

EARTH ROOT

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About E-magazine

“Earth Root” is an open access e-magazine in the discipline of Environmental sciences published by Earth Root Foundation. The aim of the e-magazine is to provide information and upgradation of knowledge about environmental issues on wider scale and to share ideas and resources to the readers. Using essential knowledge people can lead a healthy life, which is more sustainable and can connect with ongoing efforts for stopping catastrophically the climate change. E-magazine caters to all related environmental aspects ranging from big issues like climate change, renewable energy and pollutants in the atmosphere to the health of human and living beings on Earth. We also take topics of water resources and efforts and measurement to provide optimum use of it; including large scale atmospheric circulation linked with oceans and ecology.

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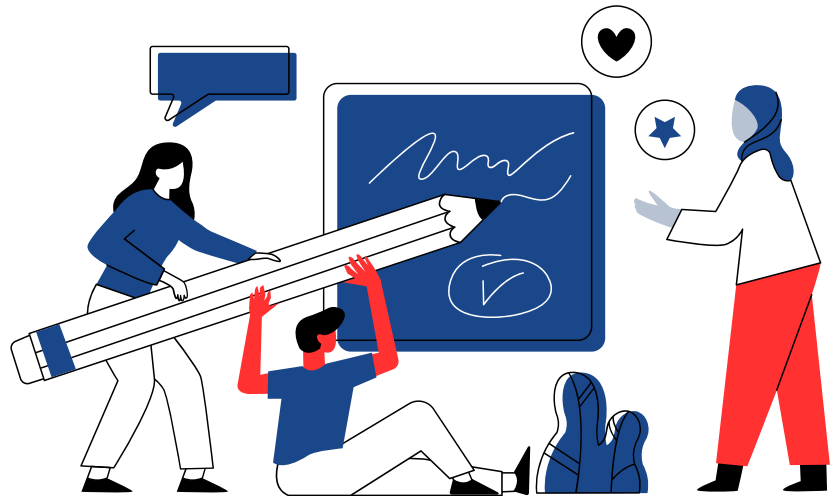
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MEDICINE: A CURE FOR HUMANS, POISON FOR THE ENVIRONMENT

-Srishti Vyas, USEM,
Guru Gobind Singh Indraprastha University

Disease emergence has been concomitant to human evolution. The infamous episodes of epidemics and pandemics highlight the significance of medicine in the society. Originating as natural remedies, the cure gradually transformed into artificially designed chemical drugs, an effective tool for reinforcing the healthcare system.

Pharmaceutical industry is a major component of healthcare sector. Aiming at the improvement of public health, it develops drugs and formulations for the treatment of existing and nascent maladies. Medicine is a double-edged sword that conceals its detrimental effects on the environment and global health under the mask of short-term relief.

Effects of medications on the Environment

The upstream, midstream and downstream processes involved in drug production consume a significant amount of energy and water, and release numerous air pollutants (such as particulate matter, methylene chloride, methanol, toluene, hydrogen chloride, and volatile organic compounds) along with greenhouse gases. These operations increase

the environmental footprint of the pharmaceutical sector and lead to high scope emissions.

Pharmaceutical waste management is a major challenge. Waste, including chemicals, expired drugs, vials, and packaging materials (plastics), when improperly disposed of in the environment, can contaminate nearby soil and water bodies, permeate the aquifers polluting the groundwater, impact land productivity, water quality, ecosystem health, and associated biodiversity.

Considered as major sources of pharmaceutical waste, residues from drug manufacturing units, healthcare institutions, households, agriculture and animal husbandry comprise of Active Pharmaceutical Ingredients (APIs), hormones, antibiotics, pain relievers, antidepressants, antineoplastic drugs and parasiticides. These Environmentally Persistent Pharmaceutical Pollutants (EPPPs) remain potent even after their consumption and excretion, and persist in the environment for a long time, affecting non-target species of the biosphere.

Animal husbandry employs several veterinary pharmaceuticals, including topical antiseptics, fungicides, antiparasitic drugs and steroids, to improve animal health and productivity. The land application of livestock manure (obtained from drugs-administered animals) in agriculture can lead to soil contamination with bioactive compounds, thus impacting the soil biota, nearby flora and fauna, and crop growth.

Diclofenac, a veterinary non-steroidal anti-inflammatory drug used in livestock farming, was banned from use due to its nephrotoxic effects on the vulture populations, causing a sharp decline in the species numbers.

Aquaculture employs fish feeds containing high levels of toxic compounds, including polychlorinated biphenyls, brominated flame retardants, polycyclic aromatic hydrocarbons, and methylmercury. Release of the uneaten feed pellets and fish wastes from farms into nearby water bodies causes bioaccumulation of these organic water pollutants in the marine food chain. Additionally, the antimicrobials used for disease prevention in fish cages can disrupt the naturally existing microbial community and give rise to new strains.

