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CARBON EDGE

LEADING THE MARKET FOR A SUSTAINABLE FUTURE

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CARBON EDGE

LEADING THE MARKET FOR A SUSTAINABLE FUTURE

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MESSAGE

Rajeev Juneja
PRESIDENT, PHDCCI

Dear Members and Stakeholders,

It gives me great pleasure to introduce the Carbon Edge Knowledge Paper Series on India's carbon market, which marks a significant turning point in our common goal of economic resilience and sustainability. Adopting creative ideas that solve environmental challenges and promote economic growth is essential as we tackle the difficulties posed by climate change. India has a unique place in the global carbon market thanks to its diverse ecosystems and rapidly growing economy. We can create the groundwork for a sustainable and inclusive future with strong carbon pricing systems and forward-thinking projects.

The PHD Chamber of Commerce and Industry, which speaks for the business community, understands that real cooperation between the government, business, and civil society is essential to realizing the carbon market's full potential. By cooperating, we can create frameworks that support green innovation, foster sustainable corporate practices, and hasten the shift to a low-carbon economy.

With major ramifications for India, the adoption of Article 6.4 at COP29 represents a turning point in global climate governance. This development offers opportunities as well as problems for our industry. Indian businesses can both support climate action and establish themselves as leaders in the global transition to a low-carbon future by embracing the changing structure of the carbon market and coordinating corporate strategies with global sustainability objectives.

I encourage every stakeholder to actively interact with the information presented in this knowledge series. As we collaborate to fortify India's carbon market and create a robust, sustainable economy, your involvement is essential. Let's take advantage of this wonderful opportunity to set a good example and protect the environment more effectively for future generations.

Warm regards,

(Rajeev Juneja)

MESSAGE

Dr. Ranjeet Mehta
CEO & Secretary General, PHDCCI

Dear Members and Stakeholders,

As we stand at the forefront of a crucial transition toward sustainable development, I am pleased to share our latest carbon edge knowledge paper series, which delves into the intricacies and opportunities of the Indian carbon market.

This white paper is the culmination of extensive research and collaboration with industry experts, policymakers, and environmental advocates. It aims to provide a comprehensive overview of the current landscape of carbon trading in India, identify key challenges, and explore innovative solutions that can enhance market efficiency and effectiveness.

Our findings underscore the immense potential of the carbon market to drive economic growth while significantly contributing to our climate goals. As we navigate this complex ecosystem, it is imperative that we foster collaboration among stakeholders and encourage participation across sectors.

I invite you to read this knowledge series and join us in the ongoing dialogue about the future of carbon markets in India. Together, we can build a resilient and sustainable future for generations to come.

Thank you for your continued support and commitment to this vital initiative.

Warm regards,

(Dr. Ranjeet Mehta)

Greening India's MSMEs: Aligning Small Enterprises with ESG, BRSR, and Global Sustainability Agendas

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Introduction

The challenges of climate change, ecological degradation, and resource scarcity have redefined the role of businesses worldwide. Large corporations are increasingly being held accountable for their environmental and social footprints, with sustainability disclosures becoming mandatory in many jurisdictions. In India, the Business Responsibility and Sustainability Report (BRSR) introduced by the Securities and Exchange Board of India (SEBI) in 2021 represents a major step in this direction (SEBI, 2021).

While MSMEs are not directly mandated to comply with these disclosures, they form an integral part of the supply chains of large corporations, both domestically and internationally. Thus, their sustainability performance indirectly influences corporate compliance. Furthermore, given that MSMEs collectively represent a substantial portion of India's industrial energy consumption and carbon emissions, greening them is indispensable to achieving India's Net Zero by 2070 target announced at COP26 (Government of India, 2021).

This article describes the need & impact of greening MSMEs, beginning with their economic role, moving through global and national regulatory frameworks, examining carbon emission challenges, and concluding with opportunities and policy directions for a green transition.

MSMEs in the Corporate and Export Ecosystem

MSMEs form the backbone of India's corporate and export ecosystem, driving both industrial output and global trade linkages. According to the Ministry of MSME (2023), MSMEs employ ~110 million people, contribute ~30% of GDP and 45% of exports, producing 6,000+ products from textiles and auto-components to leather and chemicals. The sector not only supports large corporates by providing cost-effective inputs and specialized services but also enhances India's competitiveness in international markets. For example, auto-component MSMEs in Pune and Chennai supply directly to firms like Maruti Suzuki and Hyundai, while textile clusters in Tirupur cater to global brands such as H&M and Decathlon. Similarly, leather-processing MSMEs in Kanpur and Agra feed into export markets in Europe and the US, highlighting their critical role in bridging India's local enterprise base with international demand. However, this embeddedness also makes MSMEs increasingly exposed to global sustainability norms and reporting frameworks, thereby linking their survival and growth with the ongoing transition toward green and responsible business practices (PwC, 2023; World Bank, 2020).

With the advent of climate change and alignment towards the overall paradigm of sustainability. ESG compliance is becoming a mandatory requirement across the globe. The regulatory and policy landscape is increasing

these pressures. At the international level, the European Union's Carbon Border Adjustment Mechanism (CBAM) applies exclusively to imports into the EU, requiring importers of carbon-intensive goods such as iron & steel, aluminium, cement, fertilizers, hydrogen, and electricity to declare embedded emissions and purchase CBAM certificates at the EU carbon price. India has aligned with these global trends through SEBI's BRSR framework. The Business Responsibility and Sustainability Reporting (BRSR) framework, introduced by SEBI in 2021, represents a shift in India's corporate reporting practices by replacing the earlier Business Responsibility Report (BRR) with a more robust, ESG-integrated disclosure system. Unlike BRR, which was largely qualitative, BRSR mandates quantitative and comparable metrics, thereby aligning Indian companies more closely with international sustainability standards. The framework is structured into three parts: General Disclosures, covering company profile, operations, product portfolio, workforce size, and supply chain; Management and Process Disclosures, focusing on governance structures, sustainability policies, risk management, and stakeholder engagement; and Principle-wise Performance Disclosures, which are explicitly aligned with the nine principles of the National Guidelines on Responsible Business Conduct (NGRBC).

Corporations today are increasingly assessed on the sustainability of their entire value chains, extending well beyond their direct operations. A significant portion of corporate carbon footprints falls under Scope 3 emissions, which include indirect emissions across the supply chain spanning raw material procurement, supplier practices, logistics, distribution, and even product use and disposal. In most industries, Scope 3 emissions constitute the majority of a company's climate impact, far exceeding emissions from direct production or purchased energy.

Within this context, micro, small, and medium enterprises (MSMEs) play a decisive role. As critical suppliers and service providers, they influence not only the carbon intensity but also the social and environmental credibility of corporate value chains. Even though MSMEs are not directly required to follow ESG reporting frameworks like India's BRSR, they are increasingly being pulled into the ecosystem through indirect channels. Their close ties to large corporations make them vital to the ESG performance of supply chains. For example, when companies like Tata Motors or ITC disclose their Scope 3 emissions, they must account for the practices of hundreds of MSME suppliers. This has led to stricter supplier audits, green procurement guidelines, and codes of conduct, essentially pushing MSMEs to align with sustainability standards (PwC, 2023).

Also, Indian companies and their MSME suppliers exporting to the EU will face pressure to provide accurate, verifiable emissions data, since failure to do so could result in higher default values and reduced competitiveness otherwise and risk losing contracts in EU-linked supply chains. This makes value-chain emissions a direct trade determinant, adding to global investor demands for transparent ESG reporting under frameworks like TCFD and SASB. Buyers in Europe or North America often require certifications such as OEKO-TEX for textiles or FSC for wood and paper products. Agro-processing, leather, and food packaging industries face comparable demands for verifiable compliance with ESG-linked norms (OECD, 2022).

Individually, most Micro, Small, and Medium Enterprises (MSMEs) in India appear modest in scale, but collectively their environmental footprint is substantial. MSMEs account for nearly a quarter of India's total industrial energy use, making them among the largest contributors to carbon emissions (TERI, 2019). Clusters such as brick kilns in Uttar Pradesh, foundries in Howrah, ceramics in Morbi, and textiles in Tirupur are particularly energy and pollution intensive. Traditional brick kilns alone release more than 60 million tons of CO_2 annually (World Bank, 2017), while textile dyeing and finishing units discharge untreated effluents into local water bodies (GIZ, 2020).

Inefficiencies such as energy-intensive operations, limited adoption of clean technologies can inflate a corporation's Scope 3 emissions, undermining its sustainability commitments. This emission intensity is reinforced by structural challenges. Many MSMEs still rely on outdated technologies, coal-fired boilers, traditional kilns, and obsolete

machinery, that consume far more energy than modern alternatives. Awareness and technical know-how are limited, with many owners and workers unfamiliar with concepts like carbon accounting or energy efficiency (UNIDO, 2021). If unaddressed, these challenges will keep MSMEs as major pollution hotspots, jeopardizing India's Paris Agreement commitments and its Net Zero by 2070 target. Conversely, targeted measures such as cleaner technologies, concessional green finance, cluster-level emission tracking, and integration into corporate sustainability programs could turn MSMEs into critical allies in India's climate transition (TERI, 2019; MoEFCC, 2022).

Financing further constraints change: banks often view MSMEs as risky borrowers, limiting access to credit for cleaner technologies (SIDBI & GIZ, 2022). Moreover, the informal nature of many enterprises excludes them from energy audits and carbon markets, locking them into unsustainable practices. Finance infact is emerging as a key driver of this shift. Banks and investors are increasingly applying ESG criteria in credit assessments. MSMEs seeking loans, green bonds, or concessional finance from institutions like SIDBI are now required to disclose data on energy use, emissions, and labor practices (SIDBI & GIZ, 2022).

This has created a "trickle-down compliance" effect (CII, 2023). Even where laws do not directly mandate disclosure, supply chain linkages, trade requirements, and financing conditions are making sustainability unavoidable. In effect, the very factors that make MSMEs large emitters are also pulling them into sustainability frameworks through markets, exports, and finance.

Greening MSMEs is therefore no longer optional; it is a strategic necessity for survival and growth in both domestic and global markets. Indirect ESG pressures are reshaping expectations while highlighting both the opportunities and barriers MSMEs face in adopting sustainable practices. Their ability to adapt depends on leveraging inherent strengths and addressing structural weaknesses.

These shifts present a double-edged reality. MSMEs unable to align with ESG requirements risk losing global market access and supply contracts. Conversely, those that proactively adopt sustainable practices can secure green finance, long-term supply agreements, and stronger positions in export-driven industries.

Greening MSMEs - Enablers and Barriers

The path toward greening Micro, Small, and Medium Enterprises (MSMEs) in India is a story of both potential and constraint. On the positive side, MSMEs possess several attributes that make them well-suited to adapt to sustainability demands. Their relatively small size and flexible structures allow them to innovate quickly and respond faster to changing markets or regulations than larger corporations. Many operate in clusters such as textiles in Tirupur, ceramics in Morbi, and foundries in Howrah where shared facilities like common effluent treatment plants (CETPs) or renewable energy systems can be developed collectively, reducing costs and environmental impacts. Beyond economics, MSMEs also play a critical social role by generating employment and supporting inclusive growth, thereby contributing directly to Sustainable Development Goals (SDGs) such as poverty reduction, gender equality, and decent work. Their frugal engineering culture and resourcefulness often result in low-cost, practical green innovations tailored to local contexts.

Yet, these strengths are offset by significant barriers. Many MSMEs lack affordable access to finance, making investments in energy-efficient technologies or cleaner production systems difficult as both equally require high initial investments. Knowledge gaps are another hurdle, with limited awareness about ESG frameworks, reporting requirements, or low-carbon transition pathways. A large portion of the sector remains informal operating without adequate documentation or emission inventories which restricts their participation in formal sustainability programs or carbon markets. Dependence on fossil fuels such as coal, furnace oil, and diesel further compounds the problem, leaving MSMEs disproportionately carbon-intensive compared to larger firms.

Unlocking their potential, therefore, requires targeted interventions. Access to concessional green finance, capacity-building programs

at the cluster level, and improved renewable energy infrastructure are critical steps. With the right support, MSMEs can overcome structural limitations and emerge not just as participants, but as active contributors to India's green transition.

The opportunities and challenges that MSMEs face in adopting a green approach also shape how they approach ESG reporting. Their flexibility helps them adopt it, but gaps in finance and awareness still hold many backs.

ESG Reporting - an Option for MSMEs

Voluntary reporting also opens doors to finance. Banks, development institutions, and investors are now integrating ESG considerations into their lending and investment decisions. Access to green credit lines, concessional loans, or sustainability-linked finance often depends on some level of ESG disclosure (SIDBI & GIZ, 2022). For smaller enterprises that often struggle to secure affordable capital, voluntary ESG adoption can become a gateway to the funds needed for modernization and growth.

Real-world examples show these benefits clearly. Textile exporters in Tirupur who invested in wastewater recycling regained access to European markets, while ceramic manufacturers in Morbi participating in GIZ-led energy efficiency programs reduced costs and improved competitiveness. These cases demonstrate how voluntary ESG adoption is not just about meeting global expectations, it is about securing resilience, growth, and long-term success.

For MSMEs, ignoring ESG reporting can carry serious risks. Large companies now need detailed supply chain information to meet rules like India's BRSR or the EU's CBAM. If smaller suppliers cannot provide this data, they may lose contracts, be replaced by more transparent competitors, or see their goods treated as more polluting through the use of higher default carbon values in export markets. Over time, as ESG requirements expand in India, MSMEs that delay adapting will face steeper costs and less time to adjust ultimately putting themselves at a disadvantage in both local and international markets.

Policy and Institutional Support for Greening MSMEs

- The greening of MSMEs in India is not only being shaped by market pressures but also actively supported through government schemes and international collaborations. Over the past decade, several initiatives have been launched to help MSMEs adopt cleaner technologies, improve efficiency, and align more closely with sustainability and ESG expectations.
- One of the flagship initiatives is the Zero Defect, Zero Effect (ZED) Certification, which encourages MSMEs to improve product quality while minimizing environmental impact.
- Beyond its focus on manufacturing excellence, ZED directly enhances the environmental and social credibility of MSMEs, making them more compatible with ESG frameworks and strengthening their visibility in corporate supply chains.
- The Credit Linked Capital Subsidy Scheme (CLCSS) has eased the adoption of energy-efficient technologies by reducing capital investment barriers. By enabling smaller firms to replace outdated machinery with modern, efficient alternatives, the scheme directly reduces carbon footprints$_2$ an environmental metric increasingly scrutinized in ESG reporting and BRSR disclosures.
- Technology Centres provide targeted technical support in industries like foundries, auto components, and leather. These centres not only drive process innovation but also help MSMEs meet labor, safety, and product standards, thereby aligning with the social and governance dimensions of ESG.
- At the same time, India's big push for renewable energy is opening fresh opportunities for MSMEs. The government's supportive solar rooftop policies, the rapidly falling cost of solar panels, and the recent drop in battery prices, clean energy is becoming much more affordable. For smaller businesses that spend heavily on

electricity, switching to solar can mean big savings on power bills while also cutting their carbon footprint. This not only helps MSMEs run more efficiently but also boosts their credibility with customers and buyers who are looking for greener supply chains.

- International collaborations have also been instrumental. UNIDO-GEF projects facilitated the replacement of polluting furnaces with cleaner induction technologies in foundry clusters, while GIZ cluster programs in Morbi and Tirupur introduced systematic energy audits and efficiency upgrades. Such cluster-level interventions create replicable models for reducing emissions, cutting costs, and enhancing compliance with sustainability certifications demanded in global value chains.
- Together, these initiatives highlight how policy and institutional support is bridging the gap between MSMEs' operational realities and the broader ESG ecosystem. By preparing MSMEs for reporting frameworks like the Business Responsibility and Sustainability Report (BRSR) and future ESG-linked regulations, these schemes are helping small enterprises transition from being seen as high-emission hotspots to becoming credible, sustainable partners in India's climate and development goals.

These interventions show that with the right policy push, MSMEs can transition to greener operations.

Conclusion

Greening MSMEs is not only about protecting the environment, but it is equally an economic and strategic necessity. Given their central role in exports and value chains, the way MSMEs operate has direct consequences for both corporate competitiveness and India's broader sustainability goals. With frameworks like BRSR gaining prominence and ESG compliance becoming the global norm, MSMEs are steadily being drawn into the sustainability ecosystem.

At the same time, their carbon footprint cannot be ignored. Left unchecked, emissions from MSMEs could undermine India's Net Zero ambitions. Yet, with the right mix of financial support, technical guidance, and policy interventions, these enterprises can shift to cleaner, more efficient models. Voluntary ESG adoption, cluster-based innovations, and sector-specific solutions present practical and achievable routes forward.

In the long run, a greener MSME sector will not only secure India's position in global trade but also make a significant contribution to meeting the Sustainable Development Goals (SDGs) and climate targets. By turning today's challenges into opportunities, MSMEs can evolve from being seen as carbon-intensive hotspots to becoming vital drivers of sustainable growth.

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Building Climate Resilience through Restoring Health of Waterbodies: A Case Study of Moradabad

Madhukar Swayambhu, Head R &D at Vaidic Srijan

Abstract

Moradabad city is often referred as the 'Brass capital' of India. Every home is involved in brass-based handicraft and both side of the city there are brass manufacturing industrial corridors. so much of metal work had its impact on the natural resources too. All Waterbodies were contaminated with efluent, Air Quality Index was bad (beyond permissible limits, above 300 since year 2017), ground Water was report depleting since year 2009, major biodiversity loss was observed and every monsoon there was an outbreak of vector-borne diseases. Urban flood & Water logging was also a common phenomenon post monsoon.

We got a project in April 2022, for 'in-situ' rejuvenation of six Waterbodies spread across the city on the periphery, through our Nature-based Solution (NbS) that we call as 'Cownomics Technology', wherein we focus on 'resurrection of the native ecology' of the Waterbodies & wetlands with a clear objective of 'restoration of the 'ecosystem services'.

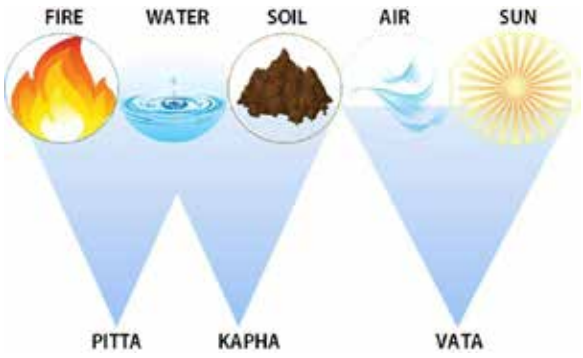
As a result, the ground Water recharge was reported by August, 2022. There was steep decline in post monsoon vector-borne diseases (as observed and reported by the residents in the vicinity). They won the National Award for Best work in Air pollution mitigation (for last 360 days their AQI is recorded below 80). Return of birds, bee, butterflies and aquatic life has been observed in all ponds. And the Water quality is maintained as per IS 2296, class B category for outdoor bathing Water, as per the guidelines of National Green Tribunal (NGT).

Approach

Vaidic Srijan LLP is a Climate Tech startup, who has developed Cownomics- Technology, for resurrection of the native ecology of Soil, Water and Air, through the Waterbodies. It restores the "ecosystem services" of the Waterbodies & Wetlands, "in-situ" conditions, without diverting the inlets, irrespective of the type / kind of the wasteWater inputs. Be it sewage (treated or untreated), industrial efluent, agri- fields run offs or even storm Water, anything coming in the Waterbodies, carrying a lot of contaminants and nutrient overload. All this can be brought back to the cycle, since nature doesn't have any concept of waste or wealth. The rejuvenated Water gets transformed into neuro-immuno booster for plants and animals, thus if the same Water is used in Agriculture, Aquaculture and Animal husbandry, the farms go chemical and antibiotics free reducing the input cost and multiplying the yield. In short, the farms go diseases, pests and weather resilient.

Based on Vaidic Sciences, the Cownomics$_2$ philosophy is similar to Ayurveda. Like every human body is considered to be a separate individual ecosystem based upon the "three Gunas" of "Vata, Pitta and Kapha" which are in-turn derivatives of combination of "Pancha Mahabhootas", as show in the Figure -1 below, The Cownomics$_2$ approach is a step before the "three Gunas" because herein we are dealing directly with the Soil, Water and Air, through the other two of the "Panch Mahabhootas".

Figure-1, Constituent element of the "three Gunas"



The Problem

We've been considering Waterbodies as just a pool or reservoir of Water and that's why we take an approach of "cleaning" or "beautification" of the lakes & ponds, or even the "river front development projects" are focused towards the same goal.

We should've pondered about the Nature's plan too, in order to build a holistic understanding of the whole approach. When the globe was already 73% covered with Water in form of sea and oceans, what was the need to create landlocked Waterbodies in form of river / rivulet / ponds or lakes?

The answer to this question can be understood with the very concept of "ecosystem services".

Waterbodies are conjunction points of Soil, Water and Air, and the exchanges between these layers provides plethora of ecosystem services to the vicinity, understanding which will not just help us resolving the Water stress in the most sustainable and holistic way, but also solve many other global issues, some of which we don't even perceive to be related with Water, e.g., we have a problem of overcrowded cities with depleting natural resources. Bad Air quality, sewage, biodiversity losses, drinking Water availability, polluted Waterbodies, increasing GHG emissions, sanitation & hygiene issues, depleting agricultural production and declining farm profitability, Chemicals & Antibiotics in Human food chain, floods & droughts, Water logging and so on.

All these problems are the chain reaction of Water, Soil and Air getting contaminated. And therefore, a holistic & sustainable nature-based solution can solve all of them in one go. This is where we step in as the only solution that solves plethora of issues in one go.

The Solution & it Approach

There are various ecosystem services provided by waterbodies and wetlands, and we restore all of them through our projects, including $_2$ Aquifer Correction and Recharge, Flood and Drought Mitigation and avoiding water logging in the vicinity. Maintaining a healthy aquatic life, and aquatic food chain.

Consumption and Digestion of the nutrients ensuring the phenomena of eco-dredging through which the bottom deposits of sludge get consumed and the natural water holding capacity gets maintained.

Photosynthesis within the aqua-ecology by autotrophic microbes resulting carbon sequestration and oxygenation of the atmosphere in the vicinity, also creating a blue carbon sink. Maintaining low ambient temperature in the vicinity to nullify UHI and PVHI effects. Air pollution mitigation. Biodiversity conservation. Safeguarding the vicinity from outbreak of Water and vector borne diseases. Making highly potent water available for aquaculture, agriculture and animal husbandry.

Following are some of our inventions, that we utilize in a project, after conducting the detailed study of the subject and collection of field data $_2$

1. Cownomics : Technology: resurrection of native ecology of Waterbodies & Wetlands to restore the ecosystem services from them, impacting Soil, Water, Air, Biodiversity, Ground Water correction & Recharge, outbreak o f Water, Vector and Air pollution borne diseases in the vicinity
2. Ecolining : The use natural biodegradable substance as a catalyst to speed up the process of establishing an equilibrium between Soil, Water and Air in order to enable Water retention in a freshly built Water structures
3. EcoDredging : In-situ decomposition and consumption of the bottom sludge deposits in any natural waterbody or wetlands to be rearranged for production of planktons to strengthen the aquatic food chain
4. EcoDrainR : The process of in-situ Rejuvenation of the natural flowing drain (non-concretized and non-covered) through plantation of shrubs and hedge plantation on the drain embankment to keep the water quality controlled "in-situ" conditions, to be discharged in a natural Waterbody.
5. Symbiotic Sustainable Agriculture: Is the technique developed by VSLLP, in which the Water is rejuvenated, and used as a foliar spray on the plants, using them as a tool to impact Soil and Air, since they are on the conjunction point of Carbon & Nitrogen cycle with roots in Soil and leaves in Air.

Using rejuvenated Water as foliar spray on them impacts both Soil & Air, giving rise to a micro-climate in the farm. The farm goes chemical & antibiotic free and disease, pests and weather resilient, also making the farmer grow profitable and economically strengthened.

The Process

the approach is to carefully study the Waterbody / wetland first. For the study, certain inputs are required form the site, based on which the analysis is conducted. Thus, for defining the methodology, following steps could be defined

A. Conducting the study of the Waterbody (key points are explained in Annexure).

B. Based on the study, the key ingredients of the liquid concentrate called "Cownomics$_2$ Extract" is prepared, which is a 100% botanical / herbal preparation.

C. This concentrate is shipped to the location, along with the prescription of amalgamation ratio. The concentrate is amalgamated with fresh water from the same agroclimatic zone to increase the receptivity of the Waterbody for the herbal concoction.

D. The homogenous mix of the concentrate amalgamated with the fresh Water is poured in the Waterbody, in early morning hours, during sunrise.

E. The sunlight exposure enables the aqua-ecology to synthesize the herbal concentrate and the process of "Resurrection of the Native Ecology" starts to happen naturally.

The Treatment Phases

1 Phase-1: The Resurrection: the complete treatment process is focused upon resurrecting the native microbiota of the wetland / Waterbody. The phase lasts for a period of three (3) months, during this phase the foul smell & the mosquito population dwelling in the Waterbody gets eradicated. I laboratory reports, there's a substantial improvement show in the TDS, TSS and COD values. The Water viscosity gets reduced, color becomes lighter and the transparency improves. Waves are back the still water in this phase itself.

2 Phase-2: The Restoration: In this phase, because the native microbiota is already resurrected, the focus now shifts towards reestablishing the soil capillary link to aquifer through complete consumption of the sludge deposits. From the surface, the Water level appears to be lowering down or receding. Some people might take it as drying of Water, but that's no the real process. The sludge deposited in the bottom, is getting consumed and digested due to the eco-dredging process and Water is reclaiming the space. Thus, the more sludge gets consumed, the deeper the waterbody will become. Basically, we can call it "Restoration of the Water holding capacity of the Waterbody. Again, the phase lasts for three (3) months.

3- Phase-3: The Rejuvenation: In this phase (lasting for six (6) months) the metabolic rate of the Waterbody for digestion of contamination is calibrated with the daily fresh incoming load of pollution / contamination, i.e., if the inlet of fresh sewage is 10MLD, the digestion capacity is adjusted to suit the same on a daily basis. This complete full one year of treatment, and the Waterbody is back to its native state.

Projects & Impact so far

Since inception of the technology, they've completed 40+ projects across the country and at least 15-20 are always ongoing for last 1.5 years, spread over 28 cities / towns, in 13 states of the country, restoring 100+ million liters of sewage, back to usable Water. Saving 100+ acres of Waterbodies across the country, over 3 million people from Air pollution and associated diseases, over 2 million people from Water & Vector-borne diseases, recharging over 100+ million liters of Water and conserving 50+ native species of biodiversity.

We've earned the following award in our journey so far - Most Innovative New technology of the Year, CII National Award for Excellence in Water Management, Best environmental Startup, ESG enabler technology of the year, Nature Care Award, Technology & Implementation Partner for AMRUT 2.0, "Idea Worth Spreading" TED, Global Top 3 Author by SWM - Spain, Water Hero Award by MoJS in October, 2019.

Building Credible Carbon Markets:

The Intersection of India's Climate Finance Taxonomy and Global Frameworks

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1. Introduction

Climate change and the global push towards net-zero emissions have elevated carbon markets to the centre of international climate finance debates. As countries seek to mobilise private capital for the green transition, the question of what qualifies as "green" or sustainable finance has become pivotal. Taxonomy frameworks have emerged as essential legal tools to provide this clarity. They establish common definitions for environmentally sustainable activities, prevent "greenwashing," and enable cross-border comparability of investments. India's Draft Climate Finance Taxonomy explicitly situates itself within this global movement, emphasising interoperability with other international regimes and aiming to channel finance toward low-carbon pathways while remaining aligned with domestic priorities. The ASEAN Taxonomy for Sustainable Finance, designed around a two-layered Foundation Framework and Plus Standard, offers a flexible yet science-based classification system that accommodates diverse member states while supporting transition finance and regional carbon market linkages. By contrast, the EU Taxonomy represents the most prescriptive and binding model, requiring financial institutions and corporates to disclose the proportion of their activities aligned with strict technical screening criteria across six environmental objectives. Against this backdrop, India's forthcoming Carbon Credit Trading Scheme (CCTS) raises important legal questions about how carbon credits and offsets are to be treated within such taxonomic frameworks. This article examines the intersection of carbon credit trading with the Indian taxonomy, situating it within comparative perspectives from ASEAN and the EU, and highlights the implications for law, policy, and the design of credible, internationally accepted climate finance systems.

2. Carbon Credit Trading in India's Draft Climate Finance Taxonomy

India's Draft Climate Finance Taxonomy represents a significant step in building a credible domestic framework for climate finance while aligning with global standards. It combines qualitative principles with quantitative performance thresholds to guide investment toward mitigation, adaptation, and transition, and it explicitly positions itself as a safeguard against greenwashing. Thresholds are framed in terms of emission reductions, efficiency improvements, and best-in-class benchmarks, with disclosure obligations making robust measurement, reporting, and verification a central feature of the framework. The draft also makes clear its strategic orientation, setting objectives that connect Net Zero by 2070 with

the broader developmental vision of "Viksit Bharat 2047," and emphasising science-based criteria that support transition activities in hard-to-abate sectors.

In terms of sectoral scope, the taxonomy prioritises power, mobility, and buildings as the initial focus for mitigation, while also incorporating adaptation co-benefits. Agriculture, food, and water are identified as priority areas for resilience, and targeted transition pathways are set out for industries such as steel and cement. Transition is further operationalised through a three-tier structure, including a "Transition Supportive" category for activities that reduce emission intensity where absolute decarbonisation is not yet technologically or economically viable. This feature reflects an effort to balance ambition with pragmatism, while requiring strong disclosure to avoid stranded assets.

The taxonomy is closely linked to India's evolving carbon market architecture. The Carbon Credit Trading Scheme (CCTS), notified under amendments to the Energy Conservation Act in 2022–23, extends market-based incentives beyond the PAT scheme and now applies to nine energy-intensive sectors. Although the taxonomy itself does not treat carbon credits as taxonomy-aligned instruments, it acknowledges the policy context in which CCTS will operate, creating a complementary relationship between the two. The taxonomy provides the definitional and disclosure backbone for financing low-carbon projects, while the CCTS supplies the market signal, together opening compliance-driven and voluntary pathways for investment.

This dual-track approach is not without challenges. Verification, double counting, and the robustness of MRV frameworks remain pressing concerns. The draft explicitly positions itself as an anti-greenwashing tool, requiring transparent and objective methodologies, and implicitly recognising that without strong governance, carbon credits risk undermining credibility. The success of India's taxonomy will therefore depend not only on its classification criteria but also on its ability to integrate effectively with the CCTS while maintaining integrity and international interoperability.

3. ASEAN Taxonomy and Carbon Credits

The ASEAN Taxonomy for Sustainable Finance, Version 3 (2024) represents a pragmatic and regionally adaptive approach to sustainable finance. It adopts a multi-tiered structure, consisting of the Foundation Framework (FF) and the Plus Standard (PS). The Foundation Framework provides a principles-based traffic-light system–green, amber, and red–designed to classify activities at different stages of alignment with sustainability goals, while the Plus Standard builds on this by offering science-based technical criteria for activities that can qualify as fully sustainable. This dual structure allows ASEAN member states, with their wide variance in development levels and regulatory capacity, to operate under a common framework while moving at different speeds.

Unlike the Indian or European models, the ASEAN Taxonomy explicitly recognises the role of carbon credits in financing transition. The Executive Summary of Version 3 highlights that voluntary carbon markets (VCMs) can complement the region's sustainable finance architecture, particularly in hard-to-abate sectors where direct decarbonisation pathways are not yet technologically feasible. By doing so, ASEAN positions carbon credits as a legitimate transitional tool, provided that they are used alongside, rather than in place of, credible decarbonisation activities.

Regional interoperability is a core design feature of the ASEAN Taxonomy. Version 3 directly references the principles of Article 6 of the Paris Agreement, emphasising environmental integrity, transparency, and avoidance of double counting in the international transfer of mitigation outcomes (ITMOs). This explicit linkage reflects ASEAN's recognition that its taxonomy must operate within global carbon markets, and that credibility depends on harmonisation with international rules governing carbon trading.

Nevertheless, ASEAN faces structural challenges in implementing this vision. Member states differ widely in terms of national legal frameworks, institutional capacity, and readiness to adopt

uniform MRV systems. Some countries, such as Singapore, already operate advanced voluntary carbon market platforms, while others lack even the baseline regulatory infrastructure for carbon accounting. This fragmentation risks undermining the credibility of the taxonomy unless regional institutions can enforce consistent MRV standards.

The ASEAN model thus stands out as transition-friendly and flexible, with explicit recognition of carbon credits and voluntary markets, but it also highlights the risks of uneven implementation. Its success will depend on whether it can achieve not only regional interoperability but also international recognition under Article 6, thereby ensuring that ASEAN credits and taxonomy-aligned activities can be trusted and traded globally.

4. EU Taxonomy and Carbon Credits

The EU Taxonomy for Sustainable Finance is the most prescriptive and legally binding of the three regimes, grounded in Regulation (EU) 2020/852 (the "Taxonomy Regulation"). It establishes a classification system for environmentally sustainable economic activities, requiring that projects make a "substantial contribution" to at least one of six environmental objectives: climate change mitigation, climate change adaptation, sustainable use of water and marine resources, circular economy, pollution prevention, and protection of biodiversity and ecosystems. This framework is underpinned by detailed technical screening criteria (TSC) and the "do no significant harm" (DNSH) test, alongside minimum social safeguards.

Unlike ASEAN's flexible model or India's emerging integration with the Carbon Credit Trading Scheme, the EU Taxonomy does not treat carbon credits or offsets as a recognised pathway to taxonomy alignment. Instead, it places emphasis on the environmental performance of the underlying activity itself. This reflects a deliberate legal and policy choice: while the EU operates one of the world's largest carbon pricing mechanisms through the EU Emissions Trading Scheme (EU ETS), the Taxonomy Regulation and its delegated acts remain focused on financing projects that directly reduce or avoid emissions, rather than relying on purchased offsets.

The EU's disclosure architecture further reinforces this cautious stance. Financial market participants, large companies, and institutions are required under the Non-Financial Reporting Directive (NFRD) and its successor, the Corporate Sustainability Reporting Directive (CSRD), to disclose the extent of their alignment with the Taxonomy. These rules ensure that investors and stakeholders receive consistent, verifiable information about whether an activity is truly sustainable. Carbon credits, even when purchased under compliance markets like the ETS, cannot be reported as "taxonomy-aligned" because they are not considered to constitute an underlying sustainable economic activity.

This approach has earned the EU both praise and critique. On the one hand, it provides legal certainty and shields European sustainable finance from the risks of greenwashing associated with poorly governed offset markets. On the other, it is markedly stricter than the frameworks adopted by India or ASEAN, both of which recognise carbon credits as having some role in transition financing. Critics argue that this rigidity may limit flexibility for industries in transition, especially where near-term abatement options remain limited. Yet the EU's position underscores its broader philosophy: that taxonomy credibility rests on real, measurable changes in the economy's carbon footprint, not on offsetting mechanisms external to it.

5. Comparative Analysis

A comparative reading of the Indian, ASEAN, and EU taxonomies reveals important legal divergences in the treatment of carbon credits, yet also a degree of convergence around the principle of activity-level integrity.

In India, the Draft Climate Finance Taxonomy (2025) adopts an activity-based, principles-driven approach. It does not classify carbon credits as taxonomy-aligned instruments but instead keeps them outside the framework, to be operationalised separately under the Carbon Credit Trading Scheme (CCTS) notified under the Energy Conservation Act amendments of 2022-23. As clarified in the draft framework, the taxonomy is intended to be interoperable with international regimes while the CCTS is

expected to create a dual system encompassing both compliance and voluntary markets.

By contrast, the ASEAN Taxonomy for Sustainable Finance, Version 3 (2024) adopts a more transition-friendly orientation. The Foundation Framework (FF) and Plus Standard (PS) provide a dual-layer system that explicitly accommodates member states at different stages of readiness. While carbon credits are not recognised as substitutes for taxonomy alignment, Version 3 acknowledges their role as complementary instruments in voluntary carbon markets.

The European Union, in contrast, maintains the most stringent and binding legal stance. Under Regulation (EU) 2020/852, the EU Taxonomy defines environmentally sustainable economic activities by reference to "substantial contribution" to six environmental objectives, compliance with "do no significant harm" (DNSH), and adherence to minimum social safeguards. Offsets and carbon credits are excluded from taxonomy recognition, reflecting a legal policy choice to prevent greenwashing and ensure that disclosures under the CSRD/NFRD regimes are tied to direct, verifiable emissions reductions.

Despite these divergences, the three taxonomies converge legally on one critical principle: carbon credits cannot substitute for taxonomy alignment. Whether through India's separation of taxonomy and CCTS, ASEAN's complementary but non-substitutive recognition of VCMs, or the EU's outright exclusion of offsets, each system insists that taxonomy alignment must rest on the integrity of the underlying activity.

The legal common ground across these frameworks is provided by Article 6 of the Paris Agreement, which governs cooperative approaches and the transfer of mitigation outcomes. Article 6.2 emphasises environmental integrity and avoidance of double counting, while Article 6.4 sets out the framework for a new international crediting mechanism. Each taxonomy implicitly or explicitly draws on these principles to ensure that carbon markets, while valuable for financing, do not erode the credibility of green finance classifications. For India in particular, embedding Article 6 safeguards into both its taxonomy and CCTS will be essential to gaining acceptance from ASEAN and EU investors, whose taxonomies already reflect this principle of legal integrity in sustainable finance.

6. Implications for India

The intersection of India's Climate Finance Taxonomy with its evolving Carbon Credit Trading Scheme (CCTS) carries several important legal and policy implications. First, it situates India at the center of the global debate on how emerging economies can use carbon markets to finance transition without compromising credibility. If the taxonomy and the CCTS are implemented with weak verification standards, India risks creating a "junk carbon market," which could damage investor confidence and limit opportunities for interoperability with ASEAN and EU frameworks. Conversely, a taxonomy that integrates rigorous measurement, reporting, and verification protocols, clear disclosure obligations, and credible dispute-resolution mechanisms would enhance trust and make Indian credits attractive for international investors.

Second, harmonisation is essential. India's taxonomy must align with Article 6 of the Paris Agreement, particularly the principles of environmental integrity and avoidance of double counting, if it wishes to participate meaningfully in global carbon markets and attract cross-border capital. The EU's exclusionary approach to offsets means that Indian credits will only be bankable in Europe if backed by robust activity-level standards. ASEAN, by contrast, provides India with an immediate opportunity for regional cooperation, given its openness to voluntary carbon markets and transition financing. By strategically aligning with ASEAN, India can build regional interoperability while gradually moving toward the level of credibility demanded by European investors.

Third, India's taxonomy creates a distinctive financing pathway for transition sectors such as steel and cement. By classifying certain activities as "transition supportive" and linking them to both compliance and voluntary credit markets, India can mobilise private capital into sectors where full decarbonisation is not yet technologically or economically viable. This

offers a model for other developing economies, but it also requires careful legal safeguards to ensure that credits complement, rather than substitute for, structural emissions reductions.

Finally, there are significant institutional implications. Effective implementation will require coordination among multiple regulators, including SEBI, RBI, and the Ministry of Power, as well as alignment with India's international commitments. Without such convergence, the taxonomy risks remaining only a paper framework. With effective coordination, however, India has the potential to position itself as a regional hub for sustainable finance, bridging the EU's stringent standards with ASEAN's flexible transition framework, and advancing its ambition to play a leading role in global climate governance.

Risks for India

While India's draft taxonomy and carbon market architecture present opportunities, they also carry significant risks that could undermine credibility if not addressed. A primary concern is investor skepticism. International capital providers, particularly in Europe, remain cautious of offset-based markets and may view Indian carbon credits as insufficiently robust unless supported by internationally recognised MRV systems. This creates the risk that Indian instruments are sidelined in global finance flows despite the existence of a taxonomy.

There is also the risk of political and institutional pushback. Implementing stringent disclosure and verification requirements could impose additional costs on domestic industries, leading to resistance from sectors already struggling with competitiveness. In the absence of strong regulatory will, this could result in dilution of standards and a widening gap between stated taxonomy principles and practical enforcement.

Capacity constraints pose another challenge. Ensuring consistency in MRV across multiple sectors and regions requires a high degree of technical expertise and institutional resources. Fragmented governance across agencies such as SEBI, RBI, and the Ministry of Power could exacerbate these constraints, weakening India's ability to demonstrate integrity in its carbon markets.

Finally, there is the reputational risk of greenwashing. If India's taxonomy and CCTS fail to prevent double counting or allow low-quality credits into the market, it could trigger loss of credibility not only in international markets but also in domestic investor circles. Such outcomes would not only undermine the taxonomy's objectives but could also harm India's positioning as a serious player in the global climate finance landscape.

7.WayForward&Recommendations

To ensure India's Climate Finance Taxonomy and Carbon Credit Trading Scheme (CCTS) are credible, effective, and internationally interoperable, the following measures are recommended:

- Harmonise Taxonomies and Align with Article 6: Align India's taxonomy with international standards (EU, ASEAN) and explicitly integrate Article 6 of the Paris Agreement into domestic laws to ensure environmental integrity, prevent double counting, and facilitate cross-border capital flows.
- Strengthen Legal & Regulatory Frameworks: Embed robust MRV protocols, disclosure obligations, and dispute-resolution mechanisms within the Carbon Credit Trading Scheme to safeguard against greenwashing and enhance investor confidence.
- Establish a Dedicated Carbon Market Regulator: Create a specialised regulatory authority to oversee carbon credit issuance, market operations, and compliance with taxonomy standards, ensuring consistent governance and accountability.
- [2] Foster ASEAN Collaboration: Develop regional VCM infrastructure, share MRV best practices, and enable mutual recognition of carbon credits to support transition financing.
- Engage EU Investors: Ensure transparency, adherence to "Do No Significant Harm" principles, and activity-level integrity so that Indian credits meet the expectations of stringent European investors.

- Enhance Regulatory Coordination & Capacity: SEBI, RBI, Ministry of Power, and other agencies should align oversight, build technical expertise, and support credible implementation across sectors.
- Mobilise Transition Finance: Leverage the "Transition Supportive" category to direct private capital toward hard-to-abate sectors such as steel and cement, ensuring credits complement structural emission reductions rather than substitute for them.

8. Conclusion

Carbon credit markets play a critical role in financing the global transition to a low-carbon economy yet they remain inherently complex and contentious. Robust taxonomy frameworks provide the legal clarity and credibility necessary to guide investments, prevent greenwashing, and ensure that climate finance delivers genuine environmental impact. For India, designing its Climate Finance Taxonomy in alignment with both domestic priorities and international standards through constructive engagement with ASEAN and EU frameworks will be essential to securing cross-border acceptance, mobilising private capital, and establishing a credible, globally recognised carbon credit trading system.

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Advancing Carbon Markets and Sustainability in India

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Introduction

As the world grapples with the challenges of climate change, carbon markets have emerged as a crucial mechanism to reduce greenhouse gas (GHG) emissions. India, as a rapidly developing economy with a growing population and expanding industrial infrastructure, faces a dual challenge: ensuring economic progress while mitigating environmental impact. The rising demand for energy, transportation, and urban expansion places immense pressure on natural resources, making carbon trading an essential tool for balancing industrial growth with sustainability.

India's increasing industrialization contributes significantly to its carbon footprint, necessitating effective strategies to regulate emissions. Carbon markets offer a structured approach by incentivizing businesses to invest in cleaner technologies and trade carbon credits to offset emissions. With a population exceeding 1.4 billion and an ever-growing energy demand, integrating carbon markets with national policies is critical for steering the country towards a low-carbon economy. By leveraging market-based mechanisms, India aims to reduce emissions, attract green investments, and create a sustainable industrial ecosystem that aligns with its long-term environmental commitments. India, as a rapidly developing economy, is making significant strides in integrating carbon markets with its sustainability goals. By leveraging market-based mechanisms, India aims to balance economic growth with environmental responsibility.

Understanding Carbon Markets

Carbon markets function by setting a cap on emissions and allowing businesses to trade emission allowances. These markets can be classified into compliance markets, driven by regulations, and voluntary markets, where businesses and individuals trade carbon credits to offset emissions.

India has primarily engaged with international carbon markets through the Clean Development Mechanism (CDM) under the Kyoto Protocol. However, with the adoption of the Paris Agreement, the country is focusing on developing domestic carbon trading mechanisms to enhance its sustainability framework.

Carbon markets play a pivotal role in promoting sustainability in India by incentivizing industries and businesses to adopt environmentally friendly practices. By facilitating the trading of carbon credits, these markets encourage investments in clean technologies, such as renewable energy and energy-efficient processes. This not only helps businesses reduce their carbon footprints but also makes sustainable practices more economically viable. Additionally, carbon markets contribute to reducing industrial emissions by motivating enterprises to enhance energy efficiency, thereby aligning with India's broader sustainability goals. The ability to trade excess emissions reductions ensures a more flexible and cost-effective approach to emission control, fostering a greener industrial sector.

Moreover, carbon markets reinforce corporate environmental responsibility by encouraging organizations to voluntarily offset their carbon footprints. This is particularly significant in the context of Environmental, Social, and Governance (ESG) standards, which have become critical benchmarks for businesses worldwide. Companies actively participating in voluntary carbon markets demonstrate a

commitment to sustainability, improving their brand reputation and attracting eco-conscious investors. Furthermore, these markets support India's climate objectives, particularly its pledge to achieve net-zero emissions by 2070. By integrating carbon trading mechanisms with national sustainability policies, India can accelerate its progress toward cleaner development while maintaining economic growth.

India has introduced several policies and initiatives to foster carbon trading and sustainability:

1. Perform, Achieve, and Trade (PAT) Scheme [2] A market-based mechanism that encourages industries to improve energy efficiency and trade excess savings as Energy Saving Certificates (ESCerts).
2. Renewable Energy Certificate (REC) Mechanism [2]A system to promote renewable energy generation and trade renewable energy credits.
3. The Green Credit Program [2]Introduced under the National Action Plan on Climate Change (NAPCC) to incentivize carbon sequestration and emission reductions.
4. National Carbon Market [2] Announced in 2022 to integrate and expand existing mechanisms into a unified platform for emissions trading.

Role of Carbon Markets in Sustainability

Carbon markets play a significant role in advancing sustainability in India by:

- Encouraging Green Investments: Companies investing in clean technologies and renewable energy sources can generate carbon credits, attracting investments. By facilitating the trading of carbon credits, these markets provide financial incentives for organizations to transition to sustainable practices, such as adopting energy-efficient equipment and integrating renewable energy solutions into their operations. This ensures that green investments are not just environmentally responsible but also economically rewarding. As more businesses recognize the economic advantages of sustainable investments, the demand for cleaner energy solutions will increase, accelerating India's transition to a low-carbon economy.
- Reducing Industrial Emissions: Industries are motivated to adopt energy-efficient technologies to reduce carbon footprints and enhance competitiveness. By participating in carbon markets, businesses can identify cost-effective strategies to cut emissions, including optimizing energy use and shifting to cleaner production processes. This reduction in emissions aligns with India's long-term sustainability goals and helps industries remain competitive in the global market, where low-carbon practices are increasingly prioritized. Additionally, by lowering dependence on fossil fuels and adopting cleaner alternatives, industries can mitigate risks associated with fluctuating fuel prices and regulatory pressures.
- Enhancing Corporate Responsibility: Businesses participating in voluntary carbon markets demonstrate commitment to environmental, social, and governance (ESG) principles. By offsetting their emissions through carbon trading, organizations can build stronger reputations, enhance stakeholder trust, and meet international sustainability standards. The rise of ESG-driven investments also means that companies prioritizing sustainability gain better access to capital and long-term growth opportunities. Furthermore, businesses that proactively engage in carbon trading can distinguish themselves in the market, attract sustainability-conscious consumers, and align with evolving global environmental policies.
- Supporting India's Climate Goals: Aligning with India's commitment to achieve net-zero emissions by 2070 and meet Nationally Determined Contributions (NDCs) under the Paris Agreement. The establishment of well-regulated carbon markets enables India to systematically reduce its emissions while maintaining economic development. By integrating carbon trading mechanisms with national sustainability policies, India can create a structured approach

to emission reductions, ensuring a balance between industrial progress and environmental conservation. Additionally, as India strengthens its carbon market framework, it can position itself as a leader in international climate negotiations, leveraging its expertise to shape global sustainability policies.

Challenges and the Way Forward

Despite progress, India's carbon market faces several challenges:

- Regulatory Framework: The absence of a comprehensive carbon trading policy limits the market's efficiency. A lack of clear policies and regulatory frameworks makes it difficult for industries to fully participate in carbon trading, creating uncertainty and reducing market effectiveness.
- Market Awareness: Many businesses lack knowledge about carbon trading and its benefits. Without proper awareness and education, industries may not be able to capitalize on the opportunities presented by carbon markets, limiting the growth and effectiveness of emission reduction initiatives.
- Standardization Issues: Varying methodologies for measuring and verifying emissions reductions create inconsistencies. To enhance the credibility of carbon markets, a uniform approach to carbon credit certification and validation must be developed.
- Global Market Integration: Aligning domestic mechanisms with international standards is essential to facilitate seamless global trade in carbon credits. India must work towards harmonizing its carbon trading system with global best practices to attract international investments and expand its carbon market reach.

To address these challenges, India must:

- Establish a robust regulatory framework for a transparent and efficient carbon market.
- Enhance capacity-building programs to educate industries on carbon trading benefits.
- Develop a standardized measurement and verification system to ensure credibility.
- Encourage public-private partnerships to drive investments in green technologies.

Conclusion

India's transition toward a sustainable future is closely linked to the evolution of its carbon markets. Over the past decade, the country has made remarkable progress in establishing policies and mechanisms to integrate sustainability into its economic framework. The successful implementation of initiatives like the PAT Scheme, REC Mechanism, and the National Carbon Market demonstrates India's commitment to reducing its carbon footprint while fostering industrial growth. As the nation advances, the continued expansion and refinement of these markets will play a crucial role in achieving its long-term sustainability objectives.

Looking ahead, India has the opportunity to emerge as a global leader in carbon trading and climate action. By embracing innovation, enhancing regulatory clarity, and fostering collaborations between the public and private sectors, the country can unlock the full potential of carbon markets. With increasing investments in green technologies and a robust policy framework, India is well-positioned to not only meet its net-zero targets by 2070 but also to set an example for other developing nations. The path forward lies in scaling up efforts, ensuring inclusivity in climate policies, and leveraging carbon markets as a powerful tool to drive economic prosperity and environmental stewardship.

From Crops to Carbon Credits: Unlocking Agrivoltaics for India's Clean Energy Transition

Phoolvi Agarwal, Co-Founder Hyon Energy

1. Renewable Purchase Obligations (RPOs) in India

1.1 Definition

Renewable Purchase Obligations (RPOs) are mandated under the Electricity Act, 2003 requiring DISCOMs, captive users, and open-access consumers to procure a specified share of electricity from renewable sources [1].

1.2 Targets

India's RPO trajectory has evolved from the National Action Plan on Climate Change (NAPCC), which targeted 15% RE share by 2020 [2]. The Ministry of Power now aims for 43.3% by 2030, including energy storage obligations [3]. As of 2023, the target stood at 23%, with a goal of 39% by 2028 [4].

1.3 Compliance Mechanisms

Compliance is facilitated through Renewable Energy Certificates (RECs), which allow entities to meet RPOs without direct procurement [2]. While most states impose penalties for non-compliance, Maharashtra offers incentives for over-compliance [1]. MNRE has also established a compliance cell to monitor progress [3].

2. Challenges Faced by States in Meeting RPOs

2.1 Structural and Operational Barriers

States face challenges due to legacy thermal PPAs, limited RE potential, and poor data transparency. For instance, Haryana and Bihar struggle to meet targets compared to RE-rich states like Gujarat and Tamil Nadu [1][4].

2.2 Rising Pressure to Reduce Carbon Emissions

a) India's RPO framework supports its climate commitments:

- Under the Paris Agreement, India pledged to reduce emissions intensity by 45% by 2030 and achieve 50% non-fossil fuel capacity [5].
- At COP26, India committed to Net Zero by 2070, necessitating aggressive RE adoption and robust RPO enforcement [6].

3. Understanding Agrivoltaics

3.1 Definition

Agrivoltaics refers to the dual use of land for solar photovoltaic (PV) generation and agriculture, enabling simultaneous energy and food production [7].

3.2 Origin & Early Adoption

- The concept was pioneered in Japan in the early 2000s by Akira Nagashima, who designed narrow-width PV modules to minimize shading and shared the design publicly in 2005 [8].
- It later expanded to Germany and France, where pilot projects explored crop compatibility, system design, and land-use efficiency [9].

3.3 Core Innovation

Agrivoltaics integrates renewable power generation with agricultural productivity,

offering a synergistic approach to land use, especially in regions facing land scarcity and climate stress [7][10].

3.4 Environmental Impacts

Agrivoltaics reduces land-use conflicts by enabling dual land use, increasing land productivity by up to 70% compared to standalone agriculture or solar installations [11]. It enhances soil moisture retention-studies show that up to 15-20% higher soil moisture is achieved under solar panels due to reduced evaporation [12]. The shade provided by panels lowers soil temperature by 2-5°C, reducing crop heat stress and improving resilience during extreme weather events [13].

By displacing fossil-fuel-based power, agrivoltaics contribute to CO_2 emissions reductions, with estimates suggesting that up to 40 tons of CO_2 can be avoided per hectare annually when solar energy is used on-site [11]. Additionally, agrivoltaics systems foster biodiversity by creating microclimates that attract pollinators and beneficial insects, especially when native vegetation is used as ground cover [12].

3.5 Economic Impacts

Farmers gain additional income by leasing land to solar developers or selling surplus electricity [14].

- Agrivoltaics enables energy cost savings for irrigation and cold storage [15].
- It boosts rural employment through solar installation, maintenance, and agri-tech services [14].
- In certain climates, agricultural yields improve due to reduced crop stress and optimized microclimates [16].
- Projects may qualify for carbon credits through verifiable emissions reductions and land-use optimization [17].

4. Agrivoltaics in India: Impacts and Potential

- Additional income: Farmers in Maharashtra and Gujarat have earned
- ₹30,000–₹50,000 per acre annually by leasing land for agrivoltaic projects or selling surplus electricity through net metering schemes [14].
- Energy cost savings: Agrivoltaics integrated with solar irrigation has reduced diesel pump usage, saving farmers up to ₹15,000 per year in fuel costs, especially in Rajasthan and Uttar Pradesh [15].
- Rural employment: Pilot projects in Punjab and Karnataka have created local jobs in solar panel installation, maintenance, and agri-tech services, with estimates of 5-7 jobs per MW installed [14].
- Improved yields: In semi-arid regions like Telangana, agrivoltaic systems have shown up to 20% higher crop yields for shade-tolerant crops like tomatoes and leafy greens due to reduced heat stress and better soil moisture [16].
- Carbon credit potential: According to analysis by the Council on Energy, Environment and Water (CEEW) and The Energy and Resources Institute (TERI), agrivoltaic installations displace roughly 1–2 tCO_2 per hectare each year, as verified under Verra's VCS and Gold Standard methodologies and at prevailing voluntary carbon market prices of US $5–10 per tCO_2 (approximately ₹410–₹820 per tCO_2), the potential revenue comes out to be ₹1,000-₹2,000 per hectare annually [57].

5. How can State Leverage Agrivoltaics:

5.1 Directly through the technological implementation:

a) Total Estimated Emission Reduction from AV Systems

- Per hectare annually:
- Estimated net savings: 2.5-4.5 tons CO_2 e/ha/year [27]
- Includes avoided emissions from irrigation, fertilization, machinery, and enhanced sequestration [27].
- Per MW installed capacity:
- Avoids ~50-100 tons CO_2 e/year compared to standalone PV + conventional agriculture [26].

Table 1: Agrivoltaics Benefits and Impacts [based on different international and national studies]

Aspect	Agrivoltaics (AV) Benefits	Fossil Fuel Reduction Mechanism & Impact
Land Productivity	Increases land use efficiency by 60–80% through dual use of land for crops and solar panels [18]	Reduces land clearing and mechanized expansion, saving ~0.5–1.2 tons CO_2e/ha/year [28]
Electricity Output	Up to 1% higher annually; up to 3% in summer due to panel cooling from plant transpiration [19]	Displaces fossil-based peaker plants; ~0.05–0.1 tons CO_2e avoided per kW installed annually [29]
Crop Yield	Up to 2× fruit yield for shade-tolerant crops (e.g., tomatoes, chilies) [20]	Reduces fertilizer use by ~20–30%, saving ~0.3 tons CO_2e/ha/year from production and transport [30]
Water Use Efficiency	50–65% higher due to reduced evaporation and cooler microclimate [21]	Cuts irrigation energy demand by ~40%, saving ~0.2–0.4 tons CO_2e/ha/year from diesel/electric pumps [31]
Financial Benefits	Dual revenue streams: ₹3–5 lakh/ha/year from crops + ₹4–6 lakh/ha/year from solar energy [22]	By using alternatives to fossil fuel there is reduction of emissions in logistics and machinery by ~15–25%, saving ~0.5 tons CO_2e/ha/year [32]
Environmental Impact	Enhances biodiversity, improves soil health, and reduces carbon emissions [23]	Avoids emissions from monoculture and intensive tillage (~0.6 tons CO_2e/ha/year) [33]
Climate Resilience	Provides shade, reduces crop stress from heat/drought, and extends the growing season [24]	Reduces fossil fuel use in climate control systems (e.g., fans, pumps) by ~30%, saving ~0.3 tons CO_2e/ha/year [34]
Emissions Analysis	- Up to 65% more CO_2 absorbed via enhanced crop biomass - Reduced inputs and energy use [25]	Net savings of 1.5–2.5 tons CO_2e/ha/year compared to conventional agriculture and standalone PV systems [35]

5.2 Meeting RPOs

a) Dual Land Use Advantage

Agrivoltaics enables the dual use of agricultural land for both crop cultivation and solar energy generation, offering a strategic solution to India's land-use constraints [36]. This model is particularly valuable in densely populated or land-scarce states such as Kerala, West Bengal, and Bihar, where competition between agriculture and infrastructure limits the availability of land for large-scale solar projects [36].

Agrivoltaics in Land-Constrained Indian States

- **Kerala:** With limited flat land and high population density, Kerala faces challenges in deploying ground-mounted solar. Agrivoltaics allows solar panels to be installed above crops like turmeric and vegetables, preserving agricultural productivity while contributing to the state's renewable energy targets [36].
- **West Bengal:** The state's fertile land and fragmented holdings make land acquisition for solar difficult. Agrivoltaic pilots, such as those near Bardhaman, have demonstrated successful integration of solar panels with rice and mustard cultivation [37] .
- **Uttar Pradesh:** Though not land-constrained overall, UP has seen innovative agrivoltaic pilots like the 200-kW Dayalbagh project in Agra, which grows brinjal, tomato, and gram under elevated solar arrays [38].
- **Maharashtra:** In districts like Jalgaon, agrivoltaics has been used to grow bananas under solar panels, improving

land productivity and farmer income simultaneously [39].

b) Distributed Generation for DISCOMs

States in India can accelerate agrivoltaic adoption by promoting farmers-DISCOM Power Purchase Agreements (PPAs), which allow decentralized solar generation on agricultural land to be directly sold to local distribution companies [40]. This model not only provides farmers with a stable revenue stream but also enables the generated electricity to count toward Renewable Purchase Obligation (RPO) targets, helping DISCOMs meet their mandated clean energy quotas [40].

Benefits of Farmer-DISCOM PPAs in Agrivoltaics

- **Decentralized Generation:** Agrivoltaic PPAs reduce reliance on centralized solar parks easing grid congestion in rural areas [41].
- **RPO Compliance:** By recognizing agrivoltaic electricity under RPO frameworks, states can incentivize local generation while fulfilling national climate commitments [42].
- **Farmer Income Diversification:** Farmers can earn through land lease, direct sale of power, or shared ownership models, improving financial resilience [43].
- **Grid Stability:** Distributed solar generation near consumption points reduces transmission losses (18.5% of total electricity generated) [46] and improves voltage profiles in rural feeders [44]. Avoiding 1 MWh of transmission loss-by shifting to distributed solar like agrivoltaics or rooftop-prevents approximately 0.8 to 1.0 tonnes of CO_2 equivalent (tCO_2e), assuming coal-based generation emits ~0.9-1.0 tCO_2 e/ MWh [46].

For example, under PM-KUSUM Component A, farmers or developers can install up to 2 MW solar plants on agricultural land and sign 25-year PPAs with DISCOMs at feed-in tariffs determined by State Electricity Regulatory Commissions (SERCs). The DISCOMs receive incentives of ₹0.40/kWh or ₹6.6 lakh/MW/year for five years, encouraging procurement from decentralized sources [45].

c) Policy Inclusion and Incentives

Explicit recognition of agrivoltaics in state renewable energy policies can unlock a suite of regulatory and financial enablers that significantly boost adoption [45]. By formally including agrivoltaics within state solar and distributed energy frameworks, governments can extend targeted benefits such as:

- Capital Subsidies: States can offer upfront financial support for agrivoltaic installations, similar to PM-KUSUM Component A and B, which subsidize decentralized solar on agricultural land [45].
- Priority Grid Connectivity: Agrivoltaic projects can be granted fast-track grid access, reducing delays and uncertainty for farmer-developer partnerships [37].
- Net-Metering Benefits: Farmers can export surplus electricity to the grid and receive credits, improving project economics and encouraging prosumer participation [48].

Such policy inclusion aligns agrivoltaics with national goals of achieving 500 GW non-fossil fuel capacity by 2030 and enhances rural energy resilience. States like Maharashtra and Gujarat have begun exploring agrivoltaic-specific provisions in their solar policies, while others can follow suit by integrating agrivoltaics into their RPO compliance mechanisms and DISCOM procurement strategies [39].

d) Decentralized RPO Fulfilment

Deploying agrivoltaics along rural feeder lines offers a strategic advantage for India's energy transition by:

- Minimizing Transmission Losses: Locating solar generation close to consumption points reduces energy loss during long-distance transmission, which can be as high as 20-25% in rural grids [37]. For example, the solar microgrid implemented in Gwalior, Madhya Pradesh, where researchers optimized a hybrid system using solar PV, diesel generator, and battery storage to serve an off-grid rural community. By

- localizing generation, the system avoided transmission losses typical of rural grids (often 20-25%) [51] and achieved lower cost per unit (estimated at ₹6.5-7.2/kWh) and the microgrid avoided approximately 0.8-1.0 tons of CO_2e per MWh compared to coal-based grid supply [52].
- Improving Cost-Effectiveness: Agrivoltaics leverages existing agricultural land and feeder infrastructure, avoiding costly land acquisition and grid extension. This makes decentralized solar more viable for DISCOMs and farmers alike [49].

e) Financial Innovation

States can catalyze agrivoltaic adoption by facilitating soft loans and green bonds, which reduce upfront capital costs and improve financial viability:

- Soft Loans: By offering concessional interest rates (e.g., reducing debt cost from 8% to 3%), states can lower the Levelized Cost of Energy (LCOE) by up to 25%, making agrivoltaics more attractive to farmers and developers [39].
- Green Bonds: Agrivoltaic projects qualify as climate-resilient infrastructure under India's Sovereign Green Bond Framework. States can issue green bonds to mobilize low-cost capital for public or community-owned agrivoltaic installations [33].
- Lower Debt Servicing: Reduced interest rates and longer tenures ease repayment burdens, improving cash flow and enabling broader participation, especially by Farmer Producer Organizations (FPOs) and cooperatives [50].

6. Pathway for Agrivoltaics to Enter Carbon Markets

6.1 Mechanisms for Carbon Credit Generation

Agrivoltaics can generate carbon credits through multiple validated pathways:

- Renewable Energy Displacement: Solar PV in AV systems replaces fossil-based electricity, avoiding ~0.69 tons CO_2 e per MWh [53].
- Crop Carbon Sequestration: Shade-grown crops like lettuce and spinach absorb up to 8 tons CO_2/ha/year [54].
- Reduced Agricultural Emissions: AV reduces irrigation energy, fertilizer use, and mechanized farming, cutting emissions by 1.5-2.5 tons CO_2e/ha/year [55].

These reductions can be quantified and certified under standards like Verra's VCS and Gold Standard.

6.2 Steps to Enter Carbon Markets [56]:

Table 2: Agrivoltaics in Carbon Market; Source: TERI

Step	Description
Adoption	Farmers install AV systems and adopt sustainable practices (e.g., agroforestry, no-till farming)
Measurement	Baseline and ongoing carbon sequestration measured using RS-GIS tools
Certification	Verified by accredited bodies (Verra, Gold Standard)
Issuance	Carbon credits issued based on GHG reductions
Market Sale	Credits sold in voluntary or compliance markets
Revenue Sharing	Income distributed among farmers, FPOs, and stakeholders

6.3 Impacts of Agrivoltaics in Carbon Markets

a) Environmental

- Enhances land-use efficiency by 60-80% [58]
- Reduces lifecycle emissions by up to 4.5 tons CO_2e/ha/year [59]
- Promotes biodiversity and soil health [60]

b) Economic

- Dual income from energy and agriculture [57]
- Additional revenue from carbon credits (₹10,000-₹30,000/ ha/year potential in India) [58]
- Reduces input costs via energy savings and sustainable practices [60]

c) Social

- Empowers small and marginal farmers through FPO aggregation [58]
- Builds climate resilience and energy access in rural areas [57]
- Supports SDGs 7 (clean energy), 13 (climate action), and 2 (zero hunger) [59]

d) Governance

- Agrivoltaics reduces greenwashing risks by linking measurable agricultural outputs with solar generation, enabling transparent MRV systems and co-benefit verification [61]
- Multi-level governance is critical to scale agrivoltaics, requiring alignment of land-use, energy, and carbon market policies [62].
- Legal frameworks must enable mixed land use, feed-in tariffs, and farmer access to carbon finance [63].
- Market transformation policies can accelerate adoption through peer-to-peer energy trading and real-time performance monitoring [64].

7. Challenges & Enablers:

7.1 Challenges of Agrivoltaics in India

Table 3: Challenges for Agrivoltaics

Challenge	Description
High Upfront Costs	Agrivoltaic systems require significant capital for solar infrastructure and land adaptation, deterring smallholder farmers [65].
Lack of MRV Infrastructure	Absence of robust Monitoring, Reporting, and Verification (MRV) systems limits carbon credit eligibility and performance tracking [39].
Policy Ambiguity	India lacks standardized definitions, tariff structures, and land-use regulations specific to agrivoltaics [66].
Limited Farmer Awareness	Many farmers are unaware of agrivoltaic benefits and lack technical capacity to manage dual-use systems [39].
Land Tenure and Use Conflicts	Unclear land ownership and restrictive land-use norms hinder deployment on agricultural plots [66].

7.2 Enablers for Agrivoltaics in India

Table 4: Enablers of Agrivoltaics

Enabler	Description
Green Finance & PM-KUSUM	Subsidies under PM-KUSUM and concessional loans can reduce upfront costs and improve adoption [65].
Blockchain & RS-GIS Tools	Emerging technologies can enhance transparency in energy generation, crop yield, and carbon tracking [39].
Clear Carbon Accounting Frameworks	Developing AV-specific carbon methodologies can unlock carbon market participation [66].
Farmer Training & Capacity Building	Government-led training programs and insurance schemes can reduce perceived risks and build trust [39].
Innovative Business Models	Shared ownership models between farmers and developers, and bifacial panels with sun-tracking, show promise [66].

8. Strategic Policy Recommendations to Scale Agrivoltaics in India

a) Formal Recognition in Energy Policy

India should formally designate agrivoltaics as a renewable energy source within national and state-level energy frameworks. This includes updating RPO compliance norms to ensure that solar energy generated from agrivoltaic systems is fully counted toward state RPO targets [67].

b) Targeted Financial Instruments

Introduce a dedicated subsidy program for agrivoltaic installations, modeled on successful schemes like PM-KUSUM. Complement this with preferential feed-in tariffs or RECs to reflect the added value of dual land use. Tax incentives and concessional financing through NABARD, IREDA, and green bonds can further catalyze adoption [68].

c) Agriculture-Energy Policy Convergence

Agrivoltaics should be recognized as a legitimate agricultural activity to protect land-use classification. States should issue crop-specific technical guidelines and support pilot deployments across agro-climatic zones to build evidence for scalable models [69].

d) Carbon Market Integration

Develop a standardized carbon accounting methodology under India's Carbon Credit Trading Scheme (CCTS) to quantify emissions reductions from agrivoltaics. Enable benefit stacking-allowing projects to earn both carbon credits and RPO compliance-and create a centralized registry for transparency and ease of trading [70].

e) Grid and Infrastructure Enablement

Streamline grid connection approvals for agrivoltaic projects, especially those near rural feeders. Update hybridisation norms to allow integration with storage systems, improving reliability and dispatchability of agrivoltaic power [71].

f) Capacity Building and Demonstration

Launch nationwide training programs for farmers, developers, and DISCOM officials. Encourage demonstration projects through partnerships with agricultural universities and Krishi Vigyan Kendras to build local capacity and trust [72].

g) Institutional Monitoring and Feedback

Establish a National Agrivoltaic Mission to monitor capacity additions, RPO contributions, and carbon credit generation. Conduct annual reviews to identify implementation barriers and refine policy instruments accordingly [67].

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The Role of Technology in Achieving Net Zero Emissions in Indian Manufacturing Organizations

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Abstract

This paper explores how emerging technologies can play a pivotal role in helping Indian manufacturing organisations achieve their net-zero emissions targets. The Indian manufacturing sector, which accounts for 23% of the country's GHG emissions, faces significant challenges in transitioning to a low-carbon future. Key technological interventions include energy efficiency improvements, renewable energy integration, AI-driven optimisation, carbon accounting SaaS tools, and carbon capture solutions. However, challenges such as insufficient data, particularly in capturing Scope 3 emissions, and high capital costs continue to hinder progress. This paper delves into these technologies, challenges, and their implementation through case studies from large corporations and MSMEs.

Introduction

The global push for net-zero emissions is reshaping the industrial landscape. India, having pledged to achieve net-zero by 2070 at the COP26 summit, is focused on transforming its key sectors, with manufacturing being one of the most critical. Manufacturing contributes 17% to India's GDP and 23% of its GHG emissions, primarily driven by energy-intensive sectors like steel, cement, and chemicals.

Role of Technology in Decarbonization

Advanced technologies such as AI, IoT, renewable energy, carbon accounting SaaS tools, and carbon capture are vital for reducing emissions in manufacturing. Despite the potential, adoption has been slow due to challenges like data collection, particularly in tracking Scope 3 emissions, and high capital costs for adopting advanced solutions.

Problem Statement

India's manufacturing sector faces a dual challenge: maintaining economic competitiveness while drastically reducing its carbon footprint.

Current Emissions Profile

As of 2021, India's manufacturing sector contributes around 23% of national GHG emissions, with steel and cement being the most emission-intensive industries. For example, the steel industry accounts for 34.8% of the sector's emissions.

Challenges in Decarbonization

1. Lack of Scope 3 Emissions Data: Many Indian manufacturers struggle to collect and report Scope 3 emissions, including emissions from their supply chain and product use. Scope 3 emissions often account for over 70% of a company's total emissions, but fragmented supply chains and the absence of standardised reporting methods hinder data collection.

2. High Capital Costs: Deploying technologies such as AI-based energy optimisation, renewable energy infrastructure, and Carbon Capture, Utilization, and Storage (CCUS) involves significant financial investment.

SMEs, in particular, need help accessing financing for decarbonisation projects.

3. Regulatory Uncertainty: While India's Perform, Achieve, and Trade (PAT) scheme supports energy efficiency improvements, a lack of solid carbon pricing or clear incentives for adopting low-carbon technologies makes it difficult for companies to invest in long-term sustainability.

Technological Interventions

A. Energy Efficiency Technologies

a. Smart Manufacturing (AI, IoT): AI-driven systems and IoT are transforming factories into more efficient and intelligent environments. Companies can track and optimise energy consumption using advanced technologies, reducing emissions significantly. Advanced predictive analytics allow companies to manage energy flows dynamically, reducing unnecessary consumption. These tools enable real-time monitoring and control of machinery and energy-intensive processes, ensuring higher operational efficiency. AI-based solutions have been reported to lead to 10-20% energy reductions, helping organisations align with their sustainability goals and reduce their carbon footprints.

b. Energy Management Systems (EMS): Digital EMS allows real-time tracking of energy use across manufacturing operations, identifying inefficiencies and areas for optimisation. These systems use data analytics to forecast energy needs and automate energy adjustments. Studies have shown that companies adopting EMS can achieve energy savings of 10-15%, which directly contributes to reduced emissions. Companies can further improve energy efficiency and operational sustainability by integrating EMS with AI and IoT.

B. Carbon Accounting SaaS Tools and AI

a. Carbon Accounting SaaS Tools for Net Zero Planning: SaaS platforms designed for carbon accounting help organizations accurately measure, report, and manage their carbon emissions. These tools are especially important for tracking Scope 1, 2, and 3 emissions, offering detailed insights into the environmental impact across the entire value chain. With these tools, companies can set net-zero targets, plan their emission reduction pathways, and ensure compliance with regulatory frameworks. SaaS platforms are built with standardised reporting features, allowing for clear tracking of emissions performance against sustainability goals.

b. AI for Emissions Reduction: AI-powered tools have the potential to transform how companies manage emissions significantly. By leveraging AI, companies can analyse complex datasets across operations, detect inefficiencies, and provide insights into emission hotspots. AI models simulate operational changes, forecast potential emission reductions, and support strategic decision-making on decarbonisation efforts. These tools are crucial in emissions tracking and optimization, particularly in energy-intensive industries like manufacturing.

C. Renewable Energy Integration

a. On-Site Solar and Wind Power: India is increasing its renewable energy capacity, and many manufacturers are adopting solar and wind energy to reduce their carbon footprints. Solar rooftop installations in India grew by 41% in 2021, with many manufacturing companies leveraging these resources to meet sustainability goals.

b. Green Hydrogen: Green hydrogen holds immense potential for decarbonising heavy industries like cement and steel. India's National Hydrogen Mission targets the production of 5 million tons of green hydrogen by 2030, positioning the country as a critical player in the global hydrogen market.

D. Carbon Capture, Utilization, and Storage (CCUS)

a. CCUS technology captures up to 90% of carbon emissions from industrial processes. UltraTech Cement, for instance, has begun pilot CCUS projects that capture carbon emissions directly from the production process.

E. Direct Air Capture

Direct Air Capture Technologies extract CO2 directly from the atmosphere at any location, unlike carbon capture which is generally carried out at the point of emissions, such as a steel plant. The CO2 can be permanently stored in deep geological formations or used for a variety of applications.

F. Closed Loop Manufacturing

Closed-loop manufacturing aims to create systems where waste and byproducts are reused within the production process:

a. Recapturing and reusing materials: This could involve collecting and reprocessing scrap material from production, or designing products so that materials can be easily recovered at end-of-life and fed back into the manufacturing process.

b. Water recycling and treatment: Many industries are implementing advanced water treatment systems to purify and reuse process water, reducing overall water consumption and wastewater discharge.

c. Heat recovery systems: These systems capture waste heat from industrial processes and use it for other purposes, such as space heating or preheating process inputs, improving overall energy efficiency.

G. Leveraging Technology for Internal Carbon Pricing

a. As organizations become more focused on decarbonisation, internal carbon pricing has emerged as an effective tool to incentivise emissions reduction across business units. Technology plays a central role in enabling companies to assign accurate internal carbon prices, track emissions costs, and implement operational changes that lower their carbon footprints.

b. AI and Analytics for Carbon Pricing Models: AI tools allow companies to assess emissions data and simulate various carbon pricing scenarios. Using AI-driven models, businesses can assign carbon prices to specific activities, such as production, logistics, or energy consumption. These models provide insights into the financial impacts of emissions, allowing companies to integrate carbon costs into business decisions.

c. Carbon Accounting Platforms for Price Assignment: Carbon accounting platforms automate emissions reporting and integrate internal carbon pricing into operational management. These platforms assign carbon costs across departments or business units based on real-time emissions data, encouraging accountability for emissions-intensive activities.

d. Blockchain for Supply Chain Carbon Pricing: Some companies are utilising blockchain technology to track emissions across supply chains, applying carbon pricing at every stage of production. Blockchain ensures transparency and traceability, ensuring that emissions are accurately accounted for and priced at every level of the value chain.

Case Studies

A. Tata Steel's Journey Towards Carbon Neutrality

Tata Steel, a leading player in the steel industry, has made significant strides toward carbon neutrality through the adoption of AI, renewable energy, and circular economy principles. By implementing an AI-based energy optimisation system, Tata Steel has reduced its energy consumption by 14% over five years. The company also integrates renewable energy into its operations and is moving toward circularity by recycling scrap metal.

Outcome: Tata Steel has achieved a 14% reduction in GHG emissions, with plans to further cut emissions by 40% by 2030.

B. UltraTech Cement: Pioneering Carbon Capture Technology

UltraTech Cement, India's largest cement producer, is pioneering carbon capture technology (CCUS) in an effort to reduce the sector's emissions. The company has implemented pilot projects in partnership with Carbon Clean Solutions and adopted waste heat recovery systems to minimise energy usage.

Outcome: UltraTech's carbon capture projects have shown promising results, with the

company aiming to reduce its carbon intensity by 25% by 2030.

C. Fitsol: AI-Driven Logistics Optimization in Auto Components Manufacturing

Fitsol, a sustainability SaaS platform focussing on manufacturing supply chain led emissions management, engaged with an Indian auto components manufacturer to optimise logistics operations using its proprietary AI tool, Kyoto. Fitsol identified inefficiencies in the usage of vehicles for shipping, which led to sub-optimal routing and excess emissions. Fitsol redesigned the network by leveraging AI-driven insights to optimise vehicle routes and logistics operations.

Outcome: Carbon emissions reduced by ~200 tCO2e per year for a single plant and annual logistics costs being cut by approximately ₹2 Crore. Fitsol is now working with the client to scale these optimizations across the entire plant's logistics operations, aiming for broader reductions in emissions and costs.

D. MSME Sector: Sustainable Practices in Small and Medium Enterprises

Shakti Pumps: Renewable Energy for Sustainable Manufacturing

Shakti Pumps has embraced solar energy across its manufacturing facilities, reducing its reliance on fossil fuels by 70%. The company also helps reduce emissions in India's agriculture sector by producing solar-powered water pumps.

Outcome: Shakti Pumps has reduced Scope 1 and 2 emissions by more than 30%.

E. GreenCo Rating System: Enabling MSMEs to Reduce Emissions

The GreenCo Rating System, developed by the Confederation of Indian Industry, supports MSMEs in adopting sustainable practices through energy audits and renewable energy integration. MSMEs participating in this program, such as Kay Jay Forgings, have achieved significant reductions in energy use and carbon emissions.

Outcome: GreenCo-certified MSMEs have reduced energy consumption by 15-20%.

F. Mahindra & Mahindra's 2019 efforts to define their carbon pricing models

Mahindra & Mahindra, a leading Indian automobile manufacturer, has been a pioneer in adopting an internal carbon price. In 2016, the company set a carbon price of $10 per ton of CO_2, which was later increased to $20 per ton.

Outcome: This internal carbon price has driven several energy efficiency initiatives, renewable energy investments, and waste reduction projects. These efforts have contributed to Mahindra's commitment to becoming carbon-neutral by 2040. The company uses this internal price to evaluate capital investments, ensure that sustainability projects receive priority, and reduce its overall carbon footprint.

Economic and Policy Implications

Cost of Decarbonization:

Decarbonising the manufacturing sector requires significant investment in renewable energy and advanced digital technologies. Access to financing is an important challenge for small and medium enterprises. However, international mechanisms such as the Green Climate Fund and domestic initiatives could provide the necessary financial support. By employing technological interventions, MSMEs could create a more transparent reporting mechanism and, as a result, become more attractive debtors.

Policy Implications:

India's regulatory landscape is evolving, but more vigorous policies are needed to incentivise green technologies. Carbon pricing, stricter regulations on Scope 3 emissions reporting, and enhanced incentives for renewable energy adoption are essential to accelerate decarbonisation efforts in manufacturing.

Future Outlook and Recommendations

Emerging Technologies:

AI, machine learning, and blockchain can revolutionise how companies track emissions and optimise processes. Furthermore, advanced materials such as graphene can create more

energy-efficient manufacturing processes. These technologies should be integrated across industries to expedite the transition to net-zero.

Policy Recommendations:

To drive widespread adoption of decarbonisation technologies, India should:

- Incentivize reduction in carbon emissions industry wide
- Implement carbon pricing to make high-carbon operations costlier.
- Incentivize the adoption of green hydrogen and CCUS technologies.
- Develop stringent policies for Scope 3 emissions tracking and reporting.

Conclusion

Technology is critical to India's journey toward net-zero emissions in the manufacturing sector. AI, renewable energy, carbon accounting SaaS tools, and carbon capture technologies can significantly reduce carbon footprints, but challenges such as data collection, high capital costs, and regulatory uncertainty must be addressed. With the right policy support and technological investment, Indian manufacturers can play a crucial role in meeting the country's net-zero targets by 2070.

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Buildings Digitized

A Key to Decarbonize Built Structures...
A Window to the Future...

Dr.(Ms.) Kanwal Kamra S, Building Physicist & Sustainability Consultant
Founding Member-Carbon Leadership Forum-Bengaluru Hub
MD: "TerraLive Envirotech Pvt. Ltd" ..Knowledge Partners - Sustainable Solutions Director Sustainability : klimArt Pvt Ltd.

Buildings where we spent most of our time to live, learn, work and play, impact our health, wellness, quality of life and happiness quotient. On the flip side, building sector is also responsible for almost 40% of GHG emissions. With climate change gaping at the world as a real threat and global GHG emissions climbing up continuously despite Paris Accord pledges signed in 2016, it is a clarion call for all stakeholders including building sector to fast forward the process of effectively decarbonizing buildings, grids, and communities. Building professionals need to come forward to support and advance collaborations, start investing resources and leverage tools & technology in a focused manner towards setting sights at net zero goals and beyond. Yes, zero carbon emissions and net zero energy use, water use, and waste.

- How can real estate sector mobilize decarbonization of the built environment here onwards?
- What are the steps being taken towards Race to Zero?
- How do we address the existing stock and the new construction and define short, medium, and long-term goals?
- What actions are most viable & progressive ones that can link sustainability metrics to financial metrics?

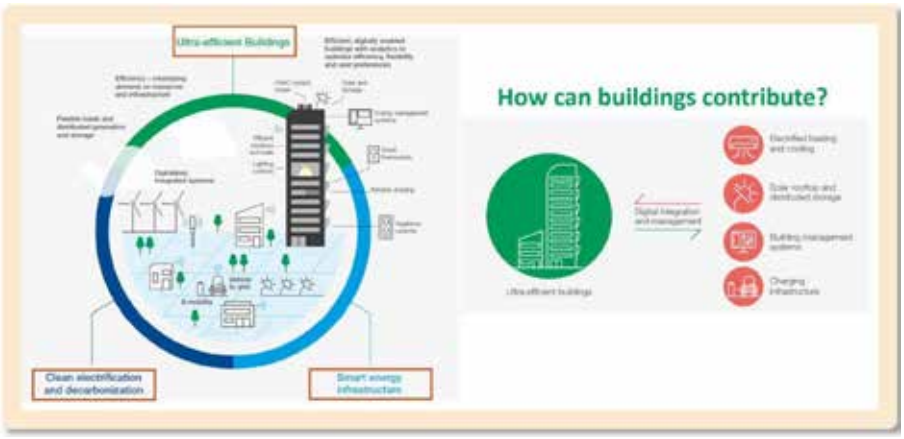
These are some of the pertinent questions that need to be addressed with urgency and sincerity.

Let us look at some of the major challenges faced in building industry: 60% of construction projects overshoot cost estimates and timelines,

Capex overrun in almost all projects is estimated to be 30% on an average, almost 30% of project cost gets spent on reworks, more than 50% of maintenance costs are caused by errors during construction as reported by TUV SUD 2020.

To overcome the inefficiencies of conventional approaches, new roadmaps are required for making new construction as well as retrofitting the heavy portfolio of the existing stock of buildings to be Net Zero and resilient following an integrated approach.

The requires that building design, construction and operations approach should shift from design- thinking to system-thinking approach keeping end goals in mind - A reverse life cycle approach. This means the architects and consultants design buildings in a way that not just surpass green building standards but also bring design excellence in building construction, procurement process and ensures highest standards for building operations and maintenance. A holistic process that passes the tests for low embodied carbon during construction & operations, ensures technical safety & performance, delivering compliance excellence while fetching maximum benefits to users, real estate owners and investors.



PC: Chungha Cha

Digitization@Design phase:

The design simulation studies from concept to detailed design, using powerful software available in the market which are capable of iterating parameters like building mass, shape & orientation, solar shading, comfort studies, daylight & lighting design, HVAC optimization, climate analysis, egress etc. can help estimate life-cycle cost analysis, compliance with global building regulations and certifications from the beginning of the project. This digital intervention proves to be a powerful method for designers to arrive at the best possible design solutions in designing buildings for given climatic conditions. Computational Fluid Dynamics (CFD) studies using such software are capable of analysing the airflows at the microscopic level, helping test and optimise the building design to achieve better performance levels be it for PUE optimization for Data Centres, heat island effect due to building mass, pedestrian comfort around the building peripheries, pollutant dispersions around buildings, for assessing building HVAC performance over the year round performance keeping user comfort according to the interior fit-outs planned, wind tunnel effects around tall buildings, health & safety compliances for the industrial buildings etc. Overall, the sustainability index of the building design is put under stringent test before going for approvals. This approach when followed as a precursor to construction stage can add immensely to the reliability factor that stakeholders can rely on.

Digitization@Construction Phase:

The digitization of design data and as-built data is bringing in next level accuracy with techniques like BIM audits, drone smart inspection and 360o laser scans, thereby creating a central digital platform that can seamlessly provide guided inspection, automated reporting & defect detection, dynamic and real-time QA/QC on a centralized platform. The drone technology, cloud-based CCTV surveillance powered by AI is being adopted fast to monitor the construction pace, quality, security, for risk aversion, automated social distance monitoring and periphery breach etc.

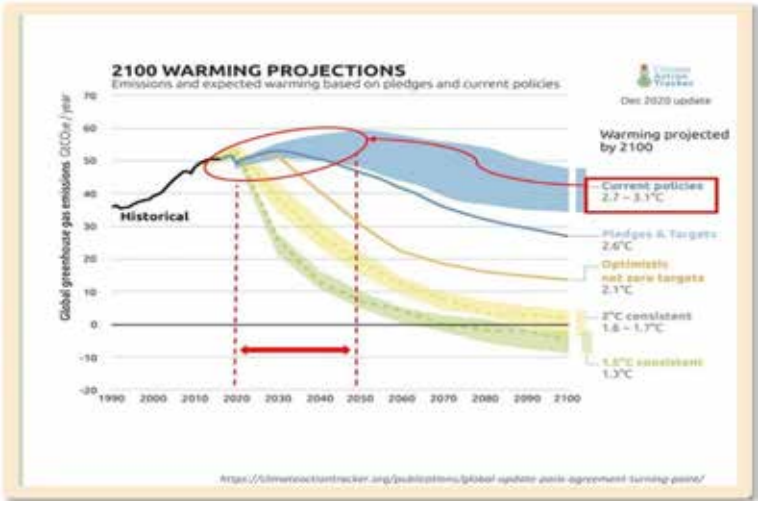
Digitization@Building Operations:

The super-efficient, digitally enabled buildings that integrate multiple parameters including energy usage, heating/cooling demand, renewable energy generation and storage, building management systems, IAQ, water demand, waste generation, space utilization, charging stations, and on top run analytics layer to optimize efficiencies, do predictive analysis with flexibility to address user preferences could be the key to decarbonization, enhanced user comfort, reduced operating cost, negligible breakdown events, prolonged life cycle of assets.

Transparent accounting of the carbon balance, looking at carbon emissions generated from energy consumption and occupant

transportation to carbon emissions avoided or offset can be achieved if all data related to Scope 1,2 and 3 could also be integrated with building performance data to reveal portfolio level carbon disclosures.

Speaking of carbon footprint reduction in buildings, the lowest hanging fruit or rather the one lying on the ground is reduction of energy consumption through the energy efficiency measures.



For Zero Energy goal, the project must generate renewable energy in amounts equal to the fossil fuel energy delivered to the project site.

Global Investors' Changing Perspective:

The Net-Zero Asset Owner Alliance, the $4trn UN-backed group of asset owners announced at the UN Secretary-General's Climate Summit on September 23rd, 2019, their commitment to transitioning their investment portfolios to net-zero greenhouse gas emissions by 2050, consistent with a maximum temperature rise of 1.5$_2$C above pre-industrial temperatures. In 2020/21, the alliance plans to advance its commitment through several tracks of work, including monitoring, reporting and verification; engagement with asset managers and corporates; policy advocacy and investment.

In 2020, BT Pension Scheme (BTPS), the UK's largest corporate pension fund, received a lot of attention when it announced a 2035 net-zero target. Victoria Barron, head of sustainable investment, says deciding to set a net-zero target "wasn't so difficult" ... more challenging part was choosing 2035 as the target date and being confident enough to announce the goal. The problem is data - "not having all the information at our fingertips".

This triggers the focus of stakeholders towards two action points:

1. Net Zero Buildings. For building sector, it is becoming clearer that the buildings need to be designed from life-cycle perspective. Leveraging digitization tools to analyse, report, assess buildings from design to construction to operation to deconstruct phases is a potential key solution.
2. Building-Digitization: It is time to weave together knowledgeable community of connected collaborators along with government & corporate policies to help create an eco- space that drives change, make available reliable, transparent, openly accessible data, and powerful tools to help building-community deliver and declare the carbon footprint of their projects.

Digital Twins will play a crucial role in the net-zero transition by enabling the creation of virtual replicas of physical systems, such as buildings, cities, and infrastructure. These digital replicas allow for real-time monitoring, simulation, and optimization of energy consumption, emissions, and resource utilization. By leveraging digital twins, organizations can identify areas of inefficiency, test scenarios for decarbonization, and implement data-driven strategies to achieve net-zero goals. This technology has the potential to accelerate the transition to a low-carbon economy, enhance sustainability, and mitigate climate change.

Carbon neutrality 2050 as a target can only be achieved when all stakeholders start focusing on what can be done NOW.

It is a clarion call for the building industry to rethink, rejig, reinvent the digital way, NOW.

Achieving Economic and Environmental goals through standardization of Carbon Markets: Exploring the potential of Blue Carbon ecosystems

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Sakshi Bisht,
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The urgent need for innovative solutions to decrease greenhouse gas emissions has been encouraged by worldwide acknowledgment of climate change. For this effort, carbon markets are platforms designed to reduce carbon emissions by allowing the trading of carbon credits. The importance of carbon market mechanisms in India has grown as the country works towards fighting climate change and promoting sustainable development. However, the current challenges, such as governance and transparency issues, compromised verification and validation processes, and a lack of clear guidelines for ecosystem-based carbon credit, hinder their effectiveness. Standardization of carbon markets is essential to address these challenges, as it creates transparency and reliability in the market. This, in turn, will encourage greater participation from both the private and public sectors and harmonize carbon pricing to reflect real market value and environmental impact.

Blue carbon ecosystems, such as mangroves, seagrasses, and salt marshes, have huge potential for carbon sequestration, mitigating climate change, and supporting biodiversity. They also protect coastal areas, offer economic benefits like fisheries and tourism, and contribute to sustainable development and human well-being (Hilmi et al., 2021). The private sector must look for ways to achieve rapid decarbonization utilizing the amazing carbon capture capacity of blue carbon ecosystems to achieve a net zero target by 2050. Beside the emission reduction, standardization of the carbon credit market via utilizing the carbon sink of forests and grasslands creates great impact. But blue carbon-carbon stored in aquatic ecosystems like mangrove forests and seagrass beds-has the potential to store five times higher than other ecosystems (Choudhary, 2024). But blue-carbon markets and projects are yet not so common and have been underdeveloped and underfunded, especially in India. Standardization and expansion of the infrastructure to supply high-quality blue-carbon credits need innovative projects and supporting tools. Economically, blue carbon projects enable the monetization of carbon credits, creating opportunities for investment in conservation and restoration efforts. Thus, preserving and restoring blue-carbon ecosystems not only supports environmental health but also offers viable economic pathways.

There are many notable international blue carbon projects (Wylie et al., 2016) that could also be replicated for the Indian carbon market. Example of some successful International Blue Carbon Projects:

- **Mikoko Pamoja (Kenya):** A community-driven project in Kenya that focuses on mangrove restoration and conservation. Financed through voluntary carbon credits, which have restored 117 hectares of mangroves, providing both carbon sequestration and coastal protection and supporting local livelihoods through activities like beekeeping and ecotourism, etc.

- **Markets and Mangroves (Vietnam):** Located in the Mekong Delta, this project integrates organic shrimp farming with mangrove conservation. Farmers are incentivized to maintain or increase mangrove coverage on their shrimp farms in exchange for premium prices for certified organic shrimp. The project has successfully combined environmental conservation with economic growth, stopping mangrove deforestation and supporting the local economy.

- **Blue Forests (Madagascar):** The Blue Forests initiative works with local communities to restore and conserve Madagascar's mangrove forests. It aims to integrate these efforts into the country's national REDD+ strategy. While still in its early stages, the project has made significant progress in securing user rights for communities and establishing the framework for future carbon credits.

- **Delta Blue Carbon Project (Pakistan):** The Delta Blue Carbon (DBC) project, launched in Sindh, Pakistan, in 2015, aims to restore the Indus Delta by planting mangroves. This public-private partnership covers 350,000 hectares and seeks to preserve biodiversity, benefit local communities, and sequester carbon.[1]

- **India Sundarbans Mangrove Restoration:** This large-scale restoration project aims to plant 6,000 hectares of mangroves in the Sundarbans, one of the largest estuarine forests in the world. It has used carbon financing under the Verified Carbon Standard (VCS) to fund activities and has successfully reduced carbon emissions while offering alternative livelihoods for local women involved in planting. The project also provides vital protection against storms and tidal variations.

Also below, we discussed some internationally notable private sectors[2] that are contributing to the blue carbon credit markets through the following projects, which could motivate the Indian MSME/ private sectors to get into the blue carbon credit markets.

- **Blue Ventures** collaborates with coastal communities in more than 120 locations around the world. The GEM project, developed by their team, is creating a user-friendly cloud-based tool called Google Earth Engine Mangrove Mapping Methodology to quickly monitor changes in mangrove cover by individuals without specialized knowledge.

- **Distributed Additive** Manufacturing (DAM) and the Worldview Impact Foundation plan to set up a "factory in a shipping container" in the Gambia to transform ocean-bound plastic waste into seedling incubators for mangrove plantings, boosting their survival rate.

- **The Nature Conservancy (TNC)** in Latin America, through its programs in Belize and Mexico, is piloting Blue Carbon Resilience Credits in Belize that will attract buyers willing to offset carbon emissions with third-party-verified metrics of carbon- and flood-reduction benefits.

- **The Ocean Foundation**, with partners including CONANP and Mexican universities, is enhancing coastal resilience in Xcalak Reefs National Park. They aim to restore seascape features like mangroves and corals to benefit the majority indigenous community and create income through blue-carbon credits.

- **Solon Capital Partners** has launched the Africa Conservation Initiative in order to support the protection and rejuvenation of the Sherbo River Estuary in Sierra Leone, West Africa. The initiative will utilize its strong connections with indigenous communities to reach both conservation

[1] Market-based solutions for sustainable development: Lessons from the Delta Blue Carbon project in Pakistan. (2023, June 5). International Growth Centre. https://www.theigc.org/blogs/climate-priorities-developing-countries/market-based-solutions-sustainable-development

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and development goals by selling carbon credits and creating new income opportunities

By applying the lessons learned from these successful initiatives, India can effectively develop its blue carbon market. The discussed blue-carbon projects could be replicated in the Indian carbon market and can advance the conservation and restoration of coastal and aquatic ecosystems. This can significantly contribute to climate goals while boosting coastal economies and enhancing community resilience. However, effective integration of blue carbon ecosystems into carbon markets requires accurate valuation and quantification of their carbon sequestration potential.

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The Role of PHDCCI Centre for Sustainability and Carbon Market Forum in Achieving Carbon Neutrality

Mithilesh Kumar, Head Centre for Sustainability and Carbon Market Forum

As global awareness of climate change intensifies, industries face increasing pressure to adopt sustainable practices and reduce their carbon footprints. The PHD Chamber of Commerce and Industry (PHDCCI) has established the Centre for Sustainability and Carbon Market Forum, which plays a pivotal role in guiding industries toward carbon neutrality and net-zero emissions.

This article explores the Centre's initiatives in sustainability assessments, carbon footprint analysis, and its broader impact on mitigating climate change.

Understanding Carbon Neutrality and Net-Zero Goals

Carbon neutrality refers to balancing the amount of carbon emitted with an equivalent amount sequestered or offset, while net-zero emissions go a step further by aiming to eliminate greenhouse gas emissions altogether. Achieving these goals is crucial for mitigating climate change and ensuring a sustainable future.

The Centre for Sustainability: Key Initiatives

The PHDCCI Centre for Sustainability and Carbon Market Forum focuses on several core areas:

1. **Sustainability Assessments:**

- The Centre offers comprehensive sustainability assessments for industries, helping them identify their environmental impact, resource consumption, and areas for improvement.
- By providing tailored reports, the Centre enables businesses to understand their current sustainability status and develop strategies to enhance their practices.

2. **Carbon Footprint Analysis:**

- One of the Centre's primary functions is to conduct detailed carbon footprint analyses. This involves measuring the total greenhouse gas emissions produced directly and indirectly by an organization.
- The Centre uses standardized methodologies to quantify emissions from various sources, including energy consumption, transportation, waste management, and supply chain operations.

3. **Training and Capacity Building:**

- The Centre conducts workshops and training sessions to educate industry stakeholders about sustainable practices and carbon management strategies.
- By equipping professionals with the necessary skills and knowledge, the Centre fosters a culture of sustainability within organizations.

4. **Collaboration with Stakeholders:**

- The Centre collaborates with government bodies, NGOs, and other stakeholders to promote sustainable policies and practices across sectors.
- These partnerships facilitate knowledge sharing and help align industry efforts with national and global sustainability goals.

5. **Market Facilitation:**

- By creating a platform for carbon trading and offsetting, the Centre helps industries access carbon markets, allowing them to invest in sustainable projects that compensate for their emissions.
- This market-driven approach incentivizes companies to adopt cleaner technologies and practices.

Impact on Industries

The PHDCCI Centre for Sustainability and Carbon Market Forum is instrumental in driving the transition of industries toward carbon neutrality:

- Enhanced Reputation: Companies that commit to sustainability often enjoy improved brand reputation and customer loyalty, as consumers increasingly favor eco-friendly practices.
- Cost Savings: Implementing energy-efficient technologies and reducing waste can lead to significant cost savings over time, making sustainability a financially sound choice.
- Regulatory Compliance: As governments enforce stricter environmental regulations, businesses equipped with sustainability strategies are better positioned to comply and avoid penalties.

Conclusion

The PHDCCI Centre for Sustainability and Carbon Market Forum is a vital player in the movement toward a carbon-neutral economy. Through sustainability assessments, carbon footprint analysis, and collaboration with various stakeholders, the Centre not only helps industries reduce their environmental impact but also fosters a culture of sustainability. As the urgency to combat climate change grows, the Centre's efforts are crucial for driving industries toward sustainable practices and ensuring a healthier planet for future generations.

The Role of Water in a Low-Carbon Future: A Comprehensive Analysis

Mohit Kumar, Sr. Assistant Secretary, PHDCCI Centre for Sustainability, Certified Water Auditor(CGWA)

Introduction

In the words of Elshorbagy, and there are other scholars who advocate the same approach as well, climate change alters the delicate balance of the hydrological cycle, causing occurrences of droughts and extreme climatic events. Such reconnections not only put human life in jeopardy but also release greenhouse gases and lead to further climate changes. For instance, human-induced water deficit deforestation and poor agricultural methodologies are largely responsible for carbon dioxide emissions to the atmosphere. In addition, changes in the amount and frequency of precipitation events can lead to more erosion of soils and higher sedimentation rates of waterbodies, both of which enhance carbon emissions. Since water interacts with climate through a variety of channels, this white paper focuses on climate markets and climate-related activities that target water projects. By stressing water conservation, efficiency, and restoration, relevant restoration and emission reduction activities can be augmented further action.

Water and Climate Change: The Water-Climate Stresses Relationship

- **Water as a Climate Change Multiplier:** Water scarcity and poor water management practices inherently contribute to the negative impact of climate change. For example, bad agricultural practices, including deforestation, result in soil erosion and poor water retention capability and agricultural viability, which all lead to increased production of greenhouse gases.
- **Climate Change and Water Resources:** It has been established that temperature elevation has the tendency to change precipitation patterns, increasing the likelihood of droughts and floods. Such occurrences create water shortages, which are necessary for agriculture, industries, households, and economic development, thereby increasing the risk of food insecurity.

Dynamics of Water Projects and Carbon Markets

Water projects can be described as having some of the easiest approaches to sequestering carbon that can also enhance climate change objectives. Some of the considerations include:

Water Conservation and Efficiency:

- **Agriculture Water Management Practices:** The use of technological advancements in irrigation, for example, drip irrigation and precision agriculture, can help in minimizing water and energy use in agriculture activities, hence reduction of carbon emissions.
- **Industrial Water Management:** Following the Central Ground Water Authority's guidance and assessing the water usage system may lead to the adoption of water-efficient technologies and practices in sectors like manufacturing and energy, thus reducing water consumption and associated energy emissions. PHDCCI has been verified by CGWA for water audits to be performed.

- **Urban Water Management:** The use of rainwater harvesting techniques, treatment of wastewater, and reduction of water leakages can reduce the energy and water required in urban centers.
- **Water Restoration and Ecosystem Services:** Water restoration as well as the provision of ecosystem services are useful, as stated below. Wetