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World Environment Day

Land Restoration, Desertification and Drought Resilience

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LAND RESTORATION, DESERTIFICATION AND DROUGHT RESILIENCE

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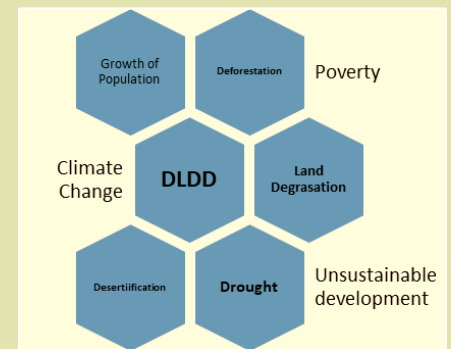
The campaign for the World Environment Day 2024 focuses on the theme of Land restoration, Desertification and Drought resilience under the slogan “Our land. Our future. We are #GenerationRestoration.” The oil rich desert Kingdom of Saudi Arabia is hosting the 2024 World Environment Day global celebrations.

Interconnected issues

DLDD issues (Desertification, Land Degradation and Drought) are all interconnected. **Desertification** is a kind of land degradation in arid, semi-arid, and dry sub-humid areas resulting from various factors, mostly climatic variations and human activities (UNCCD, 1994). Although it includes the encroachment of sand dunes on land, it is not limited only to the expansion of existing deserts. Desertification occurs because dryland ecosystems, which cover over one-third of the world’s land area, are extremely vulnerable to overexploitation and inappropriate land use. In the past decades, the range and intensity of desertification have increased, reaching approximately 30 to 35 times the historical rate and the risks from desertification are projected to increase due to climate change (IPCC).

Land degradation has been defined as “the human-caused processes that drive the decline or loss in biodiversity, ecosystem functions or ecosystem services in any terrestrial and associated aquatic ecosystems”. It is happening worldwide, affecting ecosystem functions, disrupting rainfall patterns, exacerbating extreme weather like droughts or floods, which drives poverty, conflict, and migration. It is estimated that twenty per cent of the Earth’s total land area was degraded between 2000 and 2015, resulting in a significant loss of services essential to human well-being.

Conversely, land restoration is the process of restoring a natural and safe landscape for humans, plants and wildlife. Through land restoration, it is possible to reinstate the land’s function to store carbon, to prevent droughts and floods and increase soil productivity. Restoration boosts livelihoods, lowers poverty and builds resilience to extreme weather. Restoration increases carbon storage and slows climate change.



Drought is a meteorological phenomenon caused by prolonged absence or marked deficiency of precipitation resulting in hydrological imbalances that adversely affect land resource productions systems (WMO). Droughts can occur almost anywhere in the world when there is a significant decrease in water availability (atmospheric, surface, soil, or groundwater) over a period of weeks to years. Climate change is increasing the frequencies and/or magnitudes of droughts in many regions of the world. The number and duration of droughts has increased by 29 percent since 2000, as compared to the two previous decades. It is estimated that by 2050 droughts may affect over three-quarters of the world’s population.

Overview of Past initiatives

The themes of land degradation, desertification and drought are nothing new. Desertification was the theme of the World Environment Day in 2006 and earlier in 1984. DLDD issues have figured prominently in global, regional and local discourses on environment since the beginning. Rachel Carson’s award winning book *Silent Spring* (1962) that triggered modern environmental movement produced scientific evidences to demonstrate the dangerous effects of excessive chemical fertilizers and pesticides on the land, degrading its quality and producing toxicity in cereals and vegetables that are harmful to human health. DLDD issues in arid, semi-arid and dry sub-humid areas figured prominently in the deliberations of Stockholm Conference on the Human Environment (1972) as also in Rio Earth Summit (1992). Based on the recommendations of the Earth Summit and its Agenda 21 the UN Convention to Combat Desertification (UNCCD) was adopted in Paris on 17 June 1994 as a legally binding agreement. UNCCD focused on providing support to concerned member countries to develop and implement their National Action Programmes through practical measures to combat desertification in specific ecosystems involving the local communities. Rio+20 Summit (2012) reviewed the outcome of the programmes and recommended specific measurable goals and targets to be achieved within a given time frame. The 2030 Agenda for Sustainable Development (2015-30) called for “strengthening cooperation on desertification, dust storms, land degradation and drought and promote resilience and disaster risk reduction” and adopted all-encompassing SDG-15 on ‘Conserve Life on Earth’

that sets an ambitious target: “By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world” (Target 15.3).

Limited success

On the occasion of the World Environment Day 2024 it is worthwhile to take stock of what has been done or not done for achieving the ambitious target of SDG15.3. Available data shows that while there has been some success in building resilience against drought, and in combating desertification, very little or no progress at all has been achieved for land restoration. Countries like China and India that witnessed drought related famines and deaths in millions in the past achieved relative resilience against drought through a variety of measures that include early warning, massive expansion of irrigation network, soil and water conservation measures, changes in agronomic practices, and climate adaptive agriculture. Similar successes have been achieved in many other Afro-Asian countries. International humanitarian systems responds to residual pockets where famines do occur, but these not as much due to drought as disruptions in supply chains caused by war, conflicts and other reasons.

Some successes have also been achieved in combating desertification. Some of the success stories include plantation of Great Green Wall covering several countries from the west to the east coast of Africa. China’s greening campaign that resulted in substantial increase in tree cover in Gobi desert; and community led greening projects in Peru and Bolivia.

However overall progress in land restoration has not at all been encouraging. Progress seems to have been in the reverse direction. It is estimated that between 2015 and 2023, the world has been losing at least 100 million hectares of healthy and productive land every year, impacting the lives of 1.3 billion people, who are directly exposed to land degradation. Degradation of land in Sub-Saharan Africa, Western Asia, Latin America and the Caribbean and South Asia is faster than the global averages. Human activities, such as urban expansion, deforestation and grassland

conversion, intensified by climate change, have been the drivers of land degradation. Grasslands incurred some of the greatest losses in land productivity, followed by croplands and forest areas.

At the mid-point plus in the implementation of the SDGs, if these alarming trends in land degradation continue, we would need to restore 1.5 billion hectares by 2030 to ensure a land degradation neutral world. This would require greater investments in conservation, sustainable management and restoration of land, through integrated land use planning and robust environmental and social safeguards.

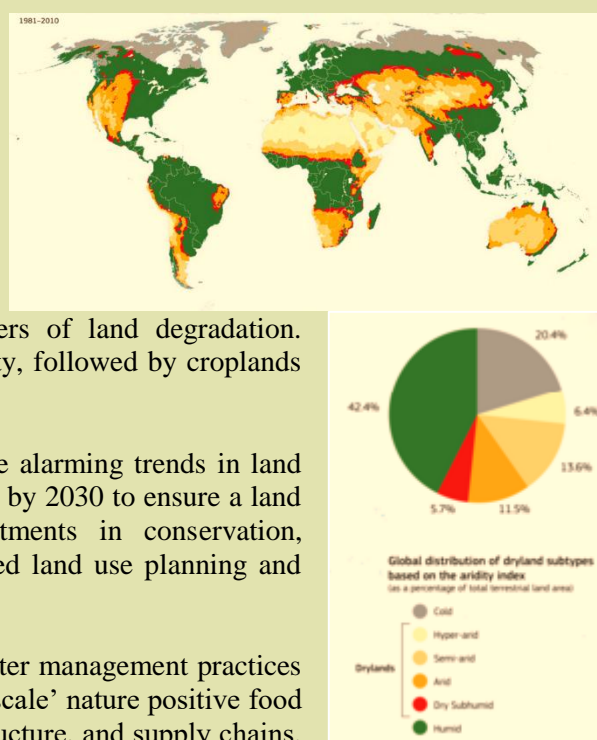
Land restoration includes a broad range of sustainable land and water management practices that can be applied to: i) conserve or ‘rewild’ natural areas, ii) ‘up-scale’ nature positive food production in rural landscapes, and iii) ‘green’ urban areas, infrastructure, and supply chains.

The land restoration agenda promotes a multiple benefits strategy that reverses past land degradation and biodiversity loss, while increasing food and water security, improving livelihoods and mitigating and adapting to climate change. Land restoration is a shared responsibility – everyone has a role to play because everyone has a stake in the health of the land, now and into the future. Governments, businesses, and communities can restore land together by seeking convergence and complementarity. Environmental and development priorities can be responsibly managed to create a healthier mosaic of land uses without compromising the needs and aspirations of current and future generations.

#Generation Restoration

Limited success in land restoration has been compensated by the coming of age of a generation of young ecopreneurs – Generation Restoration – who are choosing to build their lives around restoring the planet and our relationship to it. Degrading environment, depleting natural resources and dwindling wildlife are propelling increasing numbers of young people around the world to come up with creative, hopeful, transformative solutions that are built upon the principles of restoration. WED 2024 is being led by this Generation restoration.

Global distribution of degraded land



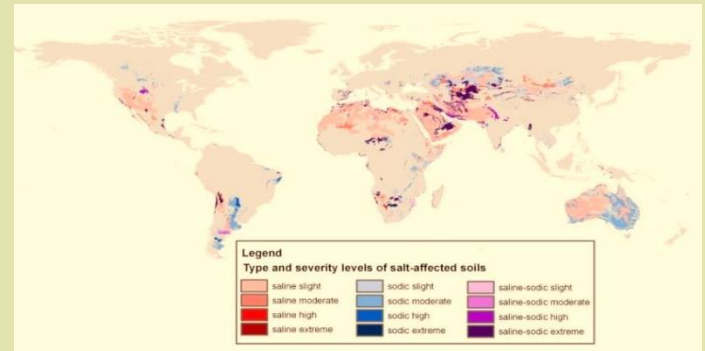
SOIL SALINITY AND SODICITY: PROBLEM AND RESTORATION

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Worldwide, two significant land degradation processes are soil salinity and sodicity. According to estimates, salinity affects 7% of the surface area on Earth. About 1.1 GHa of land worldwide is affected by salt; of this, 14% is designated as forests, wetlands, or (inter) national protected areas and is not thought to be suitable for producing biomass because of sustainability issues. Soils can become salinized and sodic due to natural processes or human activity. The processes of salt and sodium accumulation brought on by topography, water table quality, and parent material mineralogy are known as natural salinization and sodification. Water logging or irrigation without adequate leaching and drainage are the two main causes of anthropogenic soil salinization. The phenomena of soil salinization may be made worse by climate change, excessive groundwater consumption, the use of poor-quality irrigation water more frequently, extensive irrigation in a semi-arid to dry climate zone, and a lack of soil leaching.

The presence of water-soluble salts, such as sodium (Na^+), potassium (K^+), chloride (Cl^-), and sulphate (SO_4^{2-}), is referred to as salinity in soil. While Na^+ and Cl^- are not regarded as plant nutrients, other ions, such K^+ and SO_4^{2-} , do function as nutrients for plants. As a result, Na^+ and Cl^- are frequently the focus of soil salinity. An excess of Na^+ among the exchangeable cations in the soil solution is referred to as sodicity. Plant growth is impacted by salinity and sodicity in two ways: directly through their impacts on plant uptake of water and nutrients, toxicity, and indirectly through the degradation of soil physical conditions. According to estimates from the Food and Agriculture Organization of the United Nations, salinity issues damage 20% of the world's irrigated land. Soil salinization destroys 10 million hectares



of agricultural land globally each year. In order to cultivate crops and engage in other activities on the saline and sodic soil, restoration strategies must be created.

Global distribution of saline, sodic, and saline-sodic soils. Source: Encyclopedia of the environment. <https://www.encyclopediaoftheenvironment.com/>

Restoration strategies:

- 1. Site Selection:** Firstly, locations that are prone to seawater intrusion along the coast and inland locations that are susceptible to saltwater intrusion ought to be avoided. Secondly, locations with a shallow aquifer and a chance of groundwater capillary force secondary salinization are to be avoided as well.
- 2. Salt Flushing and Leaching:** Big tractor-scraper machinery can be used to mechanically remove the topmost layer of soil contaminated by salt. Nevertheless, this method is rather costly, and it often has only a temporary effect on soil salinity. The salinity of saline soil can be decreased by washing and leaching it with rainwater.
- 3. Chemical Remediation:** Chemical treatments are not suitable for restoring saline soils. Simultaneously, by adding Ca^{2+} to remove the extra Na^+ from the exchange complex, sodic soils can be recovered. Lime cannot supply enough Ca^{2+} to replace Na^+ since it is only weakly soluble in water. Therefore, highly soluble minerals like gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) are the most commonly used sources of Ca^{2+} .
- 4. Organic and Microbial Remediation:** Applying organic amendments, such as composts and animal manures, raises the concentration of organic carbon in the soil and enhances the development of the soil's structure and macro-aggregation processes which decrease the amount of salt as builds up in the top soil layer.
- 5. Irrigation Schemes:** In order to reduce the amount of salt that recharges aquifers and, consequently, limit soil salinization, flood and furrow irrigation should be avoided wherever feasible. Similarly, the risk of groundwater salinization increases with non-flooding irrigation techniques
- 6. Fertilizing and Manuring Schemes:** Chemical fertilizer use has the potential to worsen rhizosphere salinization. Furthermore, overfertilization may result in a higher groundwater nutrient recharge rate and raises the salinity of aquifers and contaminates them with harmful chemicals.
- 7. Phytoremediation:** Crops have two ways in which they can aid in the repair of the soil in sodic areas. Protons and CO_2 are released into the soil by plant roots, and these two factors decrease the pH of the surrounding soil. Increased acidity causes soil minerals that contain calcium, like lime, to partially dissolve. This releases Ca^{2+} , which pushes Na^+ out of the exchange complex.
- 8. Afforestation and Reforestation:** Restoring salty, sodic, and saline-sodic soils has been demonstrated by limiting the salinization or sodification of upper soil layers, controlling underground water outflow, and using tree and shrub species with deep root systems and high water requirements.

In conclusion, soil restoration in salty and sodic environments is a significant challenge, given the growing demand for land for human habitation. Therefore, it is crucial to develop new technologies and approaches to deal with those issues.

REJUVENATING EARTH: THE SYNERGY OF LAND RESTORATION, COMBATTING DESERTIFICATION, AND BUILDING DROUGHT RESILIENCE

Dr. Sumanta Das

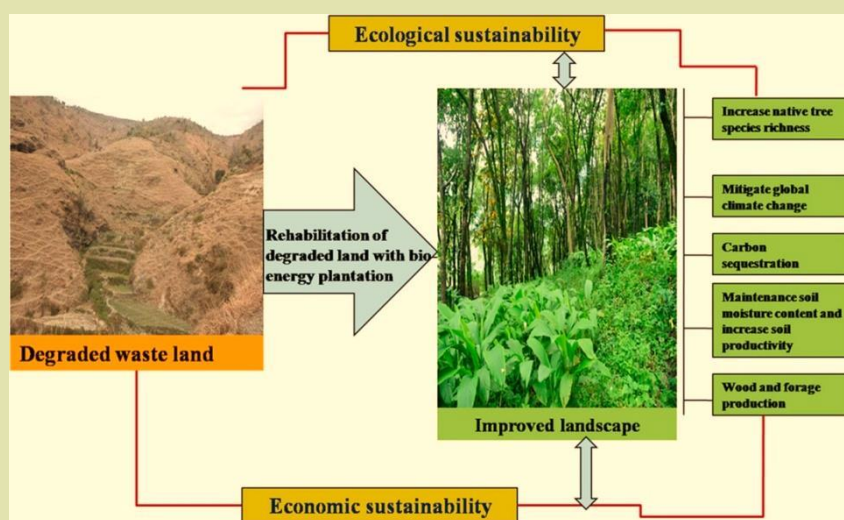
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In a world grappling with climate change, environmental degradation, and burgeoning populations, the imperative to rejuvenate Earth's lands has never been more pressing. At the heart of this endeavour lies the interconnected goals of land restoration, combatting desertification, and building drought resilience. These three components form a symbiotic relationship, offering a holistic approach to revitalizing ecosystems, safeguarding biodiversity, and securing the livelihoods of millions.

Land restoration stands as a cornerstone in the fight against environmental degradation. Through a combination of reforestation, soil conservation, and sustainable land management practices, degraded landscapes can be rehabilitated, breathing new life into barren expanses. By restoring forests, grasslands, and wetlands, not only are carbon sinks enhanced, but habitats for countless species are reinstated, fostering biodiversity and ecological balance. However, the specter of **desertification** looms large over many regions, threatening to render vast swaths of land uninhabitable. Desertification, often exacerbated by unsustainable land use practices and climate change, poses a grave threat to food security, water resources, and human well-being. Combatting desertification requires a multifaceted approach, incorporating measures such as afforestation, water conservation, and sustainable agriculture. Central to the success of land restoration and combatting desertification is the cultivation of **drought resilience**. As climate patterns become increasingly erratic, droughts are becoming more frequent and severe, exacerbating environmental degradation and threatening agricultural productivity. Building drought resilience entails a combination of water-efficient farming techniques, improved irrigation systems, and the restoration of natural water sources. By enhancing the capacity of ecosystems to withstand periods of water scarcity, communities can weather the impacts of droughts while safeguarding precious resources for future generations.

The synergy between land restoration, combatting desertification, and building drought resilience is evident in numerous success stories around the globe. In China's Loess Plateau, ambitious restoration efforts have transformed eroded hillsides into verdant landscapes, bolstering local economies and enhancing ecosystem services. Likewise, the Great Green Wall initiative across Africa aims to combat desertification by creating a mosaic of sustainable land use practices, fostering resilience in the face of climatic challenges.

Yet, while progress has been made, much work remains to be done. The scale of environmental degradation and the impacts of climate change necessitate concerted global action. International cooperation, backed by robust policies and investment, is crucial in scaling up efforts to rejuvenate Earth's lands. By prioritizing sustainable land management practices, integrating traditional knowledge with modern innovations, and empowering local communities, we can forge a path toward a more resilient and vibrant planet. Moreover, public awareness and education play a pivotal role in galvanizing support for land restoration initiatives. By fostering a deeper understanding of the intricate linkages between land, water, climate, and human well-being, individuals can become stewards of their local environments, driving positive change from the grassroots level upwards.



Overall, rejuvenating Earth's environment is not merely a matter of ecological necessity but a moral imperative. Through the nexus of land restoration, combatting desertification, and building drought resilience, we have the opportunity to reclaim degraded landscapes, restore biodiversity, and secure a sustainable future for generations to come. It is a journey fraught with challenges, but also brimming with promise—a journey towards a greener, more resilient planet.

MANGROVES ECOSYSTEM: NATURE'S SHIELD AND SANCTUARY IN ECOLOGICAL RESTORATION

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Mangrove ecosystems are special coastal habitats that act as a shield and sanctuary for nature, playing a crucial role in ecological restoration. These resilient forests, found in tropical and subtropical regions, thrive where land and sea meet, performing several vital functions that enhance environmental stability and support biodiversity. One of the most important roles of mangroves is coastal protection. Their complex root systems stabilize shorelines by binding and trapping sediments, which helps mitigate erosion and reduces the impact of storm surges and tsunamis. This natural barrier protects coastal communities from the devastating effects of natural disasters, making mangroves a vital component in climate change adaptation strategies. Additionally, mangroves are exceptional carbon sinks. They capture carbon dioxide at rates higher than most terrestrial forests, storing it in their biomass and the surrounding soil. This carbon sequestration capability makes mangroves essential in the fight against global warming, as they help reduce the concentration of greenhouse gases in the atmosphere. Preserving and restoring mangrove ecosystems can significantly contribute to mitigating climate change by enhancing carbon storage capacities.

Mangroves are not only important for protecting coastlines and controlling climate, but also for supporting a rich variety of wildlife. They provide vital habitats and breeding grounds for many species, including fish, crustaceans, mollusks, and numerous bird species. The roots and canopy of mangroves offer shelter and food, creating complex food webs and sustaining thriving fisheries that are essential for local communities. The biodiversity of mangroves also has a positive impact on neighbouring ecosystems; for instance, they play a crucial role in maintaining the health of coral reefs and sea grass beds by filtering out pollutants and preventing sedimentation that could harm these delicate habitats. Additionally, mangroves contribute to improving water quality. Their roots act as natural filters, capturing pollutants and excess nutrients from runoff before they reach open waters. This filtration process helps to keep coastal waters clear and healthy, benefiting marine life and the human populations that rely on these water resources for recreation, food, and industry. The socio-economic value of mangroves is also significant. Many coastal communities depend on mangrove ecosystems for their livelihoods, including fishing, aquaculture, and tourism. By managing and restoring mangroves sustainably, we can enhance these economic opportunities while ensuring the long-term health of the ecosystem. Educational and ecotourism programs focused on mangrove conservation can raise awareness and generate income, fostering a sense of responsibility among local populations.

Restoring mangrove ecosystems involves several innovative and effective strategies. Reforestation efforts typically include planting mangrove seedlings and facilitating natural regeneration by protecting existing mangrove areas from deforestation and degradation. Community involvement is crucial in these efforts, as local knowledge and participation can



significantly enhance the success and sustainability of restoration projects. Additionally, integrating traditional ecological knowledge with modern scientific approaches can lead to more effective and resilient restoration outcomes. In conclusion, mangrove ecosystems are essential for ecological restoration due to their multifaceted roles in coastal protection, carbon sequestration, biodiversity support, water quality improvement, and socio-economic benefits. Protecting and restoring these unique habitats is not only crucial for maintaining environmental health and resilience but also for supporting the livelihoods and well-being of millions of people globally. By recognizing and harnessing the immense value of mangroves, we can make significant strides toward a more sustainable and resilient future.

The Government of India has launched various initiatives to protect and preserve mangrove ecosystems, recognizing their crucial role in safeguarding coastlines and biodiversity. One significant program is the National Mangrove Conservation and Management Program, which focuses on safeguarding, planting, and sustainably managing mangroves along the country's coastline. The government has also incorporated mangrove restoration into broader environmental and climate action plans, such as the National Action Plan on Climate Change (NAPCC) and the Green India Mission. These efforts involve community involvement, scientific research, and collaboration among different agencies to ensure effective and resilient mangrove restoration, with the goal of strengthening coastal resilience and supporting the livelihoods of coastal communities.

CLIMATE CHANGE IMPACTS AND ADAPTATION STRATEGIES IN DAIRY FARMING

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According to data from Visual Capitalist, India is one of the most vulnerable to the impacts of global warming, including accelerated sea level rise, alongside countries like China, Bangladesh, Egypt, the Netherlands, the United States, Brazil, Australia, New Zealand, and Pacific islands such as Tonga and Fiji (World Economic Forum, 2022). Climate change, encompassing floods, droughts, heatwaves, and cold waves, has directly and indirectly impacted various facets of our planet, and agricultural production is among those affected (Cianconi et al., 2020). This has resulted in considerable economic losses (Mishra, 2017), primarily borne by farmers. The phenomenon of global climate change occurring due to GHG emissions has been directly affecting the livestock production system world over. Milk yield of cows (crossbred, Hariana, Sahiwal) and buffaloes were found to be negatively correlated with temperature humidity index (Kaur and Arora 1982, Lal et al. 1987, Shinde et al. 1990, Mandal et al. 2002). The direct heat stress on lactating cows and buffaloes causes a production loss of more than 1.8 million tonnes of milk (Upadhyay et al., 2009; Sreenivasiah, 2016). The increase in thermal stress days due to temperature rise has been estimated to cause a loss in milk production of 3 – 4 lakh tonnes in 2030 accounting about 15000 crores in the northern plains (Times of India, 2024). However, farmers are not sitting idly by; they are implementing adaptation strategies to mitigate these impacts and ensure the sustainability of their operations. In this article, we will discuss about the different negative impacts of climate change on dairy bovines and the adaptation strategies for that.

Impact of Climate on Dairy Farming:

1. **Heat Stress** - Climate change is globally due to anthropogenically derived greenhouse gas (GHG) emissions, aerosols, and land-use patterns. In the last 150 years, there is an increase in 1°C temperature of the earth and a projected rise of 5°C by 2100 (Bhakat et al., 2021). One of the most direct effects of climate change on dairy farming is temperature stress. Cows are highly sensitive to heat stress, which can lead to decreased feed intake, reduced milk yield, and impaired reproductive performance. Optimal temperatures for dairy cows range between 5°C to 25°C, and deviations from this range can cause significant stress (Polsky & Keyserlingk, 2017).
2. **Water Availability:** Climate change affects the availability and quality of water, which is crucial for dairy farming. Droughts can lead to water scarcity, making it challenging to maintain adequate hydration and hygiene for the cows, while floods can contaminate water supplies and spread waterborne diseases (Sanogo et al., 2024).
3. **Climatic Disasters:** Extreme weather events like floods and cyclones can have devastating impacts on dairy farming. Flooding can inundate pastures, destroy feed crops, and displace livestock. Cyclones can cause structural damage to barns, milking parlors, and storage facilities, leading to significant financial losses and disruptions in milk production (Godde et al., 2021). Additionally, these events can result in the loss of livestock and increased susceptibility to diseases due to stressed and displaced animals.
4. **Disease Outbreak:** Changes in temperature and humidity can influence the prevalence and distribution of diseases and parasites affecting dairy cows. Warmer temperatures can increase the incidence of vector-borne diseases and parasitic infections, posing a threat to animal health and productivity (Lacetera, 2019).
5. **Milk Quantity and Quality:** The impact of climate change reduces the quality of milk as well as the quantity of milk. Climate change can affect milk composition and quality, as heat stress alters milk fat and protein content (Chen et al., 2023). Dairy animals experience discomfort due to high THI from March to November, significantly reducing milk productivity, especially in crossbred cows, with climatic effects manifesting after a 1–3-day lag (Choudhary & Sirohi, 2022).

Adaptation Strategies:

1. **Change in Micro-climate-** Changing micro-climate by using various methods to mitigate heat stress, including using electric fans, heat-insulating roofs, coconut leaves, straw, and mist cooling systems is a very important adaptation strategy. Also planted saplings for shade in grazing areas. Strategies include increased convection with fans, evaporative cooling, and direct cooling with sprinklers and soakers (Maiti et al., 2014).
2. **Additional washing/sprinkling of cattle and buffaloes:** Wash or sprinkle water on cattle at 10 AM and 5 PM or use wallowing tanks to reduce heat stress are very cost-effective practices and have high adoption rates (Maiti et al., 2014).
3. **Flood and Cyclone Preparedness:** Climatic disasters like erosion, flooding, and submergence, leading to feed shortages and reduced herd sizes. Building resilient infrastructure, like elevating barns and implementing early warning systems, can mitigate these impacts. Livestock insurance is also a very crucial thing to get less financial loss (Maiti et al., 2014).
4. **Effect of vitamin E supplementation on milk productivity under heat stress conditions:** Supplementing dairy bovines with Vitamin E and zinc leads to higher milk yield and lowers both somatic cell count and the incidence of subclinical mastitis (Ponnusamy et al., 2019).
5. **Disease and Parasite Control:** To combat climate change-induced diseases we should adopt preventive and curative healthcare practices, including vaccination and consulting veterinary doctors, while implementing effective disease surveillance, regular health check-ups, etc.

6. **Use of Mosquito net:** Due to increased rainfall over the last 10-15 years, farmers have experienced a rise in mosquito populations. Livestock rearers initially used repellents, which proved ineffective and irritating. Consequently, the use of mosquito nets to protect their cattle could be a great initiative (Maiti et al., 2014).
7. **Interest on Local Breeds:** Due to high temperatures (up to 45°C) and humidity (80–90%) in India, crossbred animals suffer from reduced productivity and disease. However, the local breeds like Red Sindhi, Sahiwal, Gir, and native breeds
8. like Chilka buffalo, Garole sheep, and Black Bengal goat could be a great substitution for livestock rearers (Maiti et al., 2014).
9. **Capacity Building:** Enhancing livestock health care through capacity building, training, and awareness programs for farmers, especially youth and women, yielded positive results (Ponnusamy et al., 2019).



Fig: Using of fans in cattle shed



Fig: Using of Mosquito net in cattle shed

Conclusion:

As we can see, climate change presents formidable challenges to dairy farming, impacting milk yield, animal health, and overall sustainability. However, implementing adaptation strategies such as micro-climate modification, disaster preparedness, and disease control can help mitigate these impacts. It is crucial for farmers to adopt these strategies to ensure the resilience and viability of their dairy operations in a changing climate.

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SALINITY DYNAMICS IN COASTAL SALINE SUNDARBANS

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The Sundarbans, a UNESCO World Heritage Site, is the largest tidal halophytic mangrove forest in the world, situated at the confluence of the Ganges, Brahmaputra, and Meghna rivers in the Bay of Bengal. The Coastal Saline Zone (CSZ) of West Bengal covers 1,456,879 hectares across 78 blocks including South 24 Parganas, Uluberia subdivision, Bashirhat subdivision (North 24 Parganas), and Contai and Tamluk subdivisions (Purba Medinipur). The population of the Sundarbans has grown from 1.2 million in 1951 to 4.4 million in 2011. The ecosystem of the Indian Sundarbans delta is fragile and often susceptible to extreme climatic hazards, including climate change, recurrent floods, erratic rainfall patterns, and various anthropogenic activities. Agriculture in this region, primarily rice-based mono-cropping system, faces challenges from increasing soil salinity, climate change, and poor drainage, leading to more fallow land. Increased soil salinity from winter to summer limits rabi season crop cultivation to 3.05 lakh hectares out of a total cultivated area of 9.07 lakh hectares, resulting in low cropping intensity. This adversely affects agricultural productivity and exacerbates poverty in the region. Therefore, excessive salt accumulation in crop fields is one of the most critical factors suppressing cropping intensity, productivity, and yield. To understand this phenomenon, we first need to identify the sources of salinity affecting the cropland. The Sundarbans region of West Bengal experiences salinity rise due to several key sources. Understanding these sources is crucial for managing and mitigating the impact on agriculture and ecosystems. Here are the main sources of salinity in the Sundarbans:

Weathering of Parent Materials

The geological composition of the Sundarbans includes minerals that, upon weathering, release soluble salts into the soil. This natural process contributes to the baseline salinity levels in the region. Over time, the breakdown of these parent materials increases the concentration of salts such as chlorides, sulfates, and bicarbonates in the soil.

Inundation by Sea Water

The Sundarbans are a tidal mangrove forest, with regular inundation by seawater from the Bay of Bengal. This seawater contains high concentrations of chlorides and sulfates of calcium (Ca), magnesium (Mg), and sodium (Na). During high tides and storm surges, saltwater intrudes further inland, especially during cyclones and other extreme weather events, contributing significantly to soil salinity.

Evapotranspiration exceeding Precipitation

The region experiences periods where evapotranspiration (the sum of evaporation and plant transpiration) exceeds precipitation, particularly during the dry season (October to May) which could be attributed to direct sunshine and low rainfall. High evapotranspiration rates cause more water to evaporate from the soil, leaving salts behind and leading to increased soil salinity at the crop rhizosphere. Additionally, the rise in the groundwater table can bring dissolved salts from deeper soil layers to the surface through capillary action. While monsoon rains (June to September) lead to increased leaching losses, significantly reducing salinity levels at the time of rainy season (kharif season).

In some parts of the Sundarbans, farmers may use available saline water for irrigation due to the scarcity of fresh water. This practice directly adds salt to the soil. Continuous use of saline water for irrigation without adequate drainage leads to the accumulation of salts in the root zone, negatively impacting crop health and yield.

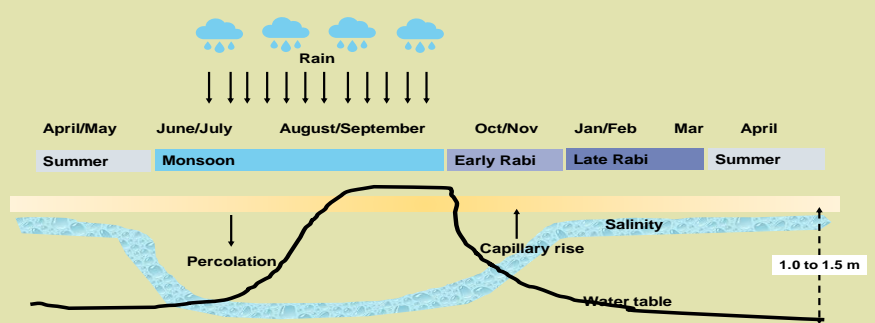


Fig: Seasonal movement of soil salinity and groundwater table

Hence, to keep these views in mind effectively managing salinity problems in the Indian Sundarbans requires an integrated approach that combines improved water management, sustainable agricultural practices, ecological restoration, community involvement, and continuous monitoring.

SEAWEED-BASED BIOSTIMULANTS: AN EMERGING SUSTAINABLE INPUT FOR COASTAL SALINE AGRICULTURE

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The crop productivity of the Coastal Saline Zone is highly compromised because of various abiotic stresses like salinity, heat, and waterlogging out of which salinity is a prominent and major yield-reducing one. High evapotranspiration and insufficient rainfall during summer exacerbate salinity build-up in the topsoil, leading to ionic imbalances and physiological disorders due to increased Na^+ and Cl^- uptake. Excessive fertilizer application further aggravates salinity. Seaweed extract, a green biostimulant, enhances crop performance and mitigates the adverse effects of climate change, offering a sustainable solution to improve resilience and productivity under these challenging conditions.

Seaweeds: A natural miracle:

Seaweeds are the macroscopic algae that serve as an important component of marine ecosystems and are generally cultivated for commercial purposes in the shallow waters of the shores by the fishing community. The liquid sap extracted from the harvested seaweed is rich in numerous bioactive compounds including phytohormones, and quaternary ammonium compounds like glycine betaine, and choline chloride apart from various macro and micronutrients. Application of seaweed extract in various forms (seed priming, root dipping, soil, and foliar application) leads to increment in growth parameters, yields, quality, and nutrient uptake in a variety of crops. Depending upon the pigments present, they can be classified as green seaweeds or Chlorophyta (*Ulva*, *Spirogyra*), red seaweeds or Rhodophyta (*Kappaphycus*, *Gracilaria*), and brown seaweeds or Phaeophyta (*Sargassum*). The saps of red and brown seaweeds are commonly used in agriculture as biostimulants.

Seaweed extract on crop performance:

Seaweed extracts significantly enhance plant height, leaf area, dry weight, and biomass accumulation when used in conjunction with inorganic fertilizers. These extracts contain growth-promoting substances such as hormones, organic acids, polysaccharides, amino acids, proteins, and micronutrients. They also stimulate soil biological activity, boosting the plant's inherent capacity for dry matter production and optimal growth. Improved plant growth subsequently enhances productivity and quality. Additionally, seaweed extracts mitigate biotic stresses, including pest and disease attacks, across various crops.



Fig: *Kappaphycus alvarezii*, *Sargassum wightii* and *Gracilaria edulis* (from left to right)

Seaweed extract in reducing salinity stress:

In coastal saline conditions, excessive fertilizer application intensifies stress on crops by increasing soil solute potential, hindering nutrient and water uptake, reducing turgor pressure, and causing stomatal closure. Reducing recommended fertilizer doses and applying seaweed extract enhances plant metabolism, facilitating nutrient and water absorption, due to a drop in solute potential thus promoting yield. Seaweed sap contains bioactive compounds that increase photosynthetic pigments, such as chlorophyll and carotenoids, preventing their degradation and enhancing photosynthesis in salinity-stressed plants. Antioxidants in the sap neutralize Reactive Oxygen Species (ROS) and mitigate oxidative stress. Osmo-protectants in seaweed extract aid osmotic adjustment by regulating ion uptake and accumulating osmolytes. Additionally, plant growth regulators in seaweed extract, including gibberellins and abscisic acid, improve seed germination, regulate stomatal closure, and enhance nutrient and water uptake under saline conditions. These combined effects contribute to better crop resilience and productivity in saline environments.

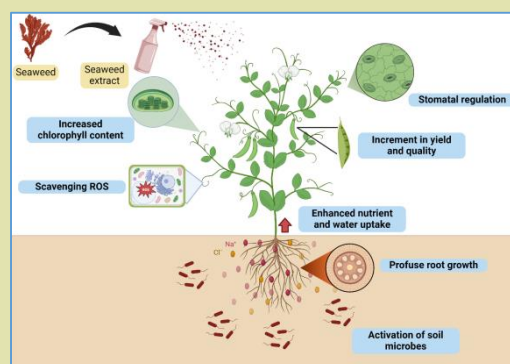


Fig: Mechanism of Seaweed extract in enhancement of crop performance in Coastal saline zone

Hence, seaweed extract being cheap and easily available serves as a promising Agri-input and also helps to mitigate environmental pollution owing to the excessive use of inorganic chemical fertilizers. They reduce the production cost and increase the productivity and net return of the farmers of the Coastal saline zones. Moreover, the commercial cultivation of seaweed extract is very sustainable due to its low carbon footprint and high nutrient-scrubbing and carbon-sequestering potential. The farmers working on the fragile ecosystem of coastal saline areas need to be made more aware of the usefulness of seaweed extract to fulfill sustainable development goals.

NATURE-BASED SOLUTIONS FOR LAND RESTORATION

Sujan Mandal

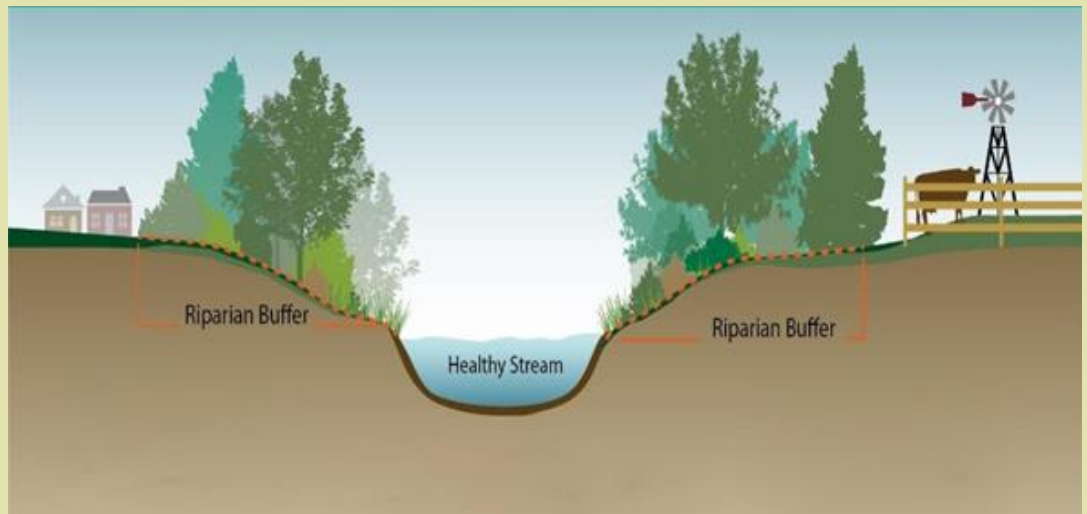
Land degradation, caused by deforestation, unsustainable agriculture, urbanization, and climate change, is a major threat to world ecosystems and human well-being. Restoration of degraded land is critical for sustaining biodiversity, protecting ecological services, and supporting livelihoods. Nature-based Solutions (NbS), which use natural processes to address social concerns, have emerged as a potential method of land rehabilitation. NbS combines ecological principles and human needs, providing several benefits to both people and the environment.

Different Strategies of Nature-Based Solutions for Land Restoration

- **Reforestation and Afforestation:** Planting trees and restoring forest ecosystems helps combat deforestation, sequester carbon, prevent soil erosion, and enhance biodiversity.
- **Agroforestry:** Integrating trees into agricultural landscapes improves soil fertility, enhances water retention, provides shade for crops, and diversifies livelihood opportunities for farmers.
- **Wetland Restoration:** Rehabilitating wetland ecosystems restores hydrological balance, improves water quality, provides habitat for wildlife, and enhances flood regulation.
- **Riparian Buffer Zones:** Establishing vegetative buffers along water bodies reduces sedimentation, filters pollutants, stabilizes stream banks, and promotes aquatic biodiversity.
- **Soil Conservation Practices:** Implementing techniques such as contour plowing, terracing, and cover cropping minimizes soil erosion, improves soil structure, and enhances agricultural productivity.

Benefits of Nature-Based Solutions for Land Restoration

Natural Biodiversity Sites are crucial for biodiversity conservation, climate change mitigation, ecosystem services provision, socioeconomic benefits, and cultural and recreational values. They create habitat corridors, promote species diversity, and



facilitate ecological connectivity, supporting native flora and fauna. Healthy ecosystems provide essential services like pollination, water purification, flood regulation, and soil fertility, benefiting both ecosystems and human societies. NbS also generates employment opportunities, improves food security, and contributes to poverty alleviation, especially in rural areas.

Challenges and Considerations

NbS programs encounter resource constraints because of finance, technical know-how, and institutional capability, especially in underdeveloped nations. Continuous observation and assessment are essential to guaranteeing its performance and sustainability. Governance and social fairness are necessary for a just allocation of rewards. The effectiveness of NbS in mitigating and adapting to climate change is influenced by climate change uncertainty. Adaptive and flexible management strategies are required. Governments, non-governmental organizations, and stakeholders in the corporate sector must work together, share expertise, and establish supporting policy frameworks in order to scale up successful NbS interventions.

A thorough and long-lasting method of restoring land, nature-based solutions take into account the complex interactions between ecological, social, and economic factors. By utilizing the innate resilience and adaptability of natural ecosystems, NbS can restore damaged land, boost biodiversity, mitigate climate change, and enhance human well-being. To fully realize the benefits of NbS, however, policymakers, practitioners, and communities must work together to solve challenges, gather resources, and incorporate nature-based methods into land management strategies. NbS can contribute to biodiversity conservation, landscape restoration, and the achievement of sustainable development goals through teamwork and creativity.

THE DUAL THREAT: HOW CLIMATE CHANGE AND HUMAN ACTIVITIES ACCELERATE GLOBAL DESERTIFICATION?

Abhijit Pal

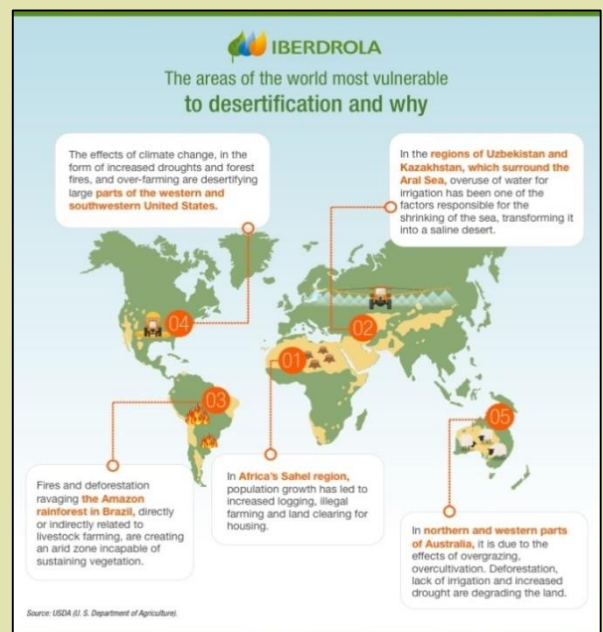
Global desertification, the process where fertile land transforms into arid desert, is a pressing environmental issue exacerbated by the dual forces of climate change and human activities. This dual threat not only accelerates the spread of deserts but also amplifies the adverse impacts on ecosystems, agriculture, and human societies.

Climate change serves as a potent catalyst in the desertification process. Rising global temperatures increase evaporation rates, reducing the moisture available in soil and water bodies. This leads to drier conditions conducive to desertification. Additionally, climate change disrupts precipitation patterns, often causing prolonged droughts in some regions while shifting rainfall away from areas that need it the most. Such changes diminish the natural regeneration capacity of ecosystems, making them more vulnerable to desertification. Furthermore, the increasing frequency and intensity of extreme weather events such as heatwaves and storms further degrade the land. Heatwaves desiccate the soil, reducing its organic matter and making it less fertile. Heavy storms can erode the topsoil, which is vital for plant growth, leaving behind barren, unproductive land. These climatic shifts create a vicious cycle: as land becomes degraded, it absorbs less carbon dioxide, thus exacerbating global warming and perpetuating further desertification.

On the other hand, human activities significantly accelerate desertification through unsustainable land use practices. Overgrazing by livestock, deforestation, and inappropriate agricultural methods are prime examples. Overgrazing strips the land of vegetation, leaving soil exposed to erosion and reducing its ability to retain moisture. Deforestation, often driven by the demand for agricultural land or timber, removes trees that play a crucial role in maintaining the water cycle and protecting soil integrity. Without these trees, the land becomes more susceptible to erosion and nutrient loss. Additionally, agricultural practices, especially those that rely heavily on monoculture and chemical inputs, degrade the soil over time. Irrigation practices that are not properly managed contribute to salinization, where the build-up of salts in the soil renders it infertile. Furthermore, urbanization and industrial activities also play a significant role. The expansion of cities and infrastructure often leads to the conversion of fertile land into impermeable surfaces such as concrete, disrupting the natural land and water cycles. Industrial pollution, including the release of harmful chemicals and heavy metals, contaminates the soil and water resources, further degrading the land.

The complex interaction between climate change and human activities creates a feedback loop that accelerates desertification. Human activities that degrade the land make it more vulnerable to the impacts of climate change. Conversely, the effects of climate change exacerbate the damage caused by human activities. For instance, deforestation not only leads to soil erosion but also reduces the land's ability to sequester carbon, contributing to climate change. As the climate warms, the altered weather patterns can lead to more frequent and severe droughts, further stressing the land already weakened by human exploitation.

Addressing the dual threat of climate change and human activities requires integrated and sustainable approaches. Reforestation and afforestation can restore degraded lands and improve carbon sequestration. Sustainable agricultural practices, such as crop rotation, organic farming, and conservation tillage, can enhance soil health and resilience. Policies that promote responsible land use, control overgrazing, and protect natural vegetation are crucial. On a broader scale, global efforts to combat climate change through reducing greenhouse gas emissions and transitioning to renewable energy sources are essential. Equally important are local and regional initiatives tailored to the specific needs and conditions of vulnerable areas.



In conclusion, the acceleration of global desertification due to the combined forces of climate change and human activities presents a complex and urgent challenge. Addressing it requires a multifaceted approach that encompasses both mitigation of climate impacts and sustainable land management practices. By doing so, we can safeguard our ecosystems, ensure food security, and protect the livelihoods of millions of people worldwide.

FROM DUST TO LIFE: LAND RESTORATION IN DROUGHT-STRICKEN REGIONS

Arundhati Aich

"Out of the dust, let life arise,
In parched lands, where hope defies.
With tender care, we heal the scars,
Restoring Earth beneath the stars."

-- Rachel Carson

Drought-stricken regions represent one of the most challenging environments for land restoration efforts. The transformation of these arid landscapes from barren dust to thriving ecosystems necessitates innovative and sustainable restoration practices. The success of such endeavours hinges on a combination of traditional knowledge, modern science, and community involvement. Drought exacerbates land degradation through processes such as soil erosion, desertification, and salinization. Without adequate moisture, soil structure deteriorates, leading to a loss of organic matter and nutrients. This degradation reduces the soil's ability to support plant life, further exposing it to erosion by wind and water. Consequently, these regions often fall into a vicious cycle where degradation begets further drought conditions by disrupting local water cycles and reducing the land's ability to retain moisture.

To combat these issues, various restoration techniques have been developed and implemented with varying degrees of success. One of the foundational methods is soil management and conservation. Techniques such as no-till farming, cover cropping, and the use of organic fertilizers help to rebuild soil structure, enhance fertility, and improve water retention. These methods not only stabilize the soil but also promote the growth of vegetation, which is crucial for restoring ecosystems. Another significant approach is the reforestation and afforestation of drought-stricken areas. In some cases, drought-resistant plant species are introduced to initiate a gradual recovery process. Water management is equally critical. Techniques such as rainwater harvesting, the construction of small check dams, and the restoration of traditional water bodies can greatly enhance the availability of water.



Community involvement is essential for the success of land restoration projects. Engaging them in the planning and implementation process ensures that restoration efforts are culturally appropriate and sustainable. Furthermore, community-based approaches often foster a sense of ownership and responsibility, which is crucial for the long-term maintenance of restored lands. Policy support and funding are also vital. Governments and international organizations play a key role in providing the necessary resources and creating an enabling environment for restoration activities. Policies that promote sustainable land management practices, incentivize conservation efforts, and support research and innovation in land restoration can significantly amplify the impact of these initiatives.



Several regions around the world have demonstrated the potential for successful land restoration in drought-prone areas. For instance, the Loess Plateau in China, once heavily degraded, has seen remarkable recovery through a combination of reforestation, terracing, and sustainable farming practices. Similarly, the Great Green Wall initiative in Africa aims to restore 100 million hectares of degraded land across the Sahel region by 2030, employing a mix of tree planting, soil restoration, and water management techniques.

Overall, restoring drought-stricken lands from dust to life is a complex but achievable goal. It requires a multifaceted approach that integrates soil conservation, reforestation,

water management, and community participation. As the global climate continues to change, the lessons learned from successful land restoration projects will be invaluable in building resilience against future environmental challenges.

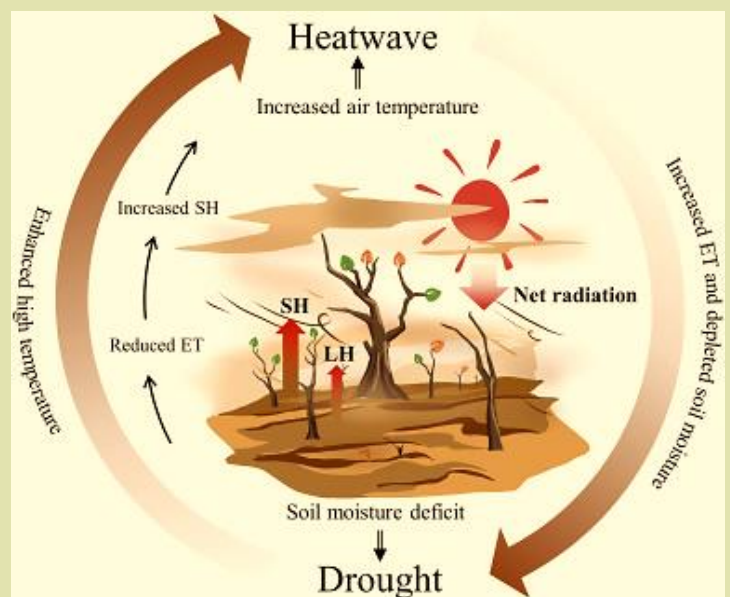
DOUBLE TROUBLE: GROWING THREATS OF COMPOUND DROUGHT AND HEAT WAVE EVENTS

Nidrothita Modak

In recent years, the intersection of climate change with extreme weather events has become increasingly evident, posing significant threats to both natural ecosystems and human societies. Among the most concerning are compound events, where two or more extreme weather conditions occur simultaneously or sequentially. Particularly troubling are the compound events of drought and heat waves, which, when combined, create a phenomenon often referred to as "double trouble."

Droughts are prolonged periods of deficient rainfall, leading to water shortages, reduced soil moisture, and severe impacts on agriculture and water supply. Heat waves, characterized by prolonged periods of excessively high temperatures, exacerbate these conditions by increasing evaporation rates and further depleting water resources. When these two events coincide, the results can be devastating. One of the primary drivers of the increasing frequency and intensity of compound drought and heat wave events is global climate change. Rising global temperatures contribute to more frequent and severe heat waves. Moreover, higher temperatures enhance the evaporation of water from soils, rivers, and reservoirs, exacerbating drought conditions. Additionally, changes in atmospheric circulation patterns can lead to altered precipitation patterns, making some regions more susceptible to prolonged dry spells.

The consequences of compound drought and heat wave events are far-reaching and multifaceted. Agriculturally, these events can lead to significant crop failures. The 2010 Russian heat wave, coupled with a severe drought, resulted in substantial losses in wheat production, leading to soaring global wheat prices and contributing to food insecurity. Similarly, the 2012-2013 drought and heat wave in the United States caused extensive damage to crops, particularly corn and soybeans, with ripple effects throughout the global food market. Ecologically, the impacts are equally severe. Forests and other natural ecosystems are highly vulnerable to the combined stress of drought and heat waves. The lack of water weakens trees and plants, making them more susceptible to diseases and pests. Additionally, the increased temperatures and dryness create ideal conditions for wildfires, which can devastate large swaths of forest, releasing massive amounts of carbon dioxide and further exacerbating global warming. The 2019-2020 Australian bushfires, fueled by extreme heat and drought, are a poignant example of the devastating effects such compound events can have on both biodiversity and human communities. Human health is also at risk during compound drought and heat wave events. Prolonged exposure to high temperatures can lead to heat-related illnesses and fatalities, particularly among vulnerable populations such as the elderly, young children, and those with pre-existing health conditions.



Addressing the growing threat of compound drought and heat wave events requires a multifaceted approach. Mitigation efforts must focus on reducing greenhouse gas emissions to limit global warming and its associated impacts. This includes transitioning to renewable energy sources, improving energy efficiency, and implementing sustainable agricultural practices. Adaptation strategies are equally crucial. Enhancing the resilience of water management systems to cope with prolonged dry spells and increased temperatures is essential. This can involve developing more efficient irrigation systems, diversifying water sources, and implementing water conservation measures. Urban planning must also consider the increased risk of heat waves by incorporating green spaces, promoting reflective roofing materials, and ensuring adequate cooling centers are available for vulnerable populations. Furthermore, early warning systems and public education campaigns can play a critical role in preparing communities for the onset of compound events.

By improving our understanding of the risks associated with these events and developing comprehensive strategies to mitigate and adapt to their impacts, societies can better withstand the 'double trouble' posed by the growing threats of compound drought and heat wave events.

REVEALING THE POTENTIAL OF MICROBES IN LAND RESTORATION: THE UNEXPECTED HEROES

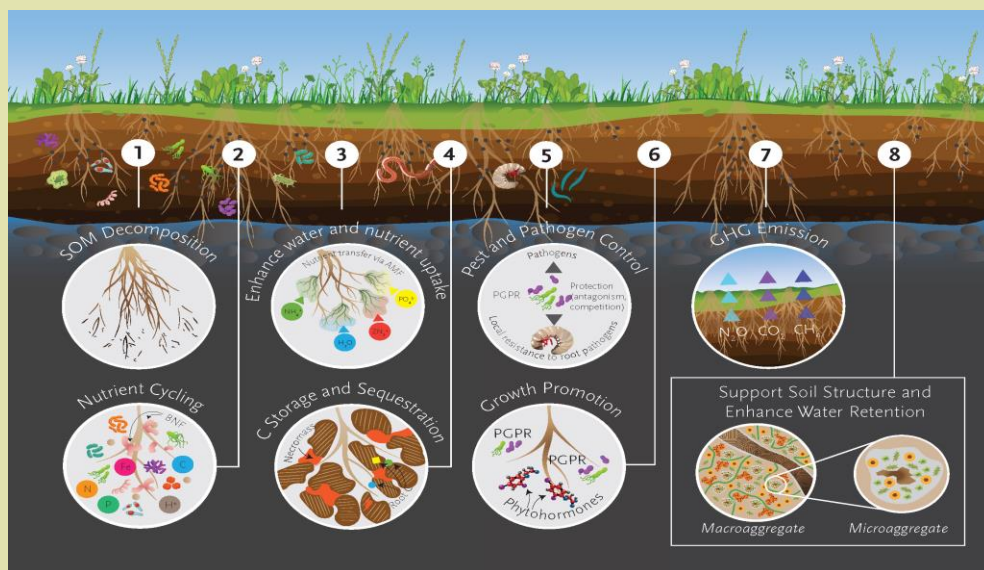
Pritthish Rauth

Imagine a microscopic metropolis teeming with life, a hidden world where millions of unseen workers toil away tirelessly. This is not science fiction; it's the reality beneath our feet- the intricate universe of soil microbes. Often relegated to the realm of the invisible, these tiny organisms, bacteria, archaea and fungi are the real heroes of our planet's health. They are the key players in the fight for land restorations in the face of a growing environmental crisis. Pioneers like *Sergei Winogradsky* and *Martinus Beijerinck* laid the foundations for our understanding of microbes' fundamental functions in nutrient cycling, organic matter decomposition, and soil formation procedures. Their work paved the path for modern microbial ecology which continues to reveal the incredible diversity and relevance of these tiny wonders.

Here's an inside look at some of these important players' fantastic roles:

The Architects of Soil Structure: Microbes are essential in producing compounds that stabilize soil aggregates, improving soil structure for water retention, aeration, and root growth. One prominent example is arbuscular mycorrhizal fungi (AMF).

Nutrient Cycling and Availability: Microbes are essential for nutrients cycling, that enables plant growth and successful land restoration. Nitrogen-fixing bacteria like “*Rhizobium*” & “*Azotobacter*” convert atmospheric nitrogen into ammonia, which is then converted into nitrates by nitrifying bacteria. A study in 2002 found that nitrogen-fixing bacteria increase soil nitrogen availability by up to 50% in degraded lands. Phosphorus, another important plant nutrient, can become trapped in soil minerals, making it unavailable to plants. Bacteria such as *Pseudomonas* come to the rescue. They secrete organic acids that dissolve these minerals, releasing trapped phosphorus and turning it into plants.



Plant Growth Promotion: Microbes, such as mycorrhizal fungi and plant growth-promoting rhizobacteria (PGPR), have formed symbiotic relationships with plants, promoting their growth and resilience. Mycorrhizal fungi facilitate nutrient and water uptake, improving plant tolerance to drought. Inoculating plants with mycorrhizal fungi can increase biomass by up to 40% and improve drought tolerance in arid and semi-arid regions. PGPR produce phytohormones, such as auxins and cytokinin's, which stimulate root growth and plant development.

Bioremediation and Pollutant Degradation: Some microbes have the ability to break down and clean pollutants, making them valuable in remediation of contaminated sites, which is often a prerequisite for successful land restoration. *Bacillus* and *Arthrobacter* can break down hydrocarbons, making them useful for cleaning up oil-contaminated soils. Fungi such as *Phanerochaete Chrysosporium* and *Pleurotus ostreatus* can degrade objectionable compounds such as polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs), which are common pollutants in degraded soils.

In conclusion the fight for a healthy earth is not just about restoring degraded ecosystems; it is also about building resilience in the face of climate change and here microbes play an important role. A healthy soil with a diverse microbial community act as an efficient carbon sink. Microbes break down organic matter, releasing carbon dioxide, but a significant portion of that carbon is converted into permanent organic compounds that remain in the soil for long periods of time.

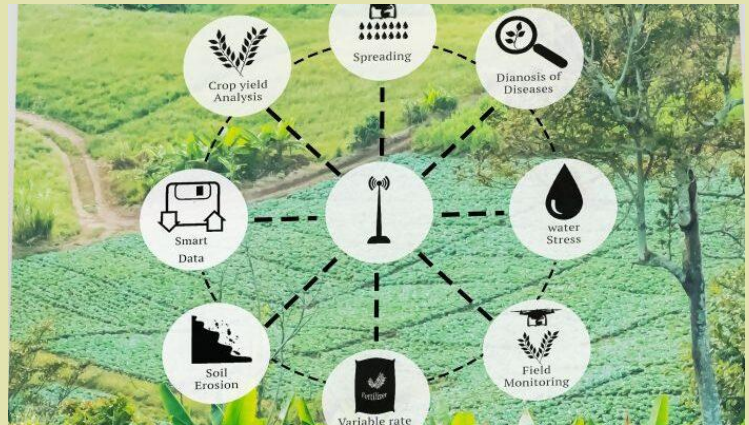
REVOLUTIONIZING DRYLAND FARMING: CUTTING-EDGE TECHNOLOGIES BOOSTING PRODUCTIVITY IN ARID ZONES

Anindya Haty

Dryland farming, characterized by cultivation in arid and semi-arid regions with limited rainfall, has long presented significant challenges to agricultural productivity. However, recent advancements in technology are revolutionizing dryland farming, making it more viable and productive. These cutting-edge technologies address water scarcity, soil health, crop selection, and overall farm management, providing innovative solutions to boost productivity in arid zones.

One of the most transformative technologies in dryland farming is precision agriculture. Utilizing data from satellite imagery, drones, and soil sensors, farmers can monitor crop health, soil moisture levels, and nutrient availability in real-time. This precise data allows for targeted interventions, such as localized irrigation or fertilization, ensuring resources are used efficiently and effectively. Precision agriculture reduces water waste and optimizes input usage, which is crucial in water-scarce environments.

Drip irrigation, another pivotal technology, has been a game-changer for dryland farming. Unlike traditional irrigation methods, which can lead to significant water loss through evaporation and runoff, drip irrigation delivers water directly to the plant roots. This method drastically reduces water usage while maintaining optimal soil moisture levels for crops. Advanced drip irrigation systems are now integrated with sensors and automated controls, enabling farmers to fine-tune water delivery based on real-time soil and weather conditions. In addition to irrigation innovations, soil management techniques have evolved to enhance productivity in drylands. Conservation tillage, for instance, minimizes soil disturbance, preserving soil structure and moisture. This practice helps maintain organic matter and reduces erosion, critical in arid regions prone to wind and water erosion.



Genetic advancements have also played a significant role in revolutionizing dryland farming. The development of drought-resistant crop varieties has been a focal point of agricultural research. Through traditional breeding techniques and modern genetic engineering, scientists have created crops that can withstand prolonged dry spells and still produce high yields. These drought-tolerant varieties are specifically designed to thrive in arid conditions, offering a reliable solution to the challenges posed by unpredictable rainfall patterns.

Another innovative approach is the use of biochar, a form of charcoal produced from organic matter. When added to soil, biochar enhances water retention, improves soil structure, and increases nutrient availability. Its porous nature allows it to hold water and nutrients more effectively, providing a more stable growing environment for crops. Biochar also sequesters carbon, contributing to climate change mitigation efforts.

Renewable energy technologies are further transforming dryland farming. Solar-powered pumps and irrigation systems provide a sustainable and cost-effective solution for water management. In regions with abundant sunlight, solar energy offers a reliable power source, reducing dependency on traditional, often expensive, energy supplies. This not only lowers operational costs but also supports the transition to greener agricultural practices.

Moreover, digital platforms and mobile applications are empowering farmers with knowledge and resources. These tools provide weather forecasts, market information, and best practice guidelines, enabling farmers to make informed decisions. Access to timely and relevant information helps farmers adapt to changing conditions and optimize their farming practices.

In conclusion, cutting-edge technologies are revolutionizing dryland farming, making it more productive and sustainable. Precision agriculture, advanced irrigation systems, improved soil management techniques, drought-resistant crops, biochar, renewable energy, and digital tools are collectively transforming how farming is conducted in arid regions. By addressing the specific challenges of dryland farming, these innovations are paving the way for enhanced food security and economic resilience in some of the world's most vulnerable areas. As these technologies continue to evolve and become more accessible, the future of dryland farming looks increasingly promising.

GLOBAL AGENDA ON COMBATING DESERTIFICATION: A CRITICAL APPRAISAL

Jubaraj Roy

Desertification means the degradation of the land in arid, semi-arid, and sub-humid areas due to primarily human activities and climate variation, which affects large-scale cultivated land, and creates significant challenges to sustainable development, food security, and people's livelihood. Combating desertification refers to the activities or strategies that come under the integrated development of land in arid semi-arid and dry sub-humid areas to prevent and reduce land degradation and sustainable development.

The United Nations Convention to Combat Desertification (UNCCD), established in 1994, serves as the primary international framework for combating desertification. The primary objective of this convention was to combat desertification and mitigate the severe effect of drought in serious drought-affected countries, particularly in Africa, through appropriate action at all levels.

To combat desertification and mitigate drought, UNCCD has adopted several strategic frameworks and initiatives, like a 10-year strategic plan (2008-2018) and Land Degradation Neutrality (LDN) targets. Different countries that are affected by desertification have developed National or regional action plans in line with UNCCD guidelines. China launched the "Grain for Green" program aims to convert degraded farmland into forest and grassland. The Green Wall initiative was taken by the African Union to restore 100 million



hectares of degraded land across the Sahel region by 2030. Our nation India built up the National Action Plan on Climate Change for a specific mission of sustainable agriculture and ecosystem restoration.

The UNCCD has succeeded in raising global awareness about the importance of combating desertification. Many countries started to include integrated desertification control into their national policies. The framework recognized the complex interaction of social, economic, and environmental factors that influence desertification. The agenda emphasizes empowering local communities, important for sustainable land management practices. Different funding mechanisms have been established like the Global Environment Facility (GEF) and National Desertification Funds (NDF) for supporting the implementation of the programs to combat desertification and mitigate the drought effects at the local level. The UNCCD shares knowledge among different nations for helping them out to adopt successful anti-desertification strategies.

Although it has been able to prevent drought to a large extent, it has faced several challenges, mostly related to implementation. Most of the programmes in most of the countries in Africa and Asia have been implemented in a top down manner without meaningful involvement and participation of the local communities. Despite the availability of the funds, many countries suffer from insufficient financial and technical resources to implement large-scale projects. The increasing frequency and intensity of droughts and extreme climatic events due to climate change are increasing the impacts of desertification, complicating mitigation efforts.

The programme has been successful in those countries where communities played important role in designing, implementing and monitoring the programmes at the local level. This is the only way to ensure that the programmes are demand driven, that these are designed to serve the local needs, and that these are implemented by the local people which alone ensures best possible utilisation of available resources.

The fight against desertification requires a sustained global effort. The UNCCD framework provides a strong base for all countries to reduce desertification, but adaptation and improvement of continuous are essential. Effective combating desertification requires a sustained and strong effort from all sectors of society, to ensure policies and actions are well-designed and strictly implemented and monitored.

LAND RECLAMATION THROUGH WASTE MANAGEMENT: A SUSTAINABLE APPROACH TO ENVIRONMENTAL RESTORATION

Rashmoni Karak

Evolutionary growth is a crucial part of development. According to World Bank data, more than 2 billion tonnes of municipal solid waste are generated annually, and it is expected that waste generation will increase by more than 3 billion tonnes by 2050. A report from The Energy and Resource Institute (TERI), India, claimed that our country generates over 62 million tons (MT) of waste annually and is ranked among the top 10 countries in the world generating municipal solid waste. Based on the EPA report from 2018, almost half of the trash went to landfills around the country. Various types of waste materials involve the use of land reclamation through waste management. By utilizing municipal solid waste, construction and demolition debris, and industrial by-products, land reclamation is possible. The process typically involves several stages of analysis, including waste collection, sorting, treatment, and final placement. The ultimate goal is to transform waste materials into a stable and usable landform while minimizing environmental impact.

- In the United States, many abandoned mine sites have been reclaimed using waste materials. For instance, in Pennsylvania, coal ash and other industrial by-products are utilized to fill and stabilize abandoned coal mines. This not only reduces the hazards associated with abandoned mines but also converts these areas into usable land for various purposes.
- In the Singapore, a land-scarce nation has developed the Pulau Semakau Landfill, an innovative project that combines waste management with land reclamation. The landfill utilizes incineration ash and treated municipal waste to create a stable landform, which is then covered with soil and vegetation. The site has become a thriving ecosystem, supporting diverse flora and fauna.
- The Netherlands is famous for its polder systems, which involve reclaiming large areas of land from the sea. In recent years, the country has been using waste materials like dredged sediments and construction debris in these projects. For example, the Marker Wadden project is using sediments to build new islands in Markermeer Lake, which not only increases land availability but also enhances ecological value.

With the advancements in technology and increased awareness of sustainable practices, the future of land reclamation through waste management looks promising. Emerging techniques, such as bioremediation and the use of advanced materials, hold the potential to enhance the efficiency and effectiveness of this approach. Moreover, international collaboration and knowledge sharing can accelerate the adoption of best practices and innovative solutions. Governments, industries, and communities must work together to create supportive policies and invest in research and development. If the government starts to pressure waste-generating industries to withdraw or collect the distributed waste in the market through various strategies and takes initiatives to educate people on how to manage their whole day generated waste at the local level through Self Help Group or ICDS center for both liquid and solid waste, then collection load and management of waste will also eventually be eliminated. For the present scenario, I think some basic vocational courses in waste management should start soon. By fostering a circular economy mindset, where waste is viewed as a valuable resource rather than a burden, we can make significant strides towards sustainable land reclamation and environmental conservation.

EL NIÑO AND LA NIÑA EFFECTS ON AGRICULTURE AND WATER RESOURCES IN INDIA

Pinanki Das

El Niño and La Niña are climatic phenomena resulting from variations in oceanic temperatures in the central and eastern Pacific Ocean. These variations significantly influence global weather patterns, with profound impacts on agriculture and water resources in various regions, including India. Understanding these impacts is crucial for effective planning and mitigation strategies in the agriculture sector and water management.

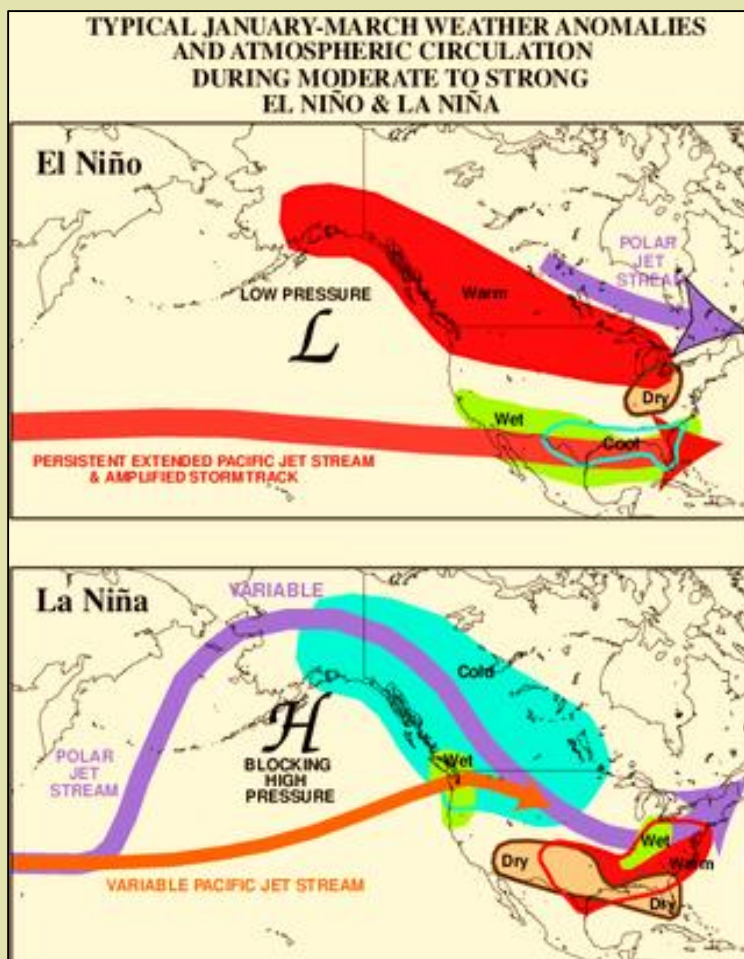
El Niño is characterized by unusually warm ocean temperatures in the Equatorial Pacific, which disrupts normal weather patterns. In India, El Niño is often associated with weaker monsoon seasons. The Indian summer monsoon, which occurs from June to September, is crucial for the country's agriculture, as it accounts for about 70% of the annual rainfall. El Niño typically leads to below-average rainfall during the monsoon season. This reduction can cause drought conditions in many parts of India, especially in the central, western, and northern regions. Moreover, the decrease in rainfall adversely affects the yield of major crops like rice, wheat, and pulses, which are heavily dependent on monsoon rains, resulting in economic distress for farmers and increased prices for food commodities, affecting the overall economy. Additionally, reduced monsoon rains lead to lower water levels in reservoirs, rivers, and groundwater. This scarcity of water resources affects drinking water supplies and irrigation.

In contrast, La Niña is characterized by unusually cold ocean temperatures in the Equatorial Pacific. La Niña generally brings above-average monsoon rains to India. La Niña typically enhances the monsoon season, leading to above-normal rainfall. This can benefit rain-fed agricultural regions by ensuring adequate water supply for crops. With sufficient rainfall, crop productivity often increases. However, excessive rainfall can lead to flooding, which can damage crops, especially in low-lying areas. Furthermore, higher humidity and rainfall associated with La Niña can create favorable conditions for pests and diseases, which may negatively affect crop health and yields.

To cope with the impacts of El Niño and La Niña, several strategies can be employed:

- **Weather Forecasting:** Improved weather forecasting and early warning systems can help farmers and water resource managers prepare for adverse conditions.
- **Crop Diversification:** Diversifying crops to include drought-resistant and flood-resistant varieties can mitigate the impact of variable rainfall.
- **Water Management:** Efficient water management practices, such as rainwater harvesting, drip irrigation, and the construction of check dams, can enhance water availability during dry periods and manage excess water during floods.
- **Insurance Schemes:** Crop insurance schemes can provide financial protection to farmers against crop failures due to climatic anomalies.

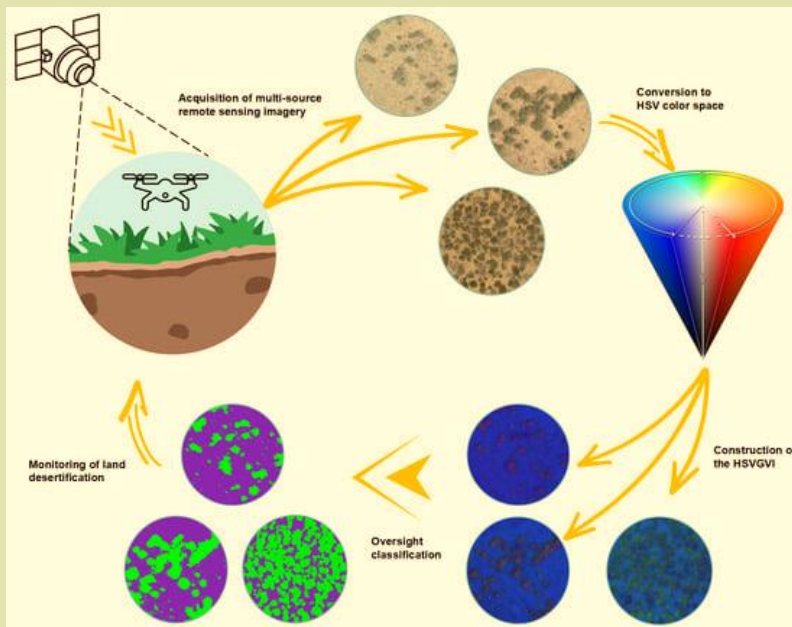
In conclusion, El Niño and La Niña significantly affect agriculture and water resources in India. While El Niño often brings drought and reduced agricultural output, La Niña can lead to excessive rainfall and potential flooding. Effective planning, improved forecasting, and adaptive practices are essential to mitigate these impacts and ensure the resilience of India's agriculture and water resources.



DESERT WATCH: HARNESSING REMOTE SENSING FOR DYNAMIC DESERTIFICATION MONITORING

Tazmin Sultana

Desertification, the process by which fertile land transforms into arid desert, poses a significant threat to ecosystems, biodiversity, and human livelihoods worldwide. With climate change exacerbating arid conditions in many regions, monitoring and mitigating desertification have become urgent priorities. In this context, remote sensing technologies offer a powerful tool for assessing and understanding the dynamics of desertification over vast and often inaccessible areas. Remote sensing involves the acquisition of information about an object or phenomenon without physical contact. Satellites, drones, and other airborne platforms equipped with various sensors can collect data on land cover, vegetation health, soil moisture, and other relevant parameters across different spatial and temporal scales. By analyzing these data, researchers and policymakers gain valuable insights into the processes driving desertification and can develop effective strategies for its prevention and management.



One of the key advantages of remote sensing in desertification monitoring is its ability to provide frequent and consistent observations over large geographic areas. Satellites orbiting the Earth capture images of the planet's surface at regular intervals, allowing for the creation of time-series datasets that reveal changes in land cover and vegetation over time. By comparing images taken at different points in time, scientists can detect trends and patterns associated with desertification, such as the expansion of barren areas or the degradation of vegetation cover. Furthermore, remote sensing technologies enable the integration of data from multiple sources and sensors, providing a comprehensive understanding of the complex processes underlying desertification. For example, combining optical imagery with RADAR, LiDAR, etc. data can improve the detection of

changes in soil moisture and surface roughness, which are important indicators of desertification. Similarly, the use of thermal infrared sensors can help identify areas experiencing heat stress and water scarcity, further enhancing our ability to monitor desertification dynamics.

Remote sensing can also support early warning systems and decision-making tools for desertification management. By analyzing spatial data in near real-time, researchers can identify areas at high risk of desertification and prioritize interventions such as reforestation, soil conservation, and water management. Another promising application of remote sensing in desertification monitoring is the development of predictive models and scenario analyses. By combining historical data with climate projections and land use scenarios, scientists can forecast future trends in desertification and assess the potential impacts of different mitigation strategies. This information is invaluable for informing long-term planning and policy development aimed at building resilience to desertification and climate change.

However, while remote sensing offers great potential for desertification monitoring, several challenges remain to be addressed. These include the need for improved data resolution and accuracy, as well as the development of standardized methods for data analysis and interpretation. Additionally, efforts to build local capacity for remote sensing and data analysis are essential to ensure that monitoring systems are sustainable and responsive to the needs of affected communities.

In conclusion, remote sensing technologies hold promise for monitoring and managing desertification on a global scale. By providing timely and accurate information about changes in land cover, vegetation health, and soil conditions, remote sensing enables informed decision-making and targeted interventions to prevent the further spread of desertification. With continued investment in research, technology development, and capacity building, remote sensing can play a crucial role in safeguarding the world's arid and semi-arid regions for future generations.

YOUTH-LED INITIATIVES FOR SUSTAINABLE LAND MANAGEMENT

Saikat Dutta

Young people are taking the lead in sustainable land management initiatives to address environmental degradation and promote sustainable practices. Their innovative approaches, energy, and passion are driving these initiatives, leading to a better future. They are involved in various activities such as reforestation projects, community-based agricultural practices, advocacy, and policy development. For example, many youth groups are actively engaged in planting trees and restoring degraded lands, which helps sequester carbon, improve soil health, and enhance biodiversity. In rural areas, young farmers are adopting sustainable agricultural techniques like agroforestry, permaculture, and organic farming, reducing reliance on chemical inputs and improving food security. Urban youth are also contributing significantly by creating community gardens and green spaces, which not only provide local food sources but also improve urban ecosystems.

Furthermore, young people are using digital platforms such as social media campaigns, online workshops, and virtual conferences to raise awareness about sustainable land management issues and to mobilize collective action. These efforts are complemented by on-the-ground activities, creating a synergistic effect that amplifies their impact. Additionally, young activists are participating in policy dialogues and decision-making processes at local, national, and international levels to ensure that the perspectives and needs of the younger generation are considered in the formulation of sustainable land management policies.

Youth-Led Initiatives around the World

- **Seedballs Kenya:** In Kenya, a youth-led organization called Seedballs Kenya works to restore land in – what they see as — the perfect way possible; using some seeds. And by some, I mean millions of them! These nutrient-rich dry balls of compost the size of a small fist are simply carriers for seeds that can be sown easily without any special tool even on difficult grounds. In this experience, we educate the youth to make and scatter these seedballs restoring and making some of the previously exploited areas green again.
- **ECO Roots Community Farm (Canada):** ECO Roots is an urban youth farm in Vancouver, Canada. — They practice regenerative, sustainable farming techniques such as permaculture (think of it as the marriage of organic ag and design), composting, and water conservation. They have also sought to turn the farm into an educational centre where they teach young people about all that was achieved regarding food security, protecting their environment, and the value of locally produced products.
- **Green Mentors (India):** Get university students actively involved as “Green Mentors” who not only create awareness on issues surrounding ecology among school children but also mentor them in adopting environmentally friendly practices. Green Mentors conduct training sessions, eco-clubs and hands-on activities related to tree plantation, waste management or water conservation in various schools all over the country.
- **Youth Mappers (Global):** Youth Mappers collect voluntary crowdsourced development data through the efforts of students and key community partnerships on sustainable development projects globally. This open-source mapping platform enables you to map rural areas, assess lands degraded that has the potential for restoration and also plan all your infrastructure projects with optimal environmental conservation.
- **Benefits and Challenges:** Sustainable land management initiatives need youth for the many advantages of on-the-ground work that bring them together, including youth leadership development, community engagement, environmental education and direct benefits. Nevertheless, they continue to confront a number of barriers including inadequate funding and policy incentives, in addition to challenges related to the broader implementation of successful projects.

In summary, initiatives led by young people for sustainable land management are having a substantial impact by promoting innovative practices, raising awareness, and influencing policy. The enthusiasm and creativity of young individuals, when combined with sufficient support and resources, have the potential to bring about transformative change in the management and conservation of land. As these initiatives continue to expand and develop, they provide hope for a more sustainable and resilient future.

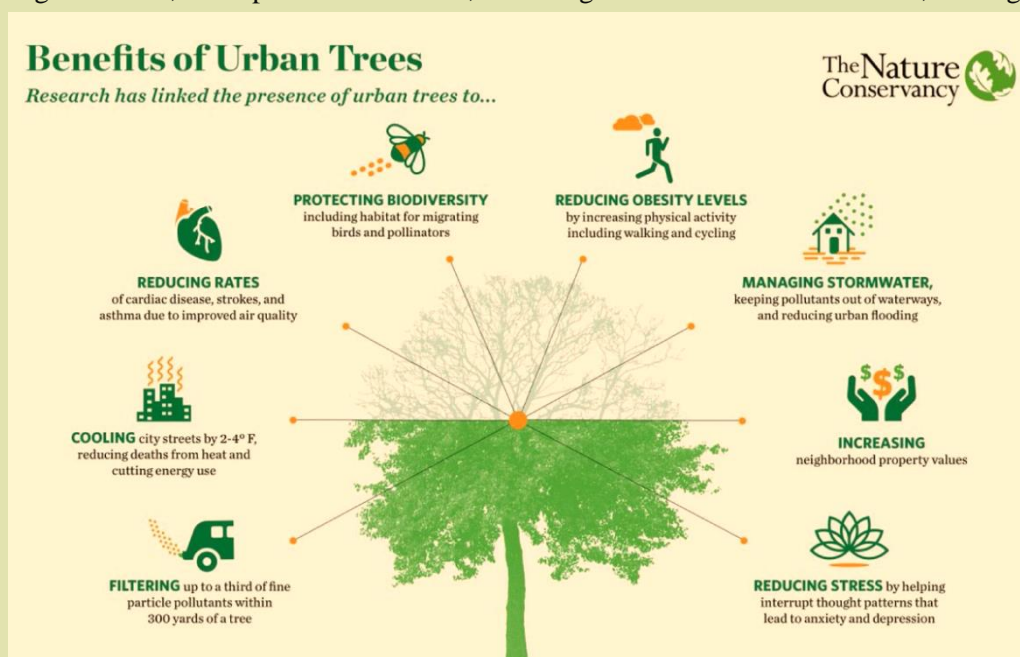
THE ROLE OF URBAN AFFORESTATION IN IMPROVING AIR QUALITY AND REDUCING THE URBAN HEAT ISLAND EFFECT

Kaberi Saha

In the current context of climate change, there is an urgent need to prioritize environmental improvement to combat its effects. Developing countries, in particular, are experiencing rapid urbanization, leading to several environmental challenges such as air pollution, deforestation, depletion of cultivated land, and increased greenhouse gas emissions, exacerbating climate change and global warming. To address these issues, urban afforestation plays a crucial role. Urban afforestation involves planting and maintaining trees and gardens within urban areas and has been identified as a key measure for improving air quality and mitigating the heat island effect in cities. As cities grapple with challenges like air pollution and rising temperatures due to on-going growth and industrialization, urban afforestation presents a natural and effective solution, contributing to the overall sustainability and livability of urban environments.

One of the most significant advantages of afforestation in cities is its capacity to improve air quality. Trees' leaves and bark act as natural air filters, effectively removing various pollutants. They capture and reduce pollutants like carbon monoxide, sulfur dioxide, nitrogen oxides, and particulate matter, resulting in cleaner air. Moreover, through photosynthesis, trees absorb carbon dioxide and release oxygen, increasing oxygen levels and enhancing the overall urban atmosphere. The physical structure of trees also aids in trapping pollutants, preventing them from remaining airborne and being inhaled by city residents.

This comprehensive reduction in air pollutants significantly improves the quality of life for urban dwellers. Urban afforestation also plays a crucial role in mitigating the urban heat island effect,



where urban areas experience higher temperatures than their rural surroundings due to human activities and infrastructure. Trees provide shade, cooling surfaces like streets and buildings, thereby reducing ambient temperatures. This cooling effect reduces the reliance on air conditioning, leading to a reduction in energy consumption and subsequent heat emissions. Moreover, trees engage in evapotranspiration, releasing water vapor into the atmosphere. This process absorbs heat and cools the surrounding air, further lowering temperatures in urban areas.

Urban green spaces, such as parks, community gardens, and green belts, play a crucial role in breaking up the continuous expanse of concrete and asphalt, which tend to absorb and retain heat. These green spaces act as cool islands within urban environments, providing relief from high temperatures and creating more comfortable microclimates. Integrating vegetation into buildings, through green roofs and walls, further supports this cooling effect. These green infrastructures not only insulate buildings from extreme temperatures but also enhance the overall vegetative cover of urban areas, promoting cooling. Additionally, the presence of trees and green spaces has been associated with improved mental health, reduced stress, and a general sense of well-being in the community. Trees also serve as natural sound barriers, reducing noise pollution by absorbing, deflecting, and refracting sound waves.

Urban afforestation presents a multifaceted approach to addressing crucial environmental challenges in cities. By enhancing air quality and mitigating the urban heat island effect, it contributes to creating healthier, cooler, and more sustainable urban environments. The strategic implementation of afforestation projects, complemented by community involvement and strong policies, is essential for maximizing these benefits without causing harm to the environment. This approach ensures the resilience and livability of urban areas for future generations.

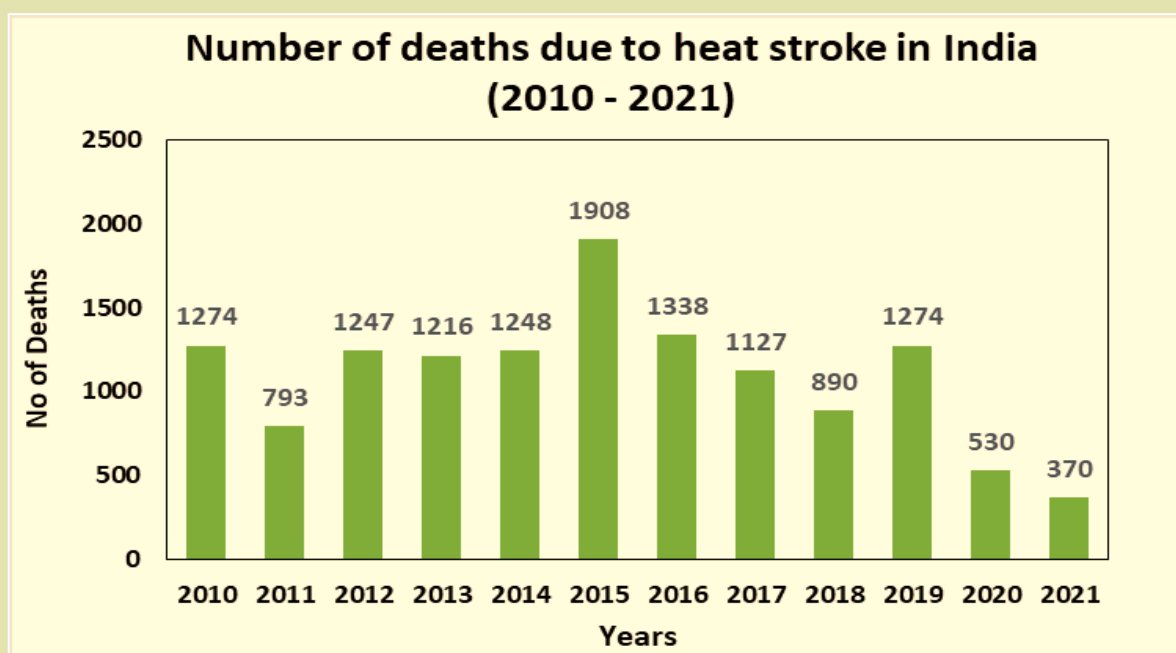
MANAGING RISKS OF HEAT WAVE IN INDIA

Banashreee Chakraborty

Since 1950, there has been a noticeable increase in heat stress in various parts of India - on the west coast, portions of Maharashtra, the southern peninsula of India, and northwest India, including Rajasthan and Gujarat, and parts of Orissa, West Bengal and Bihar. High relative humidity intensifies the effects of heat waves by decreasing sweat evaporation, which lessens the efficiency of the body's cooling system and raises the possibility of heat-related illnesses killing people.

As these extreme weather events become more frequent and intense India needs to manage the risk of heat waves effectively. Several States and cities of India have adopted Heat Wave Action Plan. National Disaster Management Authority has also issued guidelines for preparation of such plans

One of the key strategies to reduce the risk of Heat waves is to increase awareness and preparedness among the people by giving people the right information about the risks of extreme heat and how they can protect themselves during the event of a heat wave. Organizing public awareness campaigns and the use of social media and traditional media outlets can be very effective in spreading information about heat wave risks and best practices for staying safe.



Early warning systems can be another important aspect of managing the risk associated with heat waves. By closely monitoring weather patterns and providing time-to-time warnings when a heat wave is forecasted, authorities can help people take necessary precautions to protect themselves from the hit of heat waves. Early warning systems can help to mobilize resources for the relief of vulnerable populations, such as the elderly, children, and pavement dwellers.

Urban planning and infrastructure development can also play a crucial role in managing the risk of heat waves. Cities in India are particularly vulnerable to extreme heat due to the urban heat island effect, which causes temperatures to be higher in urban areas as they have fewer green areas compared to rural areas. By implementing measures such as increasing green spaces, planting trees, and using reflective materials in building design, cities can reduce the temperatures and mitigate the impact of heat waves.

Government should also invest in public health services to address the adverse effects of heat waves on the public health. Hospitals and other healthcare facilities should be equipped to admit a large number of patients with heat-related illnesses, and medical personnel should be properly trained to recognize and treat these patients properly. During the heat wave event, communities ought to have access to the cooling centers and other facilities.

In conclusion, managing the risk of heat waves in India requires a multi-faceted approach that includes increasing awareness and preparedness among the local people, developing proper early warning systems, improving urban planning and infrastructure, and enhancing investments on public health. By taking proactive measures to address the challenges posed by heat waves, India may reduce the impact of these extreme weather events that are going to be more frequent and intense.

WATER SCARCITY AND NEED FOR SUSTAINABLE WATER MANAGEMENT

Sonia Paul

Water is a vital resource that is essential for all forms of life, economic development, and environmental sustainability. It plays a crucial role in ensuring food security, supporting industrial production, and preserving the environment. Water scarcity can occur due to water stress, deficits, and crises. The main driver of water scarcity is population growth, which increases the demand for freshwater. This demand is further exacerbated by urbanization and industrialization, putting significant strain on existing water resources. Climate change is another major factor, resulting in erratic rainfall, prolonged droughts, and the melting of glaciers, which disrupt the natural replenishment of water sources. Additionally, water pollution from industrial discharges, agricultural runoff, and improper waste disposal makes water bodies unsuitable for human consumption and farming. Over-extraction of water for irrigation, industrial use, and domestic consumption depletes rivers, lakes, and aquifers faster than they can naturally replenish, leading to declining water levels and extensive ecosystem damage. Water scarcity has far-reaching effects, impacting various aspects of life and the environment. It significantly affects human health, agriculture, and economic development. The lack of clean water leads to the spread of waterborne diseases, compromising public health. Reduced crop yields due to water scarcity also threaten food security, while industries face disruptions and economic instability due to water shortages. Environmental degradation ensues as water bodies are overexploited or polluted, endangering aquatic life and disrupting natural habitats, ultimately leading to biodiversity loss.

Addressing water scarcity through sustainable management is crucial for the well-being of populations, economic growth, and the health of the planet. Efficient water use is a key component of sustainable water management and can be achieved through technological adaptations and practices in agriculture, industry, and households. These include implementing drip irrigation, water recycling systems, and using low-flow fixtures. Sustainable water management also involves promoting water conservation through awareness campaigns and incentives for adopting water-saving measures such as fixing leaks and using water-saving devices. Reducing water consumption can be further achieved by encouraging the use of native and drought-tolerant plants in landscaping. Additionally, policymakers and governments should prioritize the development of comprehensive water



management plans that consider the needs of both humans and the environment. This includes implementing legislation to prevent water pollution, investing in infrastructure for water storage and distribution, and promoting education and awareness about the importance of water conservation. These actions will help alleviate the strain on water resources and ensure a sustainable future for all. In conclusion, addressing water scarcity is an urgent global imperative that demands immediate action. Collaboration among individuals, communities, businesses, and governments is essential to effectively tackle this challenge. Through the implementation of sustainable water management practices, we can guarantee the availability of clean, safe, and sufficient water for present and future generations. It is crucial to act swiftly and decisively to conserve this invaluable resource for the well-being of all.

In India, sustainable water management is a critical issue due to the country's growing population, rapid urbanization, and agricultural demands. Water scarcity is a significant challenge, exacerbated by inefficient water use practices and inadequate infrastructure. The government has implemented various initiatives to address these issues, including the National Water Mission under the National Action Plan on Climate Change. This mission aims to improve water use efficiency and promote sustainable water practices. Efforts are also being made to rejuvenate traditional water harvesting systems, such as rainwater harvesting, and to promote community-based water management practices. Despite these efforts, significant challenges remain, including groundwater depletion, water pollution, and inadequate wastewater treatment. Continued investment in sustainable water management practices and infrastructure is essential to ensure water security for all.

CHALLENGES OF URBANISATION ON ENVIRONMENT AND SUSTAINABLE PRACTICES

Bhagyasree Chatterjee

Urbanization is the process through which rural areas transform into urban areas, marked by an increasing concentration of population in cities and towns. This transition is driven by various socio-economic factors, including the pursuit of better employment opportunities, enhanced living standards, and access to superior healthcare, education, and entertainment facilities. Urbanization typically results in the expansion of infrastructure such as roads, housing, commercial buildings, and public utilities to accommodate the growing urban populace. It involves the migration of people from rural hinterlands to urban centres, driven by both "push" factors (such as lack of resources and employment opportunities in rural areas) and "pull" factors (such as the promise of better jobs and improved quality of life in cities). As cities expand, they evolve into hubs of economic activity, innovation, and cultural exchange, fostering significant social and economic development. However, this rapid urban growth often comes with challenges, including increased environmental degradation, strain on infrastructure, and social disparities, which necessitate strategic planning and sustainable development practices to ensure balanced and inclusive urban growth.

The loss of habitats due to urbanization is a significant environmental issue, marked by the conversion of natural landscapes into urban areas to accommodate growing populations and economic activities. This process often involves the destruction of forests, wetlands, grasslands, and other natural ecosystems, leading to a drastic reduction in biodiversity. The Amazon rainforest, often referred to as the "lungs of the Earth" has experienced extensive deforestation to make way for urban and agricultural development. This not only disrupts the habitats of countless species but also reduces the rainforest's capacity to sequester carbon dioxide, exacerbating climate change. Air pollution itself is a major concern in urban areas where the concentration of vehicles, industries, and construction activities release large amounts of greenhouse gases and other pollutants into the atmosphere which not only contributes to global warming but also poses serious health risks, including respiratory and cardiovascular diseases. Water pollution is another critical issue associated with urbanization as cities grow, so their demand for water, leading to over-extraction of local water resources. Additionally, urban runoff, carrying pollutants from roads, industries, and homes, often ends up in rivers, lakes, and oceans where the discharge of untreated or inadequately treated sewage further contaminates water bodies, affecting both aquatic life and human populations reliant on these water sources for drinking and sanitation. Waste management in urban areas also poses significant challenges the sheer volume of solid waste generated by dense population is often more than what existing waste management systems can handle efficiently. Inadequate waste disposal leads to the proliferation of landfills and illegal dumpsites, which can release toxic substances into the soil and groundwater furthermore, improper waste management can lead to the spread of diseases and negatively impact urban aesthetics. Another consequence of urbanization is the urban heat island effect, where urban areas experience higher temperatures than their rural surroundings. This is due to the extensive use of concrete, asphalt, and other materials that absorb and retain heat where higher temperatures in cities increase energy consumption for cooling, exacerbate air pollution, and pose health risks, particularly to vulnerable populations during heatwaves.

To address environmental challenges in urban areas, it's important to integrate sustainable practices into urban planning and development. This includes implementing green infrastructure like parks, green roofs, and urban forests to mitigate air pollution, reduce the urban heat island effect, and provide recreational spaces. Promoting sustainable transportation, effective waste management, and incorporating sustainable building practices are also crucial for creating environmentally friendly cities.



EXTINCTION OF SPECIES IN THE EPOCH OF THE ANTHROPOCENE

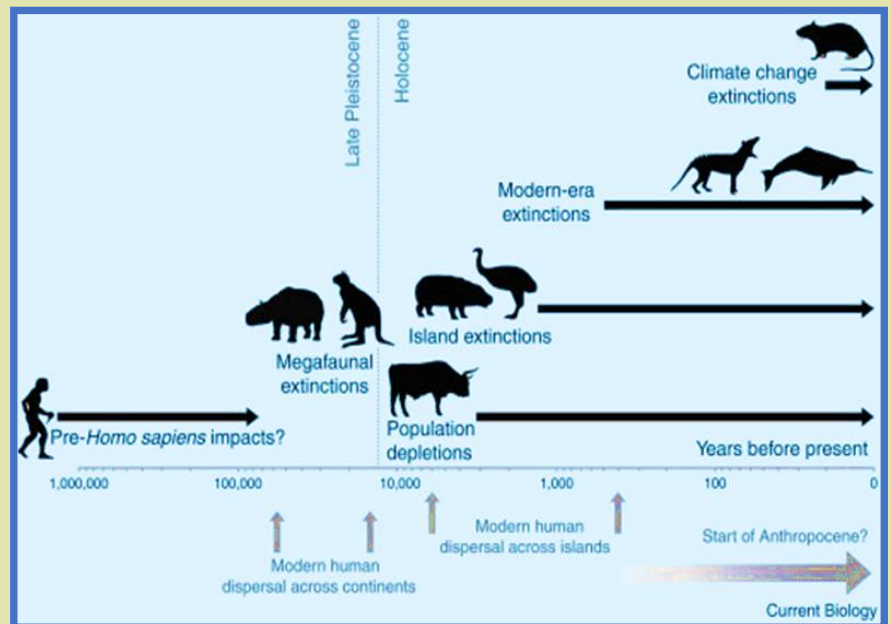
Chetana Tunga

The Epoch of the Anthropocene is the era of ecological disruptions caused by human activities. No other disruptions are starker than the "Anthropocene Extinction," signifying an alarming rate of loss of species during this epoch.

Coined in 2000, the Anthropocene signifies a new geological epoch characterized by unprecedented species extinction, rivalling the catastrophic events of the past. Nestled within the broader Quaternary Period, spanning from 2.6 million years ago to the present, the Anthropocene stands as a testament to humanity's profound impact on the planet's surface, atmosphere, oceans, and nutrient cycling systems. Advocates for recognizing this epoch argue for its succession over the Holocene Epoch, which commenced around 11,700 years ago, with a suggested inception in 1950, denoting the onset of significant anthropogenic influence.

Derived from the Greek words for "recent age of man," the term Anthropocene encapsulates humanity's newfound role as a geological force. In 2002, Nobel laureate Paul Crutzen proposed the Anthropocene epoch, highlighting human domination of the environment. Recent studies indicate that Earth may have already lost 7.5% to 13% of its species, signaling a crisis.

Judging by their conscious agency, humans stand at the nexus of ecological crisis. With Earth's history spanning billions of years, punctuated by geological epochs and mass extinctions, the Anthropocene represents a pivotal moment in the planet's evolutionary trajectory. However, unlike previous epochs defined by natural phenomena, the Anthropocene is uniquely marked by human-driven environmental alterations, from habitat destruction to pollution and climate change.



Central to the Anthropocene narrative is the profound impact of human activities on biodiversity loss. Anthropogenic drivers, including habitat loss, overexploitation, pollution, and climate change, have collectively accelerated species extinction rates to unprecedented levels. The consequences reverberate across ecosystems, threatening iconic species and destabilizing delicate ecological balances. Notable examples include the passenger pigeon and the Steller's sea cow, hunted to extinction for human consumption.

Species with limited ranges and specific traits, such as large body size in mammals and dioecy in plants, face heightened extinction risks. While extinction from overexploitation often garners attention due to its rapid and direct impact, habitat change-induced extinctions unfold over prolonged periods, leaving species teetering on the brink. Beyond extinction, the Anthropocene reshapes the evolutionary landscape, with human activities influencing speciation rates and processes. Human-induced alterations to niches, contact zones, and selection pressures have profound implications for species diversification. While some species adapt to human-altered environments, others face barriers to speciation, exacerbating biodiversity loss.

However, alongside extinction, human activities have also catalyzed evolutionary processes. Hybridization events, facilitated by human-mediated introductions and habitat modifications, have led to the emergence of new species, as seen in cichlid fish populations in Lake Victoria.

In conclusion, the Anthropocene Epoch stands as a defining chapter in Earth's history, characterized by humanity's profound impact on the planet's ecosystems and biodiversity. As we confront the challenges of extinction and evolution in the Anthropocene, we must heed the call to action, embracing conservation and sustainable practices to preserve Earth's natural heritage for generations to come.

EXPANDING GLACIAL LAKES IN THE HIMALAYAS

Kasturi Datta

The Himalayan Mountains in the Indian sub-continent is also well known as the 'Third Pole' due to their extensive snow cover and large glacial deposits. Many glaciers of the Himalayas have huge moraine dammed glacial lakes that are source of numerous rivers and streams contributing to the perennial river systems of the sub-continent - the Indus, the Ganges and the Brahmaputra.

According to an Indian Space Research Organisation (ISRO) study based on satellite imageries there are 2431 large glacial lakes in the Himalayas, each measuring more than 10 hectares in area; of which 676 glacial lakes are in vegetated

located in and forests. 314 of situated in the 5,000 MSL and 5,000 MSL.

Analysis of reveals that 130 expanding at an which 65, 7 and Indus, Ganga,



zones, as these are around the alpine these lakes are range of 4, 000 to 252 lakes are above

ISRO data further glacial lakes are alarming rate, of 58 are located in the and Brahmaputra

River Basin respectively. These lakes are expanding their size mainly due to the melting of glaciers on account of global warming and climate change. Recurring seismic activities, incessant heavy rainfall and cloudbursts have also contributed to the breach of these lakes. Expansion of glacial lakes is fraught with the risks of breaches of the moraine dams leading to Glacial Lake Outburst Floods (GLOF) with disastrous consequences for the communities living in downstream locations. One such GLOFs was in Chorabari Lake in 2013 that resulted in disastrous flood in Kedarnath Shrine causing loss of more than 5000 lives.

The growing discourses on GLOFs have identified a few glacial lakes in Nepal, Bhutan, Pakistan and in the Indian States of Uttarakhand, Himachal Pradesh, Jammu & Kashmir and Sikkim that are prone to lake outburst floods. Floods of these types can be devastating to infrastructures and communities in downstream regions and also highly detrimental to the surrounding ecosystems. High volumes of water can also interrupt water discharge in rivers thus affecting the availability of water, farming, and ultimately a source of living for people who rely on water resources.

In order to reduce the risks associated with the growth of glacial lakes, there is a need to prevent the GLOFs by employing different measures. First of all, combating the primary cause of glacial melt and retreat should be addressed by employing worldwide measures aimed at controlling greenhouse effects. Secondly, the deployment of early warning systems for monitoring the glacial lakes and weather, along with warning dissemination mechanisms based on threat levels to the communities living in the vicinity of the frozen water bodies are very crucial. Third, proactive undertaking of engineering measures for reducing the volume of glacial lakes and regularly monitoring them can be effective in mitigating the risks of GLOFs. This may entail the installation of structures like spillways, drainage systems, and dams in a bid to regulate the water level and calibrated water discharge. Furthermore, measures such as afforestation, regulation of water flow in watersheds and buffer zones as well as protective measures for human settlements are also crucial for reducing the risks of GLOFs. Lastly, there is a need to engage the local communities in the risk assessment, planning, and decision-making processes to manage the glacial lakes effectively. The act of locally empowering communities on how to handle disasters through learning proper disaster response and evacuation procedures can aid the community in handling GLOFs and other calamities. Cooperation between countries on an international level that have common basins of glacier-fed rivers is also vital for steady management and minimized risks.

Therefore, efficient and effective prevention and mitigation of the growing risks of GLOFs demand a multi-sectoral effort that include climate change mitigation and adaptation, generation and dissemination of early warning system, structural and non-structural engineering interventions, development natural infrastructure for eco-system based risk reduction, engaging communities, and international partnership. There have been some initiatives on each of these measures in the countries of the region, but these are much too less than what is needed. Lots more need to be done if we have to reduce the emerging risks of GLOFs in the Himalayas.

WELCOME TO THE WORLD OF GREENWASHING: PROTECT MOTHER EARTH, SEE THROUGH THE GREEN TRICKERY

Arkadip Mondal

As a conscientious shopper navigates the store aisles, their eyes scan for products that align with their environmental values. Vibrant green packaging adorned with images of untouched forests and pristine waterfalls leaps out, promising "All-Natural" ingredients, "Earth-Friendly" practices, and a commitment to "Sustainability". A sense of satisfaction washes over the shopper – they're making a difference with their purchase...or are they? What if those leaves and feel-good words are just a disguise? Welcome to the murky world of greenwashing, where companies paint themselves a deceptive shade of so-called "greening" to cash in on our desire to make good choices.

Greenwashing is a deceptive marketing strategy where companies focus more on creating an environmentally friendly image than on actually implementing sustainable practices. According to a report by McKinsey, Generation Z is more inclined to spend money on brands perceived as ethical. Similarly, Nielsen's Global Corporate Sustainability Report found that 66% of consumers would pay more for a product from a sustainable brand, rising to 73% among millennials. This creates a financial incentive for companies to appear socially conscious, even if their actions are not genuinely sustainable. Greenwashing involves exaggerating the impact of minor eco-friendly initiatives to obscure more damaging aspects of a company's operations. It can also involve using vague terms like "natural" or "eco-conscious" to appeal to consumers without providing concrete evidence of sustainability.



To combat this deceptive practice, consumers must become better informed and vigilant. Vague, feel-good terminology should be met with scepticism, prompting deeper inquiries into a company's specific practices. Distracting imagery of green leaves, fruits, natural ingredients and other Go-green types of numbo jumbo labels on their products is irrelevant if the product and the company's overall operations are both environment and safety compromised. A single, heavily advertised sustainable initiative should trigger scrutiny, especially when a company's primary business model remains environmentally harmful. Consumers must beware of self-invented "eco-labels" or unfamiliar certifications, as these are often just tools to bolster their deceptive games.

The impact of greenwashing goes beyond deceiving consumers. It erodes public trust, making it more difficult for genuinely sustainable companies to receive recognition and support. Large-scale polluters can use greenwashing to hide their harmful practices while benefiting from the positive reputation of appearing environmentally responsible. Research and investigations have exposed the prevalence of greenwashing across various industries. For example, fast-fashion brands promoting "conscious" clothing lines still heavily rely on

polluting synthetic fibers and unsustainable production processes. Oil and gas companies often emphasize their minor investments in renewable energy while downplaying their on-going large-scale fossil fuel operations – a common greenwashing tactic. The fight against greenwashing demands that consumers become informed decision-makers, demanding transparency, seeking out reputable certifications, and thoroughly researching a company's track record. By supporting businesses that prioritize genuine sustainability, consumers send a powerful message against deceptive marketing. Let's demand genuine change, champion true sustainability, and ditch greenwashing for good.

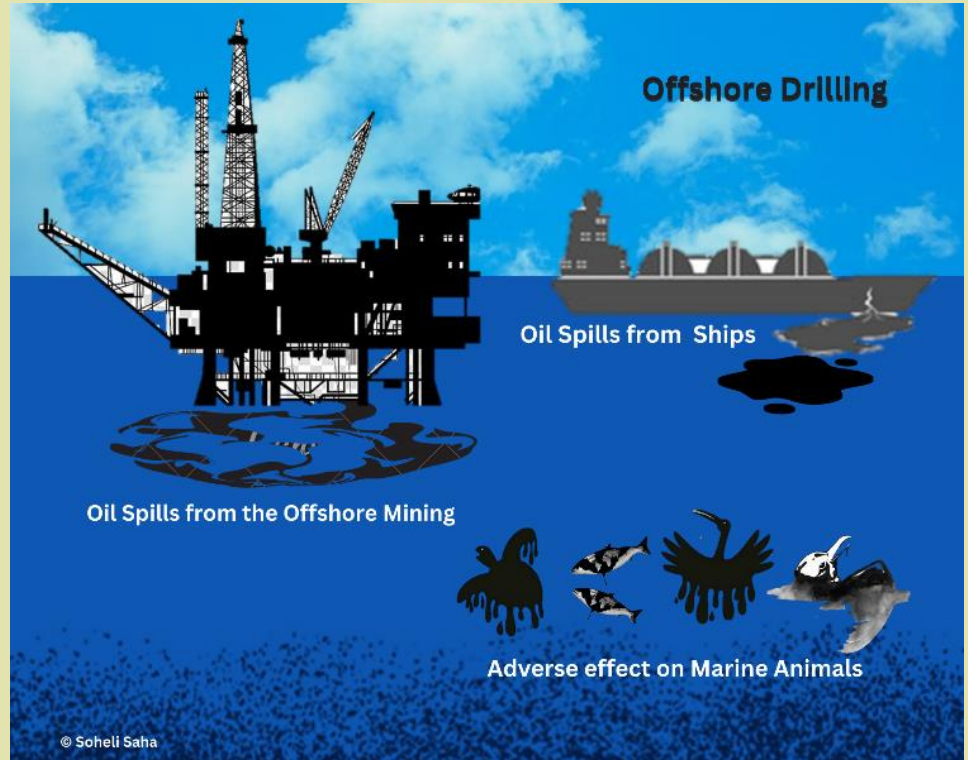


OFFSHORE DRILLING: MITIGATING ADVERSE IMPACTS ON MARINE ECOSYSTEM

Soheli Saha

Beneath the shimmering surface of our world's oceans lies a treasure trove of resources fuelling economies and societies worldwide. Yet, the pursuit of these underwater riches—primarily through offshore drilling—has sparked an ongoing battle between economic prosperity and environmental preservation. Offshore drilling operations, from exploratory surveys to the extraction process, can profoundly impact marine environments. One of the primary concerns with offshore drilling is the risk of oil spills. Even with rigorous safety protocols, the potential for catastrophic spills remains, as seen with disasters like the Deepwater Horizon spill (2010), off the coast of the United States in the Gulf of Mexico, estimated to have injured or killed over 25,000 whales and dolphins, as well as 80,000 birds, "tens of thousands" of sea turtles, and an unknown quantity of fish and shellfish.

Oil spills can have devastating effects on coastal habitats, and disrupt delicate food webs, coating wildlife in thick crude and poisoning marine life. The long-term impacts on ecosystems can be severe and difficult to fully remediate. Furthermore, pollutants may be introduced into the marine environment by the offshore platform's discharge of drilling muds, generated waters, and other waste streams. These waste streams may contain heavy metals, chemicals, and other contaminants that can bioaccumulate in the food web and have cascading impacts on ecosystems. Marine life can be displaced or disturbed by the physical infrastructure of platforms, pipelines, and support vessels. Additionally detrimental to animals that depend on sound for communication and navigation is underwater noise from seismic surveys and drilling.



Regulatory agencies and industry groups have developed best practices to address these impacts. This includes conducting environmental assessments, implementing noise-reduction measures, and carefully managing waste discharges. By means of stringent rules, cutting-edge technologies, and interdisciplinary cooperation, can endeavour to achieve a cautious equilibrium between the energy requirements and the conservation of our invaluable marine habitats. Before drilling begins, operators must also have comprehensive environmental impact studies completed and contingency plans ready. Mitigation strategies include ramp-up processes and acoustic monitoring can protect marine mammals and other vulnerable species from harm. To reduce these concerns, strict waste management and treatment procedures are necessary, as is routine environmental monitoring.

Looking to the future, the transition towards renewable energy sources will be crucial in reducing the long-term environmental impacts of offshore drilling. To guarantee that any offshore drilling operations are carried out in the most environmentally responsible way feasible in the interim, industry regulators, and environmental stakeholders must cooperate. Companies are also looking into more environmentally friendly technology, such as subsea production systems, to lessen their physical footprint, employ predictive analytics and real-time monitoring to optimize drilling operations, and can use data from sensors and other sources to better anticipate and adapt with the changing conditions. By striking a balance between resource extraction and environmental stewardship, we can ensure the long-term viability of both our energy supplies and our oceans. The road ahead requires concerted efforts from industry leaders, policymakers, scientists, and communities. Together, can pave the way for a future where offshore drilling coexists harmoniously with a thriving, resilient marine ecology.

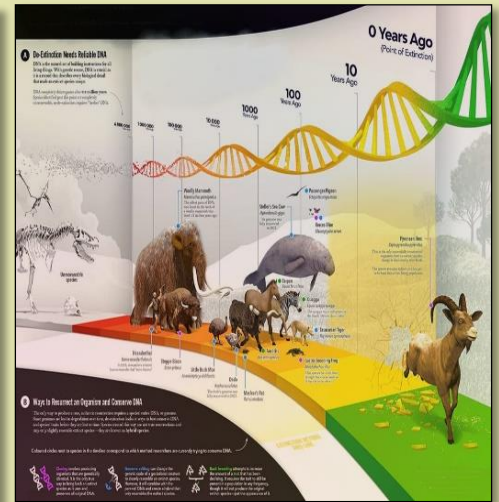
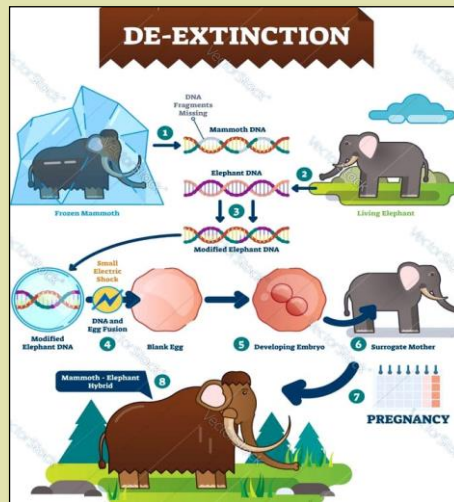
DE-EXTINCTION: CAN WE BRING BACK EXTINCT SPECIES?

Shreya Mitra

"We should focus on preserving what we have left rather than trying to bring back what we've lost" — Hendrik Poinar (evolutionary geneticist)

De-extinction, the process of reviving extinct species, is a fascinating and controversial scientific endeavour. It leverages advancements in genetics, biotechnology, and cloning to bring back species that have vanished from Earth. While it captures the imagination of scientists and the public alike, it raises significant ethical, ecological, and practical questions.

The primary methods of de-extinction include cloning, selective breeding, and genetic engineering. Cloning involves creating a genetically identical copy of an organism, as demonstrated by Dolly the sheep. Selective breeding aims to produce an organism with traits of extinct species over multiple generations. Genetic engineering, particularly through CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats) technology, allows for precise gene editing to resurrect characteristics of extinct species.



De-Extinction Process & Extinct Species with their names

Re-introducing extinct animals into their original ecosystems can potentially bridge gaps in our understanding of evolution and restore balance in the food chain. This process offers several advantages for research and ecosystem restoration, as the extinction of one species affects all members of the food chain, including plants and animals. For example, re-introducing a woolly mammoth-like animal could help repopulate tundra regions, regrow ancient plains, and potentially slow the melting of ice caps. However, de-extinction can also negatively impact existing species and ecosystems. It may lead to competition for food, the extinction of prey, and other environmental changes. The process is expensive, challenging, and difficult to implement in already damaged ecosystems. Additionally, re-introducing a species may not yield positive environmental benefits, and the species may not fulfill the same role in the food chain as it once did. Despite these challenges, de-extinction research continues to advance, driven by technological progress and a desire to correct past ecological wrongs. It also opens avenues for broader scientific inquiry, potentially offering insights into genetics, evolution, and conservation biology.

De-extinction is a complex scientific process aimed at bringing extinct species back to life. Some prominent candidates include the *Woolly Mammoth*, which could be re-introduced to Arctic tundra regions to maintain ecosystems and combat climate change. The *Passenger Pigeon*, another species, could be recreated by editing its genome. The *Pyrenean Ibex* could be cloned from preserved tissues, while the *Tasmanian Tiger* could be recreated using genetic material from preserved specimens. The *Aurochs*, an extinct wild ancestor of domestic cattle, could be back-bred to restore European forests and grasslands. The *Heath Hen*, another species, could be revived using its DNA from its closest relatives, such as the *Prairie Chicken*. These projects combine advanced genetic techniques and raise ethical, ecological, and technical challenges. In conclusion, while de-extinction is a remarkable scientific possibility, it is not without its controversies and hurdles. The future of bringing back extinct species hinges on careful consideration of ecological impacts, ethical implications, and practical feasibility. As the technology progresses, society will need to weigh the potential benefits against the risks to determine whether the revival of extinct species is a goal worth pursuing.

EVERY ACTION COUNTS: INDIVIDUAL STEPS TOWARDS A GREENER PLANET

Sangita Saha

In an era where the ramifications of climate change and environmental degradation are more evident than ever, the adage "every action counts" takes on profound significance. The collective impact of individual efforts towards a greener planet cannot be overstated. While systemic changes and governmental policies are crucial, personal responsibility and everyday actions play a vital role in steering us towards a sustainable future.

One of the simplest yet most effective ways individuals can contribute to a greener planet is by reducing waste. This can be achieved through the three R's: 'reduce', 'reuse', and 'recycle'. By being mindful of our consumption and opting for products with minimal packaging, we can significantly cut down on the waste we generate. Reusing items, whether through upcycling old furniture or repurposing containers, not only reduces waste but also curtails the demand for new products, which in turn lowers the carbon footprint associated with manufacturing. Recycling, though widely practiced, still needs improvement in terms of proper sorting and adherence to local recycling guidelines to maximize its effectiveness.

Conserving energy is another critical area where individual actions can make a substantial difference. Simple habits such as turning off lights when not in use, using energy-efficient appliances, and setting thermostats to eco-friendly settings can lead to significant energy savings. Additionally, individuals can invest in renewable energy sources, such as installing solar panels on their homes. While the initial investment may be considerable, the long-term benefits, both environmentally and financially, are substantial.

Water conservation is equally important in the quest for a greener planet. Simple measures like fixing leaks, using water-saving fixtures, and reducing water usage in daily activities (e.g., taking shorter showers, running dishwashers only when full) can greatly reduce water wastage. Moreover, adopting sustainable gardening practices, such as xeriscaping or using rain barrels, can further contribute to water conservation efforts.

Dietary choices also have a significant impact on the environment. Reducing meat consumption, for instance, can lower one's carbon footprint since livestock farming is a major contributor to greenhouse gas emissions. Embracing a plant-based diet, even partially, and choosing locally-sourced, organic produce can promote sustainable agricultural practices and reduce the environmental impact of food production and transportation.

Transportation is another area where individual choices matter. Opting for public transportation, carpooling, biking, or walking instead of driving alone can significantly reduce greenhouse gas emissions. For those who must drive, choosing fuel-efficient or electric vehicles can make a substantial difference.

Supporting sustainable products and businesses is a powerful way for individuals to influence the market. By choosing products made from sustainable materials and supporting companies that prioritize environmental responsibility, consumers can drive demand for greener alternatives. This, in turn, encourages more businesses to adopt sustainable practices, creating a positive feedback loop that benefits the planet.

Finally, spreading awareness and educating others about the importance of environmental stewardship can amplify the impact of individual actions. In conclusion, while the challenges facing our planet are daunting, the cumulative effect of individual actions can lead to significant positive change. By adopting sustainable practices in our daily lives, we not only reduce our own environmental impact but also inspire and enable others to do the same. Every action, no matter how small, contributes to a collective effort that can drive the world towards a greener, more sustainable future. Indeed, every action counts.



GREEN BUDGETING: INITIATIVE BY PUDUCHERRY

Ashmita Rakshit

Achieving sustainable development goals (SDGs) and addressing climate change, biodiversity loss, and environmental degradation require collaborative strategic planning, cohesive policies, robust institutions, and organized financial allocations. Integrating climate and environmental considerations into annual government budgets can mainstream SDGs and climate actions into development efforts, aiding in the evaluation of governmental environmental commitments. 'Green budgeting' is a policy tool that identifies and monitors funding sources, expenditures, and policies, supporting coherent policy design and financial planning for green goals, especially climate and environmental objectives. Through proactive planning and reflection, departments can realign their objectives, programs, and policies to better incorporate environmental and climate considerations.

In its annual budget session for 2023-24, the Government of Puducherry has introduced a green budget in collaboration with The Energy and Resources Institute (TERI) and the Department of Science, Technology, and Environment. This initiative involved a comprehensive evaluation of the annual budget in consultation with various departments of the Puducherry government. Puducherry, as a Union Territory, receives funding from the Central Government through various

channels, including Central Assistance, Centrally Sponsored Schemes, CRF, and Loans. Notably, Puducherry is the only UT with a legislature that has a separate public account. Internally, the UT manages its funding and budget allocation through its own resources such as tax and non-tax receipts, grants from centrally sponsored schemes, and borrowing from the open market and central financial institutions. The total budget estimate for Puducherry for the current financial year 2023-24 is INR 11,600 crore, with a focus on identifying green allocations within this

Pillar	Outcome
Pillar 1: Integrating environmental sustainability	Encouraging innovation within current schemes while staying within the available budget.
Pillar 2: Allocating resources for sustainability	Boosting funds dedicated to environmental sustainability within the existing budget.
Pillar 3: Planning and coordination for sustainability	Incorporating and planning for environmental sustainability within current schemes.
Pillar 4: Monitoring and evaluation	Assessing performance in achieving long-term SDG targets related to the environment.
Pillar 5: Ensuring transparency and accountability	Providing public access to information on environmental sustainability initiatives.
Pillar 6: Policy signals for greening initiatives	Influencing the attitudes of key stakeholders, including government, civil society, and businesses towards sustainability.

Table: Pillars and Outcome of Green budgeting

budget as a proportion of total expenditure increased from 1.66% to 4.17%. The number of departments identifying green components also rose, from 9 to 15.

It is important to note that green budgeting has limitations as an accounting tool, as it currently focuses only on positive environmental expenditures and does not assess their effectiveness. However, it has the potential to integrate various work streams related to climate change, biodiversity, sustainable energy, and more, and can facilitate implementation and coordination of policies at different levels. Additionally, it can help fulfil international reporting obligations and provide feedback on existing initiatives.

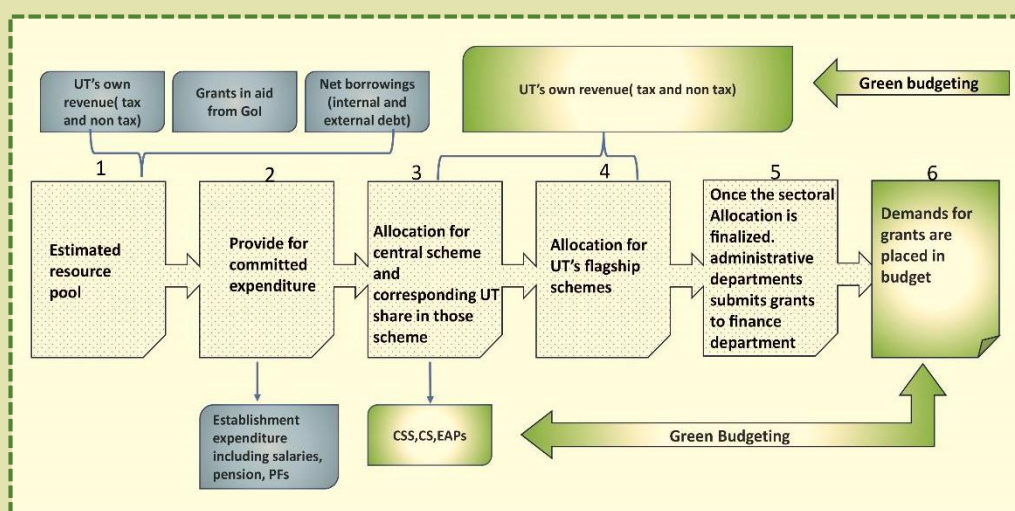


Figure: Framework of Green Budgeting

expenditure. This strategic approach aims to optimize activities and budget allocations towards greener initiatives, addressing environmental and climatic challenges, sustaining resources, and developing clean energy sources.

The Government of Puducherry saw a significant 153% increase in its green budget, from INR191 crore to INR483 crore in FY 2023-24. The percentage of the green budget allocated to identified schemes rose from 7.78% to 16.42%. Additionally, the green

FROM EMISSIONS TO SOLUTIONS: ROLE OF CARBON CAPTURE AND STORAGE TECHNOLOGIES

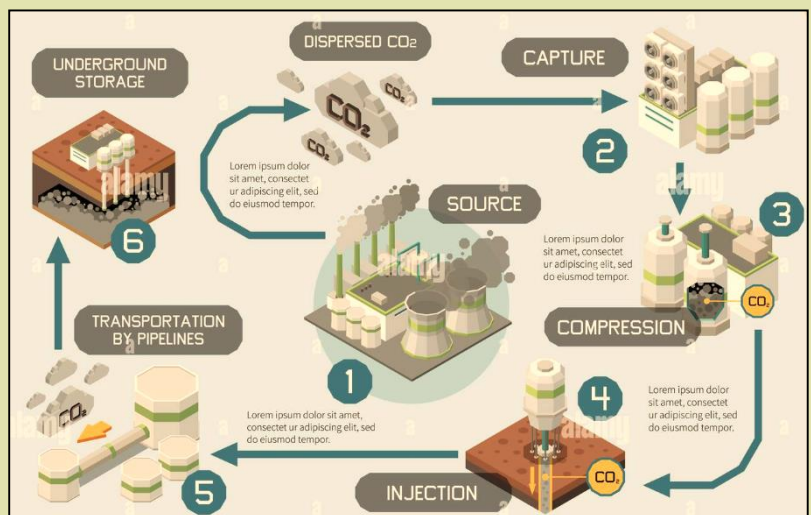
Sanchari Roy

Global climate change is a critical environmental issue driven by human activities like fossil fuel burning, industrial processes, and land use changes, resulting in high concentration carbon dioxide (CO₂) emissions in the atmosphere. Understanding CO₂ emissions involves an equation linking energy consumption, GDP, and emissions:

$$\text{CO}_2 \text{ Emissions} = (\text{Energy Consumption} / \text{Unit GDP}) \times (\text{CO}_2 \text{ Emissions} / \text{Unit Energy Consumption})$$

Policies target energy and carbon intensity through efficiency improvements and transitioning to low-carbon fuels and renewables. Carbon capture and storage (CCS) reduces carbon intensity by capturing and storing CO₂ from industrial processes and flue gases.

CCS involves isolating, compressing, and transporting CO₂ to storage sites for sequestration, with bioenergy with carbon capture and storage (BECCS) gradually reducing atmospheric CO₂ levels. CCS and carbon capture, utilization, and storage (CCUS) are used interchangeably, with CCUS repurposing captured carbon. CO₂ capture is most cost-effective at large industrial sites, utilizing methods like post-combustion capture, pre-combustion capture, and oxy-fuel combustion. Permanent CO₂ storage methods include gaseous storage (in deep saline formations and exhausted gas fields) and solid storage (reacting CO₂ with metal oxides producing stable carbonates). Geo-sequestration involves injecting supercritical CO₂ into geological formations such as oil fields, gas fields, saline formations, unmineable coal seams, and basalt formations. Physical (caprock) and geochemical trapping mechanisms prevent CO₂ from escaping. Unmineable coal seams can store CO₂ and release methane (enhanced coal bed methane recovery), which offsets costs but produces more CO₂ when burned. Saline formations offer large storage potential but are less understood and lack cost-offsetting side products. Trapping mechanisms like structural, residual, solubility, and mineral trapping reduce leakage risks.



CCS is crucial for mitigating climate change by capturing CO₂ emissions from power plants and industrial sources, reducing greenhouse gases and helping meet international climate goals like the Paris Agreement. CCS supports the renewable energy transition by lowering the carbon footprint of fossil fuels and providing backup when renewable generation is low, ensuring a stable energy supply. CCS also reduces emissions from hard-to-decarbonize industries like cement, steel, and chemicals. It captures and stores CO₂, significantly lowering industrial carbon footprints. Additionally, the utilization aspect (CCUS) turns captured CO₂ into valuable resources for oil recovery, synthetic fuels, and consumer goods, creating economic opportunities while managing emissions.

Challenges to adopting CCS technologies include high costs and energy requirements for capture, compression, and storage. The need for substantial infrastructure investments in pipelines and storage facilities adds to the financial burden. Regulatory and policy uncertainties hinder large-scale deployment. Technical issues, such as potential leakage from storage sites and impurities in CO₂ streams causing corrosion, pose risks. Public perception and opposition, as seen with the cancelled Navigator Heartland Greenway project, also impede progress. Moreover, limited knowledge about long-term storage impacts and the scalability of CCS in diverse geologic formations further complicate widespread adoption.

Future prospects for CCS technologies are promising, with innovations like Direct Air Capture (DAC) leading the way. DAC captures CO₂ directly from the atmosphere, offering flexibility and scalability. Advances in materials and processes aim to reduce costs and improve efficiency. Integrating CCS with renewable energy sources and utilizing captured CO₂ in products like fuels and building materials are emerging trends. Enhanced storage techniques and expanded infrastructure investments will further boost CCS's role in achieving global climate goals.

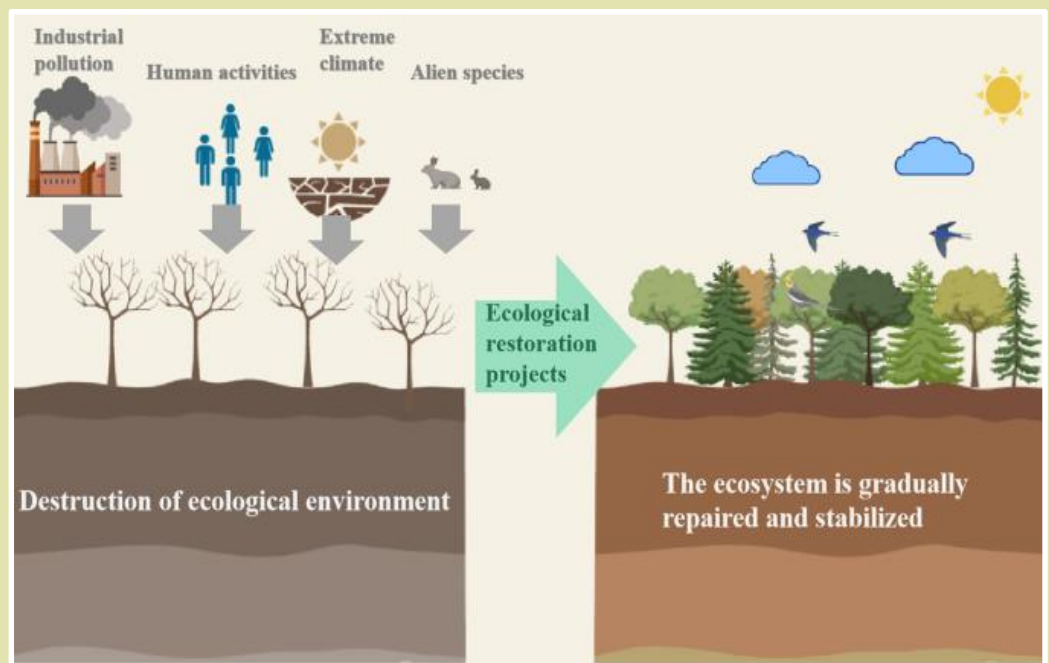
ECOLOGICAL RESTORATION: CHALLENGES AND POSSIBILITIES

Sravana Chanda

Humanity has surpassed six of the nine "planetary boundaries" that delineate the safe operating space for our civilization's development. As human activities increasingly pressure natural systems, protecting our ecosystems and the services they provide becomes imperative. Conservation efforts must extend beyond safeguarding remaining habitats to encompass the global restoration of areas degraded by land use change, pollution, and overexploitation. Governments worldwide have acknowledged the urgency of this task, inaugurating the UN Decade on Ecosystem Restoration in 2021 and pledging to undertake large-scale restoration initiatives.

Ecological restoration is a vital process aimed at repairing and rejuvenating ecosystems damaged or degraded by human activities. This involves a range of activities, from re-establishing native vegetation to reintroducing endangered species. While the objective of ecological restoration is clear—to enhance ecosystem health and sustainability—achieving this goal is often beset by challenges and uncertainties. One key challenge is implementing restoration initiatives on a scale sufficient to halt and reverse net losses of forests, grasslands, wetlands, mangroves, and other habitats. Another challenge is ensuring the full engagement of local stakeholders in these large-scale restoration efforts. The complexity of natural ecosystems presents another formidable challenge. Ecosystems comprise numerous interconnected components, and reconstructing or repairing these intricate systems is no easy task. Different species interact in complex ways, and efforts to restore one part of an ecosystem can lead to unforeseen consequences elsewhere. Invasive species pose a constant threat to restoration efforts. They can rapidly colonize restored ecosystems, outcompete native species, and impede restoration progress. Managing invasive species is an on-going battle in ecological recovery, requiring continuous monitoring and intervention. Funding presents yet another major challenge in ecological restoration. The process is costly and time-intensive, and funding is often limited. Securing long-term financing for restoration projects can be challenging, particularly since tangible results may not be evident for many years.

Despite the challenges, there are exciting opportunities in the field of ecological restoration. Technological advancements and scientific knowledge have opened up new possibilities for more effective ecosystem restoration. For instance, the use of drone technology enables monitoring of restoration progress on a large scale, facilitating quicker responses to potential issues. Community participation is another significant opportunity in ecological restoration. Involving local communities in restoration efforts can

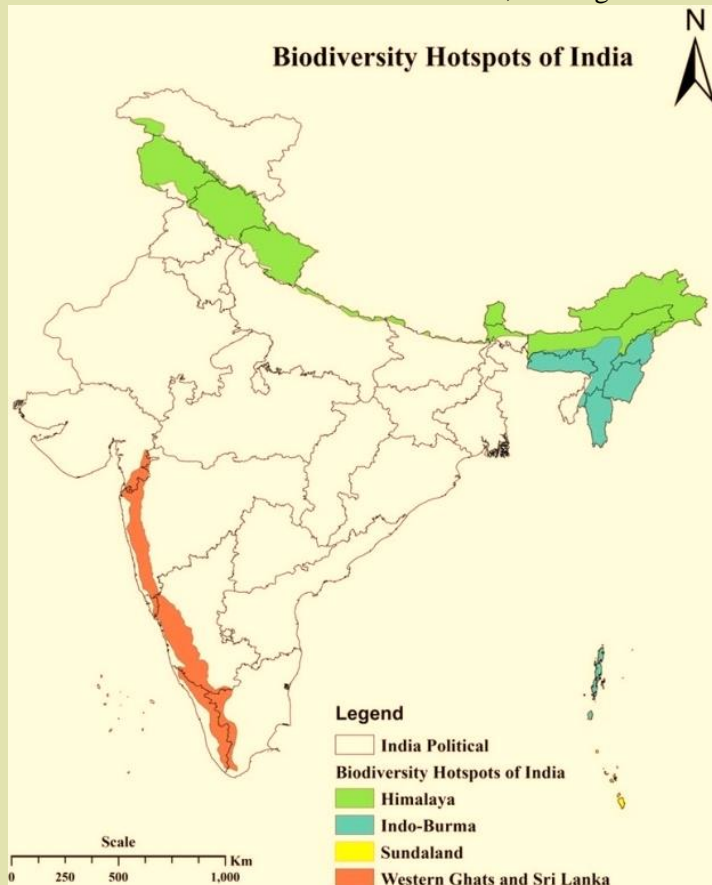


help garner support for conservation initiatives and ensure the long-term success of projects. Local knowledge and expertise are also invaluable when planning and implementing restoration projects. Restoration efforts can vary widely in scale, from small-scale projects involving a few individuals to large government-led programs with thousands of participants. They can be well-funded or modestly resourced, and they can focus on rapidly restorable ecosystems or those requiring centuries for ecological recovery. Regardless of the scale or scope, ecological restoration enhances biodiversity in degraded landscapes, boosts populations and distributions of rare and endangered species, improves landscape connectivity, increases the availability of environmental goods and services, and contributes to enhancing human well-being. Ecological restoration is a complex yet crucial endeavour. As human activities continue to impact the environment, the restoration of damaged ecosystems becomes increasingly imperative. By addressing the challenges and seizing the opportunities presented by ecological restoration, we can strive towards a more sustainable future for both humanity and the planet.

CONSERVING BIO DIVERSITY HOTSPOT OF INDIA: CHALLENGES AND OPPORTUNITIES

Ashis Sarkar

India's biodiversity hotspots, such as the Western Ghats, Eastern Himalayas, and Indo-Burma region, are facing significant threats like habitat destruction, climate change, pollution, and invasive species. Additionally, overexploitation, human-wildlife conflict, weak enforcement of conservation laws, and economic pressures are further endangering biodiversity. However, there are numerous opportunities for conservation. Expanding protected areas, involving local communities, and promoting sustainable practices are vital. Reforestation, scientific research, and eco-tourism can also play crucial roles. Strengthening conservation laws, increasing public education, and fostering international cooperation are essential steps. Advanced technologies for monitoring and protecting biodiversity are also crucial. By addressing these challenges, India can ensure the preservation of its natural heritage for future generations. Climate change and human disturbance are major drivers of forest destruction and species extinction. The Western Ghats have the highest human population density among global biodiversity hotspots, with over 300 persons per square kilometer. The Himalayas experience a regional rate of climate warming that exceeds global averages, potentially leading to the extinction of native flora. In the Indo-Burma region, high levels of forest fragmentation are prevalent. Extreme events, such as the Indian Ocean tsunami, have caused significant loss of forest cover in the Andaman and Nicobar Islands, making them vulnerable to threats like invasive species, forest fires, and droughts.



India's biodiversity hotspots cover a significant portion (16.86%) of the total global area designated as biodiversity hotspots. Within India's political boundaries, the Western Ghats account for 64.95% of these areas, the Indo-Burma region for 5.13%, the Himalayas for 44.37%, and Sundaland for 1.28%. However, the proportion of protected areas in most of these hotspots is less than 17%, which falls short of the Aichi targets set by the Convention on Biological Diversity in 2010.

Prehistoric extinctions occurred during various periods, such as the Ordovician-Silurian Extinction (443 million years ago), the Late Devonian Extinction (375-359 million years ago), the Permian-Triassic Extinction (252 million years ago), the Triassic-Jurassic Extinction (201 million years ago), and the Cretaceous-Paleogene Extinction (66 million years ago), with causes ranging from ice ages and sea level changes to climate shifts and asteroid impacts. In more recent times, species like the dodo, passenger pigeon, and Tasmanian tiger have become extinct. The dodo, native to Mauritius, was driven to extinction by hunting and introduced species, while the once-abundant passenger pigeon in North America

succumbed to overhunting. Modern extinctions are primarily caused by habitat destruction, climate change, pollution, overexploitation, and invasive species. Activities such as deforestation, urbanization, agriculture, and unsustainable hunting and fishing practices drastically reduce species populations, while non-native species often outcompete or introduce diseases to native species, further exacerbating biodiversity loss.

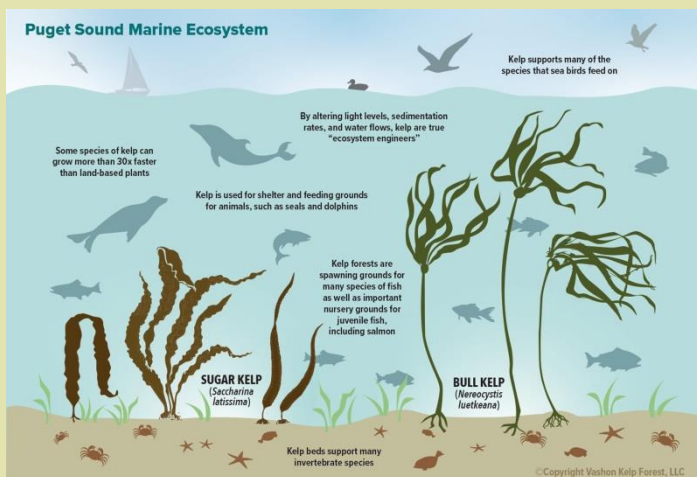
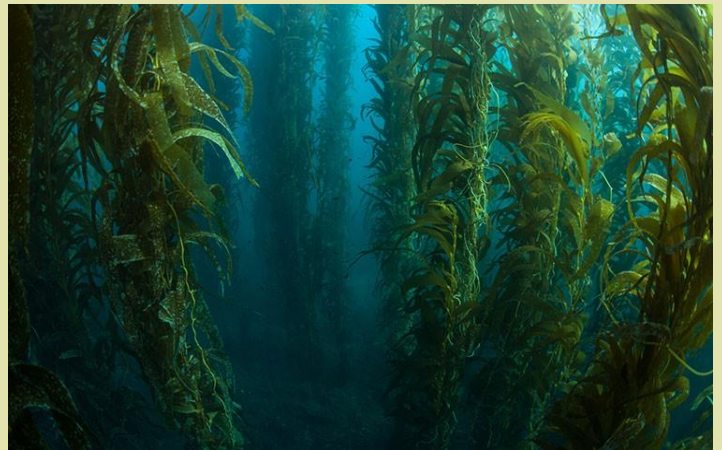
The Government of India has implemented several programs to conserve its biodiversity hotspots, including the Western Ghats, Eastern Himalayas, and Indo-Burma region. Key initiatives include the National Biodiversity Action Plan (NBAP) for strategic biodiversity conservation, the Green India Mission (GIM) for forest and ecosystem restoration, and flagship programs like Project Tiger and Project Elephant for species-specific conservation. Additionally, the Integrated Development of Wildlife Habitats (IDWH) and the designation of Eco-Sensitive Zones (ESZ) help protect critical habitats. These efforts, combined with community involvement and sustainable practices, aim to preserve India's rich biodiversity for future generations.

SEAWEED: A MARINE ALLY OR ECOLOGICAL THREAT?

Akash Chakraborty

Seaweed is the common name for a variety of different species of marine plants and algae that grow in the ocean and places like rivers, lakes, and other bodies of water. They are also known as Macro algae and include thousands of species of macroscopic, multicellular, marine algae. It is classified into brown, red, and green types. In nature there are some seaweeds that are microscopic and are important for food chain and there are some types of seaweed that are much larger, like the giant sea kelp and can form a forest known as kelp forests.

Kelp forest are important for ecology and are among the most diverse and productive ecosystems in the world as it provides habitat for a wide variety of marine creatures, and can mitigate global warming through sequestering carbon and buried in seafloor sediments and stored for centuries. But recently due to high CO₂ absorption by the ocean, sea water is becoming acidic that resulting in the decreasing of kelp forests and decreasing kelp can resulted in coastal erosion because they break the flow of sea waves, and this helps to prevent coastal erosion. Marine creatures, such as fish, that depend on seaweed forests for habitat are also at risk.



Today, kelp forests can be seen in approximately 25%-30% of the world's coastlines. As the largest marine biome, they cover 1.5 to 2 million square kilometers, which is 5 to 10 times more ocean area than coral reefs. Seaweeds have suffered widespread losses across much of their range, at a global rate of decline of 1.8 percent per year. The trajectories of change across regions are variable, because of the variety of factors affecting seaweed ecosystems. Over the past 50 years, 40%-60% of kelp forests have been degraded, with climate change, poor water quality and overfishing being the prominent causes. Human activities threaten natural seaweed ecosystems through Mechanical dredging of kelp that destroys the resource and fisheries. Also, a disease in

predators of purple urchins has caused an urchin population surge, destroying large kelp forests off California's coast.

Humans have cultivated seaweeds for centuries. Recently, seaweed farming has become a global agricultural practice. It is a great step towards mitigating climate change but sometime it can introduce Non-native seaweed species that can out-compete local marine flora, disrupting existing ecosystems. Farming also cause excessive nutrient pollution can lead to seaweed blooms, these can block sunlight, alter habitat and their decomposition can lower oxygen concentrations, and create "dead zones" where marine life is unable to live. Some seaweeds can release toxins that have potential to increase toxicity in nearby ecosystem.

According to a report *Into The Blue* by UNEP, "The removal of kelp in both California and Australia resulted in a reduction in species richness of around 30%". Seaweed ecosystems are vital to marine biodiversity and coastal stability, yet they face numerous threats from human activities and environmental changes. Protecting and sustainably managing these ecosystems is important for maintaining their ecological functions and benefits.



HOW GREEN BUILDING TECHNOLOGIES CAN IMPROVE URBAN ENVIRONMENT

Riyanka Das

Green building strategies offer a ground-breaking approach to urban development by focusing on sustainability and enhancing the quality of life in urban areas. The concept of Green Building focuses on improving efficiency in building activities by optimizing the use of resources such as energy, waste, and materials. Its objective is to minimize the negative impact of buildings on the environment and human health through sustainable sites, architecture, and development, as well as integrating energy conservation. This approach is crucial in combating global warming and reducing carbon emissions. Several case studies have been conducted to generalize and apply these principles to various investigations. The process emphasizes the tangible and intangible advantages achieved through a holistic and integrated approach, revolutionizing the practice of building construction. Although a Green Building may appear similar to any other building in an urban area, its distinguishing factor lies in its approach, which prioritizes the preservation of natural resources, human comfort, safety, and productivity. This approach reduces operating costs such as energy and water consumption and offers numerous intangible benefits.

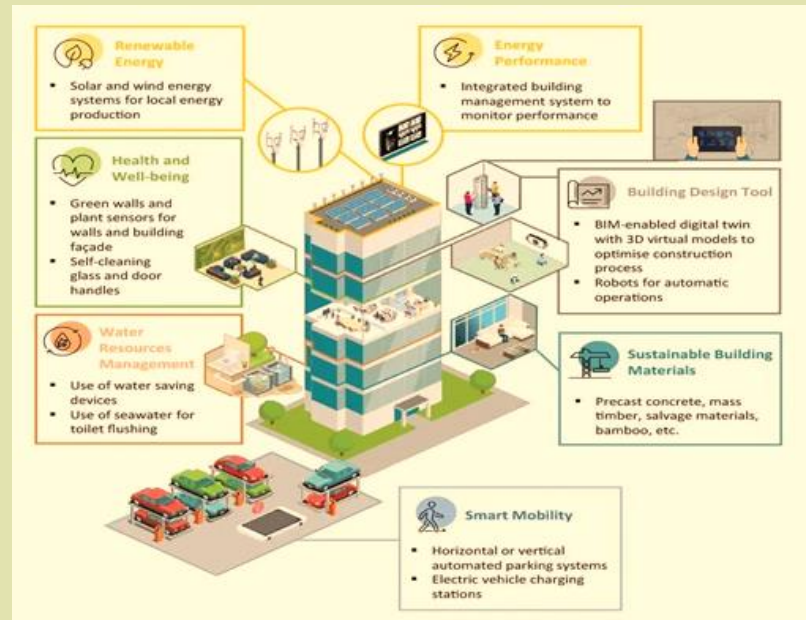
Key features include:

- Minimize impact on landscapes and site conditions by using recycled and eco-friendly construction materials.
- Reduce disruption to natural surroundings and site conditions by incorporating non-toxic and recyclable building materials.
- Maximize water efficiency and implement water recycling techniques.
- Incorporate energy-efficient and environmentally friendly equipment.
- Harness renewable energy sources.
- Ensure optimal indoor air quality for human safety and comfort.

Integrated approach for selection:

- **Interior Impact:** The color of glazing significantly affects how interior finishes appear in areas lit by daylight. It also impacts the view and the connection between occupants and the outdoor environment. Glazing with lower light transmission can make interiors feel dim on overcast days but can help control glare on sunny days.
- **HVAC Efficiency:** Choosing high-performance glazing can lower annual energy consumption, peak loads, fluctuations in individual zones, and occupant complaints. It can also provide an opportunity to downsize HVAC equipment.
- **Cost-Effectiveness:** Although high-performance glazing may have a higher initial cost compared to standard alternatives, they can potentially pay for themselves through reduced energy bills, lower mechanical equipment costs, increased occupant productivity, and by avoiding future retrofit expenses due to unforeseen issues with occupants.

Implementing Effective Controls and Building Management Systems, the building design, construction, and operation industry has a significant environmental impact. In India, buildings consume more than 20% of the electricity annually. This development leads to a shift in land usage from natural habitats to hard surfaces that lack biodiversity. Given the extensive influence of the built environment, it is crucial to take action to reduce its impact. Implementing green building practices can effectively minimize or eliminate negative environmental effects and improve unsustainable design, construction, and operational practices. Additionally, incorporating green design measures not only reduces operating costs but also enhances the marketability of buildings, increases worker productivity, and mitigates potential liability arising from indoor air quality issues. In the broader context of urban planning, green buildings are a crucial component of sustainable cities. They contribute to the creation of resilient urban areas that can better withstand environmental stresses and adapt to changing conditions. By fostering a culture of sustainability and innovation, green buildings can inspire further advancements in green technology and practices, paving the way for a more sustainable future. As urban populations continue to grow, the importance of green buildings in improving urban environmental conditions cannot be overstated. They represent a critical step towards achieving a balance between development and environmental stewardship, ensuring that cities remain livable, resilient, and vibrant for future generations.



URBANIZATION WITHOUT ENVIRONMENTAL DEGRADATION

Ditsa Maity

According to the United Nations, 55% of the world's population of 8.1 billion currently lives in urban areas. However, this proportion is expected to increase significantly by 2050, reaching 68%, adding another 2.5 billion population in urban areas. The majority of future urban population growth will be highly concentrated in a few countries. India, China, and Nigeria are expected to account for 35% of the projected increase in the world's urban population.

The massive influx of people from the rural to urban areas in these and other countries of Asia and Africa will put lot of stress on the existing infrastructure and resources of these cities, like housing, transport, water, drainage, sanitation, health care, education, recreation etc. Natural resources like clean air, water, green covers etc. are severely stressed in many cities. Most of the growing cities are facing acute air pollution, exceeding all limits safe air quality indexes. Providing adequate clean water for drinking, cooking, washing and other domestic purposes at affordable rate are challenging for many cities. As cities are expanding both vertically and horizontally, concrete jungles are replacing green areas, accentuating urban heat island effects during changing climates. Urban wetlands, lakes and other water bodies that provided water, absorbed excess rain water and reduced heat island effect besides providing areas for recreation and sports have been encroached in many cities to create space for real estate development. This has aggravated the water crisis and enhanced the risks of flooding in many cities.



In addition, environmental stresses brought about by urbanization include septic tanks and leaking sewage pipes, which exacerbate organic and nutrient pollution in surface and ground water resources. Urbanization breaks up and fragments existing ecosystems while also changing the surrounding environment. The development communities and current international agendas acknowledge the importance that cities and urbanization play in sustainable development. Making cities and human settlements inclusive, safe, resilient, and sustainable is the goal of SDG 11, which focuses on sustainable cities and communities. The 16 additional Sustainable Development Goals are also connected directly or indirectly to urban challenges. Massive transformation of cities are required to make them sustainable. Here are some of the strategic tools and techniques that can be adopted to make the cities environmentally sustainable:

- a) **Compact Cities:** Compact cities enables higher use intensities of existing space, and prevents growth of urban sprawl. This opens up space for environment friendly activities like walking, bicycling, active transportation, and public transportation, and lowers the amount of energy used for transportation per person.
- b) **Biophilia and Biophilic Cities:** According to E. O. Wilson's notion of biophilia, humans have an innate inclination towards taking care of nature. Parks, green spaces, and green networks are examples of how biophilic communities integrate nature and promote sustainable habitats.
- c) **Sustainable Corridors:** Sustainable urban corridors link cities effectively and lessen the need for wasteful movement of goods and automobiles. In addition these connect communities and protect biodiversity.
- d) **High Performance Buildings:** By utilizing natural or energy-efficient lighting, enhancing indoor air quality, and utilizing environmentally friendly materials, high performance buildings seek to reduce their negative effects on the environment and maximize energy savings. These structures reduce externalized costs, boost productivity, and provide advantages to the occupants.
- e) **High Performance Infrastructure:** High performance infrastructure combines multiple purposes in a single project, thereby enhancing internal rate of return, lowering operation and maintenance expenses, reducing per unit consumption of energy, and creating opportunities of collateral public health, financial, and environmental benefits, which make the infrastructures viable and sustainable.

INNOVATIVE STRATEGIES FOR COMBATING THE EMERGING GLOBAL WATER CRISIS

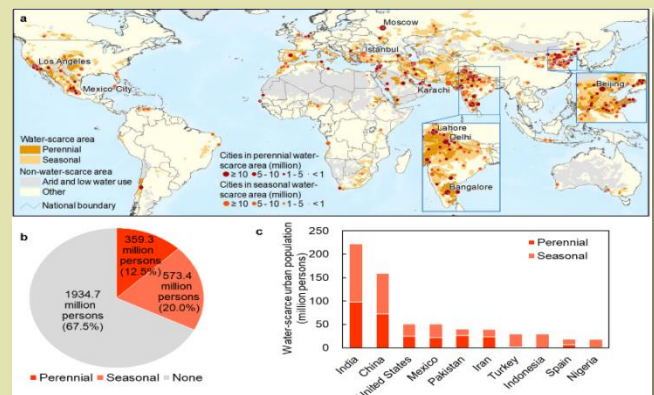
Sneha Mistri

The emerging global water crisis is one of the most pressing challenges of our time. With climate change, population growth, and unsustainable water practices exacerbating water scarcity, innovative strategies are essential for ensuring water security for future generations. Here, several cutting-edge approaches that are being implemented to tackle this crisis are explored.

Desalination, the process of removing salt and other impurities from seawater, is becoming increasingly vital in regions with limited freshwater resources. Traditional desalination methods, such as reverse osmosis, are energy-intensive and expensive. However, recent advancements are making this technology more viable. For instance, solar-powered desalination plants utilize renewable energy to reduce costs and carbon footprints. Additionally, graphene-based membranes, which offer higher efficiency and lower energy consumption, are emerging as a promising alternative to a more sustainable and cost-effective solution for water-scarce regions.

Recycling wastewater is another crucial strategy in addressing water scarcity. Advanced treatment processes can convert wastewater into potable water, reducing the demand for freshwater resources. Technologies like membrane bioreactors and advanced oxidation processes are enhancing the efficiency and safety of wastewater treatment. Cities like Singapore and Orange County, California, have implemented large-scale wastewater recycling programs, proving that treated wastewater can be a reliable and safe source of water for both industrial and domestic use. These programs not only conserve water but also mitigate environmental pollution.

Agriculture accounts for approximately 70% of global freshwater use. Therefore, improving water use efficiency in agriculture is critical. **Precision agriculture** employs technology such as satellite imaging, soil moisture sensors, and data analytics to optimize water usage. By precisely determining the water needs of crops, farmers can reduce water waste and enhance crop yields. Additionally, the integration of **Internet of Things (IoT) technology** into water management systems is revolutionizing how water resources are monitored and managed. Smart meters, sensors, and data analytics enable real-time monitoring of water usage, leak detection, and system optimization. These systems provide valuable insights into water consumption patterns and infrastructure health, allowing for timely interventions and efficient resource allocation. Cities like Barcelona and Amsterdam are pioneering the use of smart water management, demonstrating significant improvements in water conservation and system reliability.



Urban areas are increasingly adopting **water-sensitive design** principles to manage water sustainably. This approach integrates the urban water cycle into the planning and design of cities, aiming to create resilient and water-efficient urban environments. Strategies include green infrastructure, such as rain gardens, green roofs, and permeable pavements, which enhance stormwater management and groundwater recharge. Additionally, sustainable urban drainage systems (SUDS) reduce flood risks and improve water quality. Water-sensitive urban design not only addresses water scarcity but also promotes biodiversity and enhances the livability of urban spaces.

Effective water management requires **robust policy frameworks and governance structures**. Innovative policies that promote water conservation, equitable distribution, and sustainable usage are essential. For example, water pricing mechanisms that reflect the true cost of water can incentivize conservation. Additionally, transboundary water management agreements facilitate cooperation between countries sharing water resources. Strengthening institutions and engaging stakeholders at all levels ensures that water management strategies are inclusive and effective.

In conclusion, combating the global water crisis requires a multifaceted approach that combines technological innovation, sustainable practices, and effective governance. By harnessing the potential of desalination, wastewater recycling, precision agriculture, smart water management, water-sensitive urban design, and innovative policies, we can build a resilient and water-secure future.

THE IMPACT OF LIGHT POLLUTION ON NOCTURNAL WILDLIFE

Dipayan Laha

The nocturnal symphony of the natural world faces a growing threat from the expanding reach of light pollution. As urban areas sprawl and industrialization spreads, the delicate balance of nature is increasingly disrupted, casting shadows over the lives of countless creatures. Light pollution, characterized by the excessive or inappropriate use of artificial lighting, whether during the day or night, arises from poorly implemented lighting sources. A study has revealed a startling impact of artificial lighting on our ability to observe the natural wonders of the night sky. It indicates that due to excessive artificial lighting, 60% of Europeans and nearly 80% of North Americans are unable to see the Milky Way's glowing band. This phenomenon extends beyond continents, affecting entire populations in countries like Singapore, Kuwait, and Malta. Shockingly, over one-third of the world's population can no longer experience the awe-inspiring sight of the Milky Way due to light pollution. Light pollution is a pervasive problem that is worsened by various sources of artificial outdoor lighting. Urbanization, sports facilities, industrial facilities, residential lighting, advertising signs, misdirected lighting, outdated technology, and disruptions to natural darkness such as fireworks and coastal vessels all contribute to this issue. It is crucial to address these sources in order to reduce the negative impacts of light pollution on ecosystems and public health.

Some Nocturnal Wildlife: Owls, bats, hedgehogs, ocelots, raccoons, nightjars, nighthawks, kiwis, geckos, cane toads, tree frogs, catfish, eels, moths, tarantulas, crickets, earthworms, and scorpions are all examples of nocturnal wildlife.

One of the primary impacts of light pollution is the disruption of circadian rhythms. Many nocturnal species have evolved to synchronize their daily activities, such as hunting, foraging, and mating, with the natural cycles of light and dark. Exposure to artificial light at night can confuse these internal clocks, leading to desynchronization and an inability to perform vital behaviors at optimal times. Nocturnal wildlife, including owls, bats, fireflies, and sea turtles, rely on the cover of darkness to thrive. Artificial light at night can have devastating effects on their behavior, physiology, and overall survival. Research has shown that light pollution can delay breeding cycles in songbirds, causing them to miss peak periods for nesting and rearing young. Similarly, artificial light has been linked to decreased melatonin production in bats, which is essential for regulating their sleep-wake patterns and other physiological processes.



In addition to disrupting daily rhythms, light pollution directly threatens the survival of nocturnal species. Bright lights can disorient sea turtle hatchlings, causing them to stray inland instead of heading towards the ocean, where they are exposed to predators and dehydration. Nocturnal insects, such as moths, may become trapped in the glare of streetlights, preventing them from finding their natural food sources and breeding grounds. These individual-level impacts can have significant ecological ripple effects. Disruption or displacement of key nocturnal species can alter entire food webs and cause cascading changes throughout ecosystems. For example, reduced populations of nocturnal pollinators can affect the reproduction of nocturnal plants, leading to decreased biodiversity.

Transitioning to energy-efficient outdoor lighting, establishing "Dark Sky" areas, and implementing lighting curfews are effective ways to reduce stray artificial light and protect nocturnal wildlife. As human development continues to expand, it is crucial that we recognize the ecological importance of darkness and take action to mitigate the impacts of light pollution. By working to preserve the natural rhythms of the night, we can help ensure the long-term survival of the many species that depend on the cover of darkness to thrive.

SUSTAINABLE SOLUTIONS: ENHANCING LAND RESTORATION, COMBATING DESERTIFICATION AND BUILDING DROUGHT RESILIENCE

Mouli Paul

Desertification and drought influenced by climate change and unsustainable land use becomes an issue now a days. The need for sustainable solutions enhancing land restoration, combating desertification and building drought resilience are critical strategies to save the environment from the current issues.

Enhancing Land Restoration

Land restoration is an important approach and it involves rehabilitation of degraded land to restore its ecological productivity. Techniques such as reforestation, agroforestry and soil conservation are integral to this process. Reforestation helps to restore forest cover for maintaining biodiversity. Trees act as carbon sinks absorbing carbon dioxide. Agroforestry enhances soil fertility through nitrogen fixation, reduces soil erosion and improves water retention. Soil conservation techniques including contour ploughing, terracing and the use of cover crops, prevent soil erosion, enhance soil structure and increase organic matter content all contributes sustainable land use.

Combating Desertification

Desertification is a severe form of land degradation affecting millions of people worldwide. To combat this one effective strategy is the implementation of sustainable land management practices. These practices include the restoration of vegetation cover which stabilizes the soil and reduces erosion. Water management techniques like rainwater harvesting and construction of small dams enhance water availability and reduce surface runoff.

Desertification has become a global concern affecting 36 million square kilometers of land and 500 million people. UNCCD highlighted desertification as a serious challenge for humanity. The urgency in reversing desertification through land rehabilitation and sustainable land use management has become the main agenda for the international community. Desertification becomes a pertinent problem, especially with 500 million people that have been affected since the 1980s. The United Nations Convention to Combat Desertification (UNCCD) as a global advocate for land restoration to avoid, reduce and reverse desertification through a legally binding convention signed by 197 member states that commit to restore land and enact drought mitigation measures. One approach to combat desertification and drought is through urban farming and the establishment of green belts. The ongoing flagship project called the Great Green Wall was initiated by African Union where a 7,800 km green vegetation corridor will cover 11 countries of an area equivalent to 117,000 km square.



Building Drought Resilience

Drought resilience is the capacity of ecosystems, communities and economies to withstand and recover from drought conditions. Building this resilience is essential for sustaining agricultural productivity, food security and livelihoods in drought prone areas. Water management is important for drought resilience. Efficient irrigation systems: drip and sprinkler irrigation reduce water wastage and ensure that crops receive adequate moisture. Use of drought resistant crop varieties is an effective measure for reducing tillage, planting cover crops and adding organic matter can help in enhancing soil health.

Conclusion

Drought resilience, combating desertification and land restoration are critical and interconnected components essential for sustainable development, environmental health and the well-being of communities. Addressing these challenges require a multi-faceted approach that involves scientific research, community engagement, policy implementation and international cooperation. Implementing water-efficient agricultural practices, drought-resistant crop varieties and improved irrigation techniques are vital for building resilience. Developing robust drought monitoring and early warning systems can help communities prepare and respond effectively to drought conditions. Efficient management of water resources including the protection of watersheds and the use of sustainable groundwater extraction practices, is essential to ensure water availability during periods.

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