Impact on aquatic ecosystem - As the pharmaceutical residues are released into the aquatic ecosystem via direct discharge of treated and untreated wastewater, surface runoff (from landfills), and agricultural runoff, deleterious consequences are faced by aquatic life.

Commonly used for alleviating pain and inflammation in humans, non-steroidal anti-inflammatory drugs such as ibuprofen and aspirin can adversely affect the physiological processes of aquatic organisms. The drug metabolites impact the growth, reproduction and behaviour by their cytotoxic and genotoxic properties.

The biologically active components of oral contraceptives and steroid hormones can cause sex reversal in fishes and amphibians (feminization of males), sterilization,

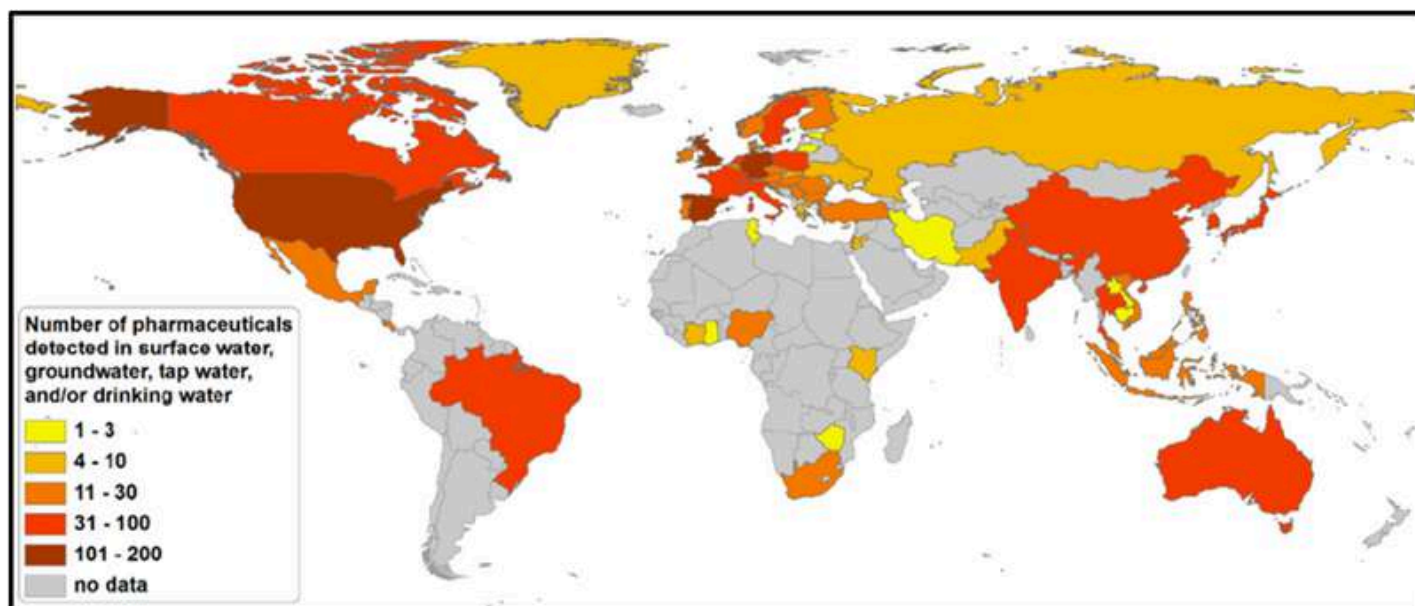
disruption of gonadal functions and decline in fecundity, thus endangering the genetic viability and survivability of aquatic species.

Capable of affecting the neuroendocrine system in living beings, psychiatric drugs like phenelzine, venlafaxine, fluoxetine (drugs used to treat depression, obsessive-compulsive disorder and panic attacks in humans) can bioaccumulate in the fishes, alter their behaviour and delay their brain and reproductive development, thus threatening the species survival. These endocrine-disruptors can biomagnify along the food chain, causing ecotoxicological effects in the long run.

Exposure to tetracycline, sulfamethoxazole, and ciprofloxacin antibiotics can stimulate cyanobacterial growth in aquatic ecosystems. Specific antibiotics (such as quinolones) are known to cause toxic chronic effects and cell damage in micro and macro life forms. Additionally, the chloroplast replication and metabolic pathways are affected in antibiotic-sensitive aquatic plants.

Antimicrobial Resistance (AMR), a major consequence of overconsumption and imprudent use of antibiotics, is a global health emergency. Exceeding concentrations of antibiotics expedite the emergence of multidrug-resistant superbugs, which are not only harder to treat but a threat to the existing microbial community.

Impact on humans - While the human communities residing in the vicinity of drug manufacturing facilities are the most vulnerable to the ill-effects of pharmaceuticals, the distant ones are also not exempted. Consumption of food crops, fish, meat, and water sources contaminated with pharmacological residues and dairy products (obtained from medicated livestock) can lead to bioaccumulation, antimicrobial resistance and multi-organ damage. Thus, the medicines perceived as a life savior can end up making the body even more frail, building an inescapable vicious circle.



Source - https://www.researchgate.net/figure/Number-of-pharmaceuticals-detected-in-surface-waters-groundwater-tap-water-and-or_fig4_330934183

Remedy for the situation:

With over-prescription, self-medication and misdiagnosis exacerbating the existing situation, the APIs have turned into serious environmental pollutants, reaching unprecedented levels.

The environmental footprints of pharmaceuticals can be reduced by shifting towards sustainable green pharma and adopting the following practices:

- Promote disease prevention and a healthy lifestyle to reduce dependency on pharmaceuticals.
- Introduce medicine-take-back schemes for returning unused or expired medicines for their environmentally sound disposal.
- Integrate environmental sustainability into the practices and policies.
- Overcome the inadequacy of currently employed conventional waste water treatment plants (for pharmaceutical effluents) by implementing modern technologies such as advanced oxidation processes (photocatalysis, electrooxidation, ultrasound irradiation, etc.) and hybrid technologies capable of removing APIs from effluents to a large extent.
- Use medicines judiciously, preventing their overconsumption.

Burgeoning populations, rising antimicrobial resistance and the emergence of new pathogen strains are escalating the demand and production of pharmaceuticals day by day, hence making them an indispensable part of human existence. Under such prevailing conditions, transition to green pharmacy is the need of the hour.

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CCUS: A HOPE FOR INDIA TO TACKLE THE IMPACT OF CARBON BORDER ADJUSTMENT MECHANISM IMPLEMENTATION

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INTRODUCTION

'Carbon emissions', the heat trappers are a major contributor to the greenhouse effect causing a rise in the earth's temperature and hence climate change. These are also responsible for causing air pollution which affects the respiratory health of the living beings.

Climate change further creates problems such as extreme weather, forest fires, food supply disruptions etc. Today, the entire world is concerned about reducing the carbon emissions in order to deal with climate change and its devastating effects. One of the ways can be eradicating the use of fossil fuels completely. But it would take around 40 to 50 years for a developing country like India to do so. Therefore, another way of reducing carbon emissions can be Carbon Capture, Utilization and Storage (CCUS). This is a very promising technique and seen as an effective method of dealing with carbon emissions produced by the industries.

WHAT IS CARBON, CAPTURE, UTILISATION AND STORAGE(CCUS)?

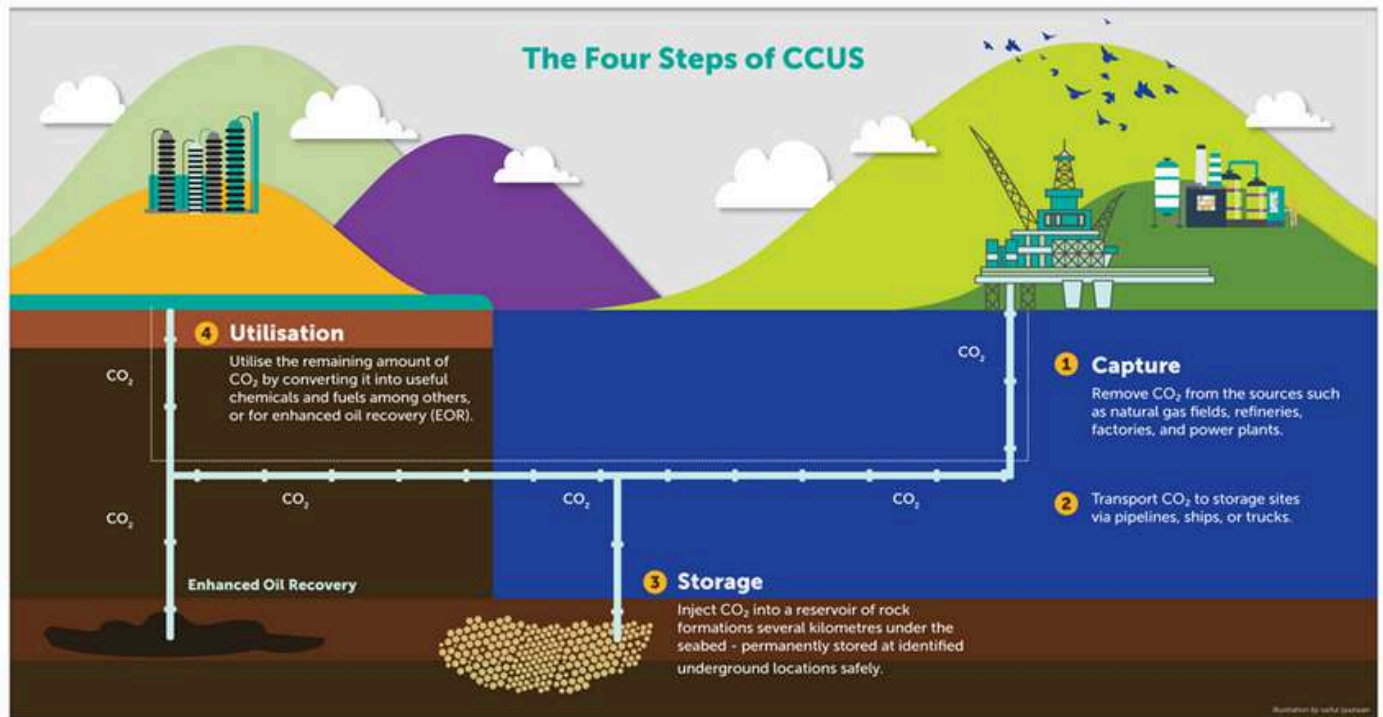
CCUS involves the capture of CO₂ generally from large point sources such as industries that use either fossil fuel or biomass as fuel. The captured CO₂ can be utilized on site or can be transported through pipelines, trucks, ships or rails to be used for various applications. The captured CO₂ can also be injected into deep geological forms such as depleted oil or gas reservoir or saline aquifers. In this way, the CO₂ released by the industries can help in enhanced oil recovery (EOR) as well.

The main idea of CCUS is to either store or to utilize the CO₂ produced by the industries so as to reduce carbon emissions and prevent them from entering the atmosphere.

CARBON BORDER ADJUSTMENT MECHANISM(CBAM)

CBAM is a carbon tariff imposed on imported carbon intensive goods to the European Union. It is the EU's tool to put a fair price on the carbon emitted during the production of carbon intensive goods that enter the EU.

In simple words, if a carbon intensive good produced in a country with less stringent carbon policies is exported to a country with more



Source: Getting to know CCUS at PETRONAS | PETRONAS FLOW

stringent environmental or carbon policies then the importer has to pay a carbon tax to the EU. The importer has to declare the carbon embedded in the imports and has to surrender the corresponding number of certificates each year. However, if the importer is able to prove that a particular amount of tax has already been paid during the production of the imported goods then that amount can be deducted.

This will help in reducing carbon emissions as the countries would avoid paying tax unnecessarily and will opt for goods embedded with less carbon emissions. Hence, the carbon intensive goods will be preferred less which will ultimately affect the business and such producers will try to adopt measures and technologies to minimize their carbon emissions.

CBAM will ensure that the carbon price of the imported good is equivalent to the carbon price of domestic production. It is a policy to reduce global carbon emissions and ensure fair trade environment by encouraging other countries to have stricter environmental regulations.

Another important aim of CBAM is to prevent carbon leakage, hence, discouraging companies to relocate to the countries with weaker environmental policies.

ROLE OF CCUS IN INDIA FOR CARBON BORDER ADJUSTMENT MECHANISM

India being a large exporter of iron, steel and aluminium to the EU is likely to face a great impact of CBAM implementation on its exports to the EU. India is highly dependent on coal for energy, resulting in more carbon emissions during the manufacturing of the goods. The Carbon Border Adjustment Mechanism will prevent countries from purchasing goods from India which will be embedded with large amount of carbon emissions. They will rather choose to buy from such companies that would have emitted less carbon during the manufacturing of the products which will ultimately save the importer from paying tax to the EU. This is going to affect the Indian trade which will be of huge loss to the country as the demand of the product will decrease due to more carbon emissions as compared to others. Shifting to renewable energy sources and completely phasing out coal is quite impossible for India in such a short span hence, CCUS can be a key for Indian industrialists to reduce carbon emissions during the production.

Capturing the carbon emitted during the goods production to utilize or store it in deep geological forms will help prevent the emitted carbon from going into the atmosphere and hence the

product will be embedded with less carbon which will be preferred by the countries and will aid India to maintain its trade in the international market.

UTILIZATION APPLICATIONS OF CAPTURED CO₂

Industries: Captured CO₂ can be used in industries to produce synthetic fuels and these fuels can replace conventional fossil fuels which will reduce emissions. This CO₂ can also be used in the making of cement, concrete and other construction material reducing their carbon impact.

Chemicals and materials: CO₂ can be used to make methanol. It can also be used for making sustainable materials like polymers, conversion of CO, catalytic hydrogenation of CO₂, hydrogen rich syngas, synthesis of olefins and aromatic compounds, and other value-added goods.

Agriculture and food: Can help improve crop growth in greenhouses. In the food industry it can be used to carbonate beverages and extend shelf life.

Algae and biofuels: CO₂ can help microalgae to grow which can further be converted into biofuels or animal feed which can reduce reliance on traditional fuels.

Oil recovery: CO₂ can aid in enhanced oil recovery, increasing oil production while storing CO₂ underground. However, the pros and cons of this approach need careful consideration.

CONCLUSION

Amid changes in global mitigation strategies like the Carbon Border Adjustment Tax in the EU to prevent 'carbon leakage', industries must shift away from the traditional approach to become less carbon-intensive and remain competitive in European markets. Despite the urgency of climate change mitigation actions and the ambitious climate commitments made by various nations, it is expected that more initiatives similar to the EU's Carbon Border Adjustment Tax will arise. As a result, industries are acknowledging the importance of CCUS, but additional stakeholders are required to facilitate the adoption of CCUS technology in India.



BRAZIL'S ECONOMY DRIES UP: THE FAR-REACHING IMPACT OF THE AMAZON DROUGHT

- Dr. Abhishek Malhotra

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The severe drought currently gripping the Amazon region in Brazil is not just an environmental catastrophe but also a significant blow to the country's economy. As rivers dry up and ecosystems falter, the economic implications for Brazil and the broader region are becoming increasingly dire. Among the most affected sectors are agriculture, fisheries, transportation, and tourism, all of which rely heavily on the water systems that the Amazon provides. The unprecedented drop in the water levels of major tributaries, such as the Rio Negro, is impacting economic activities in ways that will reverberate for years to come.

Agriculture, one of Brazil's primary economic pillars, is suffering greatly as drought conditions worsen. Much of Brazil's rural population depends on the fertile lands surrounding the Amazon Basin to cultivate crops like soybeans, corn, and sugarcane. These crops require consistent rainfall and irrigation, which have been severely reduced due to the ongoing drought. As water sources dry up, farmers are forced to scale back production, leading to lower crop yields and rising costs. The lack of water

also impacts livestock farming, as cattle ranchers face shortages of both drinking water and pasture for grazing. In turn, this pushes up the prices of meat and other agricultural products, contributing to inflationary pressures in Brazil's economy.

In addition to agriculture, the fisheries sector has also been hit hard by the drought. The Amazon River and its tributaries are home to an immense variety of fish species that form the backbone of the local economy. Fishing is not only a source of income for thousands of families but also an essential part of the food supply chain. With water levels at record lows, fish populations are declining as their habitats shrink and water temperatures rise. The mass die-offs of fish observed in recent months have devastated the livelihoods of fishermen and threatened the food security of entire communities. As fish stocks continue to diminish, the cost of seafood is rising, further straining both local markets and exports.

Transportation, which heavily relies on the river system, is also facing severe disruptions. In the Amazon region, rivers are often the only viable

means of transport, especially for remote communities. The Rio Negro and other waterways are vital arteries for the movement of goods and people. However, with water levels reaching historic lows, many boats are unable to navigate the rivers, leaving them stranded. This has caused significant delays in the transport of essential goods, such as food, fuel, and medical supplies, to isolated regions. The economic costs of these disruptions are mounting, as supply chains are severely hindered, and the flow of commerce grinds to a halt.

The tourism industry, which generates substantial revenue for the Amazon region, is also suffering the consequences of the drought. Tourists flock to the Amazon to experience its unique biodiversity, pristine rivers, and lush rainforests. However, with rivers drying up and wildlife struggling to survive, the appeal of the region is rapidly diminishing. Tour operators are reporting an increasing number of cancellations, and local businesses that depend on tourism are facing financial hardship. Hotels, restaurants, and small businesses that cater to tourists are seeing their revenue plummet, and the long-term outlook for the industry appears grim.

The economic damage extends beyond the immediate region, as the drought in the Amazon is affecting Brazil's national economy. The Amazon rainforest plays a crucial role in regulating the global climate and sustaining Brazil's water cycle. The loss of tree cover due to deforestation and the intensification of droughts are diminishing the forest's ability to absorb carbon dioxide and produce moisture, leading to more extreme weather patterns across the country. This is affecting agriculture, hydropower generation, and urban water supplies in other parts of Brazil, compounding the economic toll.

Moreover, the international perception of Brazil's environmental management is deteriorating. As deforestation and environmental degradation continue to escalate, Brazil is facing increased scrutiny and criticism from the global community.

Investors and trading partners are becoming more wary of doing business with a country that is seen as failing to protect one of the world's most critical ecosystems. This could lead to reduced foreign investment and potential trade barriers, further weakening Brazil's economic prospects.

In response to the drought, the Brazilian government is under immense pressure to take decisive action. However, the policy solutions needed to address the root causes of the crisis are complex and require a balance between economic development and environmental protection. Immediate measures such as providing financial assistance to affected farmers, fishermen, and businesses are essential, but long-term solutions must focus on tackling deforestation and mitigating the impacts of climate change. Without concerted efforts to restore the health of the Amazon and implement sustainable practices, the economic consequences of droughts will only worsen in the future.

The economic impact of the Amazon drought serves as a stark reminder of the interconnectedness between the environment and the economy. The destruction of natural resources leads to a domino effect that disrupts entire industries, affects livelihoods, and threatens the stability of national and regional economies. In Brazil, the record low water levels in the Amazon's tributaries are a clear signal that urgent action is needed to protect the rainforest, preserve biodiversity, and ensure the sustainability of economic activities that depend on the region's natural wealth.



RECORD LOW WATER LEVELS IN BRAZIL'S RIO NEGRO: A STARK WARNING OF AMAZON'S DROUGHT CRISIS

-Ankur Goel

Director, Copper Cross Solutions

In the heart of the Amazon rainforest, where the lush landscape is typically dominated by abundant rainfall and the world's mightiest river, the Amazon, flows majestically, an unprecedented environmental crisis is unfolding. The depth of one of the major tributaries of the Amazon River, the Rio Negro, has plummeted to a record low due to an extreme and prolonged drought. This situation is raising alarms across Brazil and globally as the repercussions on ecosystems, local communities, and climate patterns are becoming increasingly severe.

The Magnitude of the Drought

Brazil, the largest country in South America and home to vast stretches of the Amazon rainforest, has been facing one of its most severe droughts in decades. The drought, driven by a combination of factors, including climate change and deforestation, has caused a drastic reduction in the water levels of the Rio Negro, one of the Amazon's largest tributaries. The Rio Negro, known for its dark-colored water and substantial flow, reached a historic low in 2024, dropping to depths not seen since records began.

The Rio Negro, which meets the Amazon River at Manaus, is crucial for the local environment, economy, and communities. However, in 2024, the river's depth has dropped to just over 13 meters in some areas, breaking the previous record low set in 2010. For a river that usually has an average depth of 30 meters, this reduction is dramatic and has far-reaching consequences. The water crisis in the Amazon region is not just about the rivers and their depths; it symbolizes the deep environmental challenges facing the planet today.

The Role of Climate Change

While seasonal fluctuations in rainfall and water levels are normal in the Amazon Basin, the severity and frequency of droughts in recent years suggest that human-induced climate change is exacerbating the situation. Brazil has experienced unusually high temperatures in 2024, with some regions recording temperatures up to 5 degrees Celsius above normal. These extreme temperatures, combined with reduced rainfall, have led to soil moisture depletion, forest fires, and, most critically, a significant reduction in river water levels.

Deforestation, often driven by agricultural expansion and illegal logging, further compounds the problem. The Amazon rainforest, known as the "lungs of the Earth," plays a crucial role in regulating the planet's climate by absorbing carbon dioxide. However, as large sections of the forest are cleared, its capacity to act as a carbon sink diminishes. This loss not only accelerates global warming but also affects local weather patterns, creating a vicious cycle where deforestation leads to reduced rainfall, which in turn aggravates drought conditions.

Impact on Local Ecosystems

The Amazon Basin is one of the most biodiverse regions on Earth, home to millions of species of plants, animals, and microorganisms. The Rio Negro, with its unique blackwater ecosystem, supports a variety of aquatic life, including fish species that are vital to the local economy and culture. However, the current drought has led to devastating consequences for these ecosystems.

As the water levels drop, fish populations are struggling to survive in shallower, warmer waters. Oxygen levels in the river are also decreasing, leading to mass fish deaths. These die-offs not only disrupt the ecological balance but also threaten the livelihoods of the indigenous and local communities who rely on fishing for sustenance and income.

The drought is also affecting the region's terrestrial ecosystems. The reduced water flow in the Rio Negro is straining the surrounding forests, where many species depend on the seasonal flooding of rivers to maintain their habitats. Without this essential water supply, trees are dying, and wildlife is being forced to migrate to other areas, further disturbing the ecological balance.

Human Toll: Local Communities and the Economy

The human impact of the drought is significant, particularly for the indigenous and riverine communities that have lived in harmony with the Amazon for centuries. These communities depend on the rivers for transportation,

fishing, and agriculture. With the water levels so low, boats are becoming stranded, making it difficult for people to access essential services, such as healthcare and markets. Food security is also becoming a concern as fish stocks dwindle and agricultural production suffers due to lack of water.

The city of Manaus, a major urban center on the Rio Negro, is also feeling the effects of the drought. The city relies on the river for its water supply, and with levels at a historic low, there are concerns about water shortages and the quality of the water that remains. The local economy, which depends heavily on river transport and fishing, is taking a severe hit, with many families struggling to make ends meet.

Tourism, a major industry in the region, is also being affected. The Amazon rainforest is a popular destination for eco-tourists, but with rivers drying up and wildlife disappearing, the appeal of the region is fading. Many tour operators are reporting cancellations, and the long-term outlook for the tourism sector in the Amazon is uncertain.

A Call for Action

The record low in the Rio Negro's water level highlights the Amazon's vulnerability to climate change. While droughts are common, their increasing severity underscores the urgent climate crisis. Tackling this requires reducing deforestation, promoting sustainable agriculture, and enforcing environmental laws. Globally, cutting greenhouse gas emissions and shifting to renewable energy are crucial. Additionally, supporting local Amazon communities with resources, sustainable livelihoods, and biodiversity protection will help them adapt and build resilience against future droughts.

Conclusion

The record low water levels in the Rio Negro reflect a deeper, more complex environmental crisis that requires urgent action. As the Amazon faces the effects of climate change and deforestation, global efforts are needed to protect this crucial ecosystem. The well-being of the Amazon is closely tied to the health of the planet, making its preservation essential for the future of generations to come.

MOVIE

RECOMMENDATION

THE BOY WHO HARNESSSED THE WIND(2019)

The Boy Who Harnessed the Wind is a 2019 biographical drama directed by Chiwetel Ejiofor, based on the true story of William Kamkwamba, a young boy from Malawi. Set in a village struggling with drought and famine, the film follows William as he uses his passion for science and engineering to build a wind turbine from scrap materials, bringing water and hope to his community. Despite limited resources and facing numerous challenges, William's ingenuity and determination inspire change and survival. The film highlights themes of resilience, innovation, and the power of education.

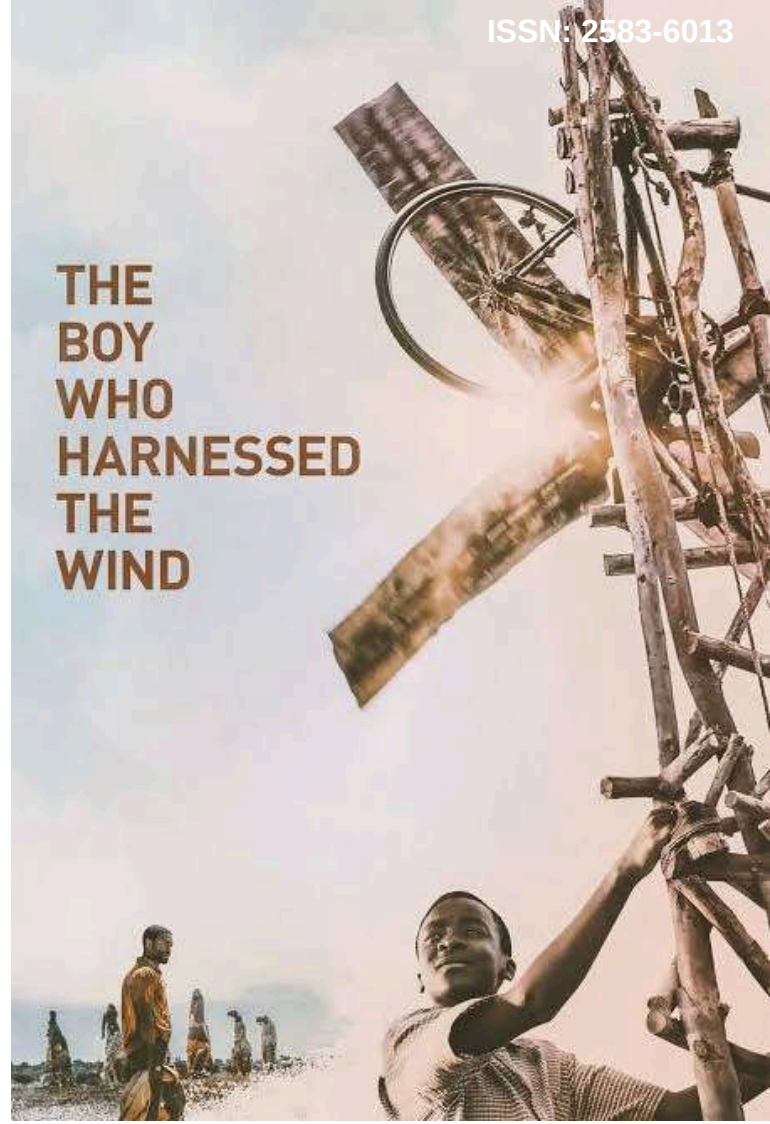
PLOT SYNOPSIS

The Boy Who Harnessed the Wind tells the inspiring true story of William Kamkwamba, a 13-year-old boy living in a rural village in Malawi. As the community faces devastating famine due to drought and failed crops, William's family, like many others, struggles to survive. With limited food and resources, tensions rise, and William's father, Trywell, struggles to hold the family together.

William is a curious and inventive boy with a passion for science. Despite being forced to drop out of school due to financial hardship, he continues sneaking into the school library, where he discovers a book on energy. Inspired by the idea of generating electricity through wind power, William begins collecting discarded parts and scrap metal from the village. His dream is to build a windmill to power a water pump that could irrigate the family's land and save their crops.

However, William faces numerous obstacles, including skepticism from his father and villagers, as well as the challenge of gathering materials in an impoverished community. Through perseverance, ingenuity, and the support of his teacher, William successfully constructs a working wind turbine. His invention allows the community to irrigate their land, leading to renewed hope and prosperity.

The film concludes with William's success bringing much-needed change to his village, showing how determination and creativity can triumph in the face of overwhelming odds.

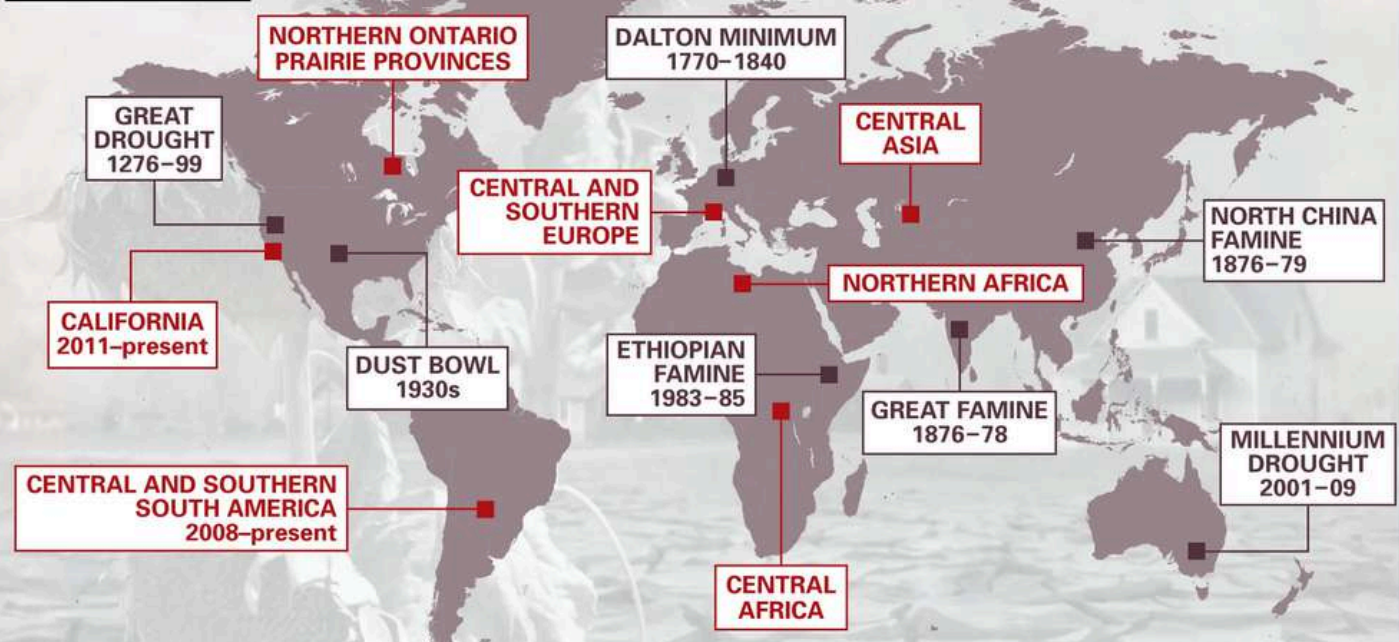


DROUGHT

An extended period of rainless weather that causes a considerable water imbalance.

Locations of ongoing and historical droughts

- Ongoing*
- Historical



*As of August 2022 according to the National Integrated Drought Information System (NIDIS).

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SOME OF THE VISIBLE SIGNS OF DROUGHT	ECONOMIC IMPACTS	SOCIAL IMPACTS
Crop damage	Crop loss	Increased human health risks
Lowered lake levels	Habitat damage	Reduced incomes
Increased soil erosion	Increased costs for food and water	Rise in drought-related deaths
Reduced flow of rivers and streams	Reduced hydropower output with rising utility rates	Increased risk of war
Increased dust storm prevalence		Increased migration
Increased wildfire risk		
SIGNS OF DROUGHT BELOWGROUND		
	Steep reductions in soil moisture	
	Drawdowns of aquifers	

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