilization and the larvae undergo complex metamorphosis to grow into a mature adult.

Contribution of sea urchins to the marine ecosystem

The prickly spines of sea urchins provide a safe house for various animals like razorfish and brittle stars. They play an important role as most efficient grazers in the marine environment by controlling seaweed growth. The excessive growth of algae can reduce oxygen content and restrict the growth of corals. Hence, these lawn mowers help to maintain the balance between coral and algae.

In recent years, sea urchins have been extensively used as model organisms in several studies. Due to their large sized eggs, sea urchins are easier to study embryo development. They are the ideal indicator organism in ecotoxicological studies where the different larval development phases are exposed to toxicants. Since sea urchins are ecologically important grazers, they are also used as model species in environmental impact and risk assessment. An edible sea urchin, *Paracentrotus lividus* is gaining importance in this area.

On the contrary, the large population of sea urchins can destroy the seagrass bed and kelp forest on the ocean floor, which can lead to loss of habitat for other marine organisms.

Threats to sea urchins

The major threat to sea urchin is habitat loss due to reclamation and human activities, which leads to pollution along the coast. Microplastic pollution also presents a serious threat to sea urchins wherein these toxicants can reduce fertilization rate, induce cytogenetic and genotoxic effects, leading to abnormalities in developmental phases.

The change in ocean salinity induced by climate change can negatively affect many marine organisms. Although some can balance the amount of water and salt in their bodies, sea urchins are not capable of withstanding these changes. A slight change in salinity can negatively impact their adhesive properties, which can finally affect their survival.

Ocean acidification and global warming causes reduced pH, alteration in saturations state of $CaCO_3$ minerals and elevated partial pressure of CO_2 (pCO_2). All these factors negatively impact marine organisms, including sea urchins. Sea urchins have calcareous structures and calcify in their planktonic (larvae) and benthic life stages (adult). Ocean acidification can lower calcification, leading to developmental problems in sea urchins. For example, the lower pH had a stunting effect on the arms of *Arbacia lixula* (Black sea urchin) larvae.

The collective threats of global warming, ocean acidification and plastic pollution on the sea urchin population can create an imbalance in the marine environment, specifically coastal ecosystems. When the Caribbean Sea urchin *Diadema antillarum*, suffered the largest die-off in the mid-1980s, it led to overgrowth of macroalgae resulting in decline in coral cover. Noticing the significant role of sea urchins in the marine environment, International Union for Conservation of Nature (IUCN) has considered them as possible candidates for protection.

Conclusion

Sea urchins are spiny globular echinoderms which are vital for marine health. Several anthropogenic factors like global warming, ocean acidification and plastic pollution threaten these species. The destruction of these significant grazers can affect the marine environment, importantly coral reefs. Hence, proper conservation measures should be adopted to control the population of sea urchins in local waters.

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Net Zero - It's Possible

Net Zero is the global goal to combat climate change. For a liveable climate, Net Zero commitments made by all the nations must be backed by credible action. Presented below is an overview of what Net Zero is all about and the present status regarding its attainment.

What is Net Zero?
Put simply, Net Zero means cutting greenhouse gas emissions to as close to zero as possible, with any remaining emissions re-absorbed from the atmosphere, by oceans and forests for instance.

Why is Net Zero important?
The science shows clearly that in order to avert the worst impacts of climate change and preserve a liveable planet, global temperature increase needs to be limited to 1.5°C above pre-industrial levels. Currently, the Earth is already about 1.1°C warmer than it was in the late 1800s, and emissions continue to rise. To keep global warming to no more than 1.5°C – as called for in the Paris Agreement – emissions need to be reduced by 45% by 2030 and reach Net Zero by 2050.

How can Net Zero be achieved?
Transitioning to a Net Zero world is one of the greatest challenges humankind has faced. It calls for nothing less than a complete transformation of how we produce, consume and move about. The energy sector is the source of around three-quarters of greenhouse gas emissions today and holds the key to averting the worst effects of climate change. Replacing polluting coal, gas and oil-fired power with energy from renewable sources, such as wind or solar, would dramatically reduce carbon emissions.

Is there a global effort to reach Net Zero?
Yes, a growing coalition of countries, cities, businesses and other institutions are pledging to get to Net Zero emissions. More than 140 countries, including the biggest polluters – China, the United States, India and the European Union – have set a Net Zero target, covering about 88% of global emissions. More than 9,000 companies, over 1000 cities, more than 1000 educational institutions, and over 600 financial institutions have joined the Race to Zero, pledging to take rigorous, immediate action to halve global emissions by 2030.

How do we ensure commitments are turned into action?
The growth in Net Zero pledges has been accompanied by a proliferation of criteria with varying levels of robustness. To develop stronger and clearer standards for Net Zero emissions pledges by non-state entities such as businesses, investors, cities and regions, and speed up their implementation, UN Secretary-General António Guterres in March 2022 established a High-Level Expert Group on the Net Zero Emissions Commitments of Non-State Entities. The Expert Group presented its recommendationsat COP27 on 8th November 2022.

Are we on track to reach Net Zero by 2050?
No, we are not. In fact, the commitments made by governments to date fall far short of what is required. Current national climate plans – for 195 parties to the Paris Agreement taken together– would lead to a sizable increase of almost 9% in global greenhouse gas emissions by 2030, compared to 2010 levels. To keep global warming to no more than 1.5°C –as called for in the Paris Agreement – emissions need to be reduced by 45% by 2030 and reach Net Zero by 2050. Getting to Net Zero requires all governments–first and foremost the biggest emitters–to significantly strengthen their Nationally Determined Contributions (NDCs) and take bold, immediate steps towards reducing emissions now.

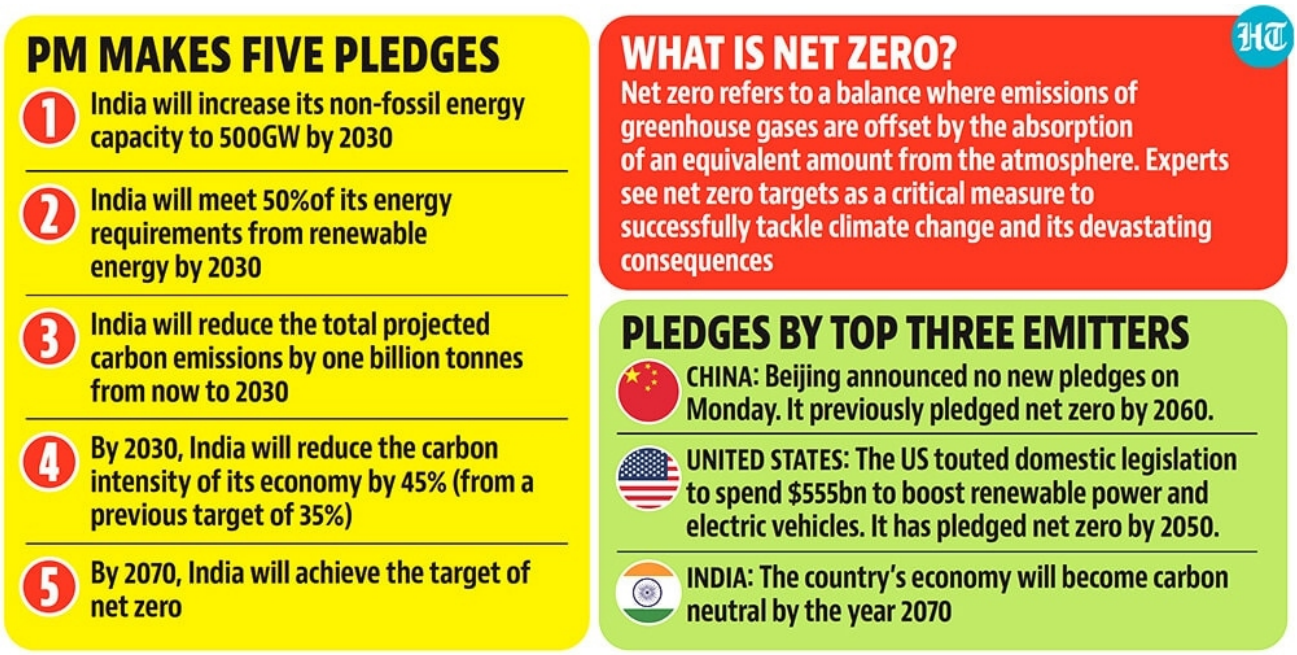

Image source: https://www.hindustantimes.com/india-news/india-pledges-new-climate-crisis-goal-net-zero-by-2070-101635793110247.html

Most emissions come from just a few countries.

The top five emitters (China, the United States of America, India, The European Union and the Russian Federation) accounted for about 60 percent of greenhouse gas emissions in 2021. The Group of 20 (Argentina, Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, Republic of Korea, Mexico, Russia, Saudi Arabia, South Africa, Turkey, the United Kingdom, the United States and the European Union) are responsible for about 76 percent of global greenhouse gas emissions. By contrast, least developed countries account for about 3.8 percent of global emissions, while small island developing states contribute less than 1 percent.

Reference

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Carbon Farming: A Sustainable Solution for Climate Change Mitigation

In the face of climate change, humanity faces an urgent need to reduce carbon emissions and mitigate the impacts of global warming. One promising solution gaining traction is carbon farming, a set of agricultural practices aimed at sequestering carbon dioxide from the atmosphere into the soil and vegetation. Carbon farming offers a multifaceted approach that not only helps combat climate change but also enhances soil health, biodiversity and agricultural resilience. This essay explores the concept of carbon farming, its benefits and its potential to revolutionize agriculture in the fight against climate change.

Carbon farming encompasses a range of practices that increase the capture and storage of atmospheric carbon dioxide in soils and vegetation. These practices include agroforestry, conservation tillage, cover cropping, rotational grazing and reforestation, among others. By enhancing natural carbon sinks such as forests, grasslands and agricultural lands, carbon farming aims to enhance the ability of ecosystems to sequester carbon while promoting sustainable land management.

Benefits of Carbon Farming:

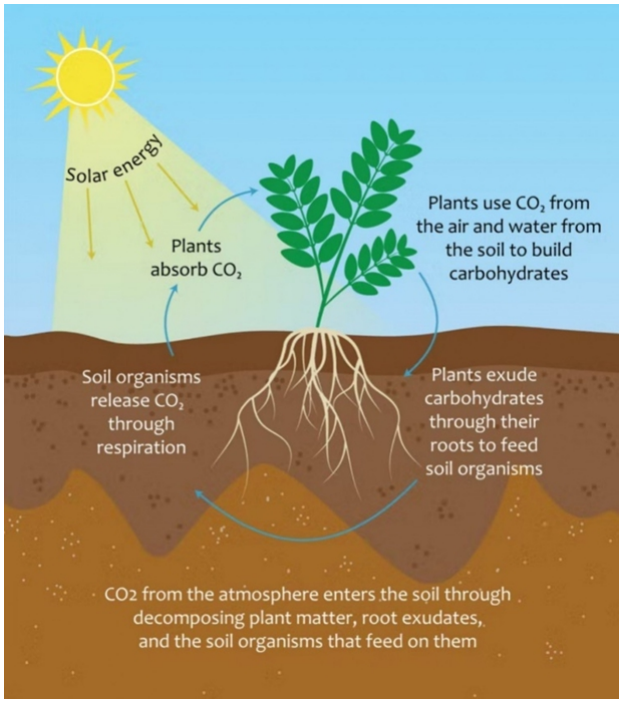
1. Climate change mitigation: Perhaps the most crucial benefit of carbon farming is its capacity to mitigate climate change by removing carbon dioxide from the atmosphere. By sequestering carbon in soils and vegetation, carbon farming helps offset greenhouse gas emissions from human activities, thereby reducing the concentration of atmospheric CO_2 and mitigating global warming.

2. Soil health improvement: Many carbon farming practices focus on enhancing soil health by increasing organic matter content, improving soil structure and fostering microbial activity. These improvements not only facilitate carbon sequestration but also enhance soil fertility, water retention, and nutrient cycling, leading to improved crop yields and resilience to environmental stress.

3. Biodiversity conservation: Carbon farming practices such as agroforestry and reforestation contribute to biodiversity conservation by providing habitat for diverse plant and animal species. By restoring degraded ecosystems and creating wildlife corridors, carbon farming promotes ecosystem resilience and enhances overall biodiversity, which is essential for ecosystem functioning and resilience.

4. Water quality and conservation: Cover cropping and conservation tillage, key components of carbon farming, help reduce soil erosion and runoff, thereby improving water quality and conservation. By maintaining vegetative cover and minimizing soil disturbance, carbon farming practices protect water resources, mitigate nutrient pollution and enhance the overall health of aquatic ecosystems.

5. Rural Development and economic opportunities: Carbon farming offers significant economic opportunities for rural communities by diversifying agricultural practices, generating new sources of income, and creating jobs in sectors such as agroforestry, sustainable land management, and ecosystem restoration. Moreover, carbon farming can enhance the resilience of smallholder farmers to climate change impacts, thereby promoting food security and rural livelihoods.



Movement of carbon into and out of soil.
Image Source: https://www.cleanenergywire.org/factsheets/carbon-farming-explained-pros-cons-and-eus-plans

Conclusion

In conclusion, carbon farming represents a sustainable and multifaceted solution to the dual challenges of climate change and agricultural sustainability. By sequestering carbon in soils and vegetation, carbon farming not only mitigates climate change but also enhances soil health, biodiversity, water quality and rural livelihoods. To fully realize the potential of carbon farming, policymakers, farmers, researchers and civil society must collaborate to promote the adoption of carbon farming practices and create supportive policy frameworks, financial incentives and technical assistance programmes. Through concerted efforts, carbon farming can play a pivotal role in building a more resilient and sustainable agricultural system while mitigating the impacts of climate change for present and future generations.

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2. Martin H, The Archean grey ……..of continental crust. In *Archaean Crustal Evolution* (Ed. Condie, KC), Amsterdam: Elsevier; 1994. pp. 205259.
3. Rao KN, Vaidyanadhan R, Geomorphic …….. and its evolution. In Proceedings of the National Symposium on Morphology and Evolution of Landforms, Department of Geology, Delhi University, New Delhi, 1978.
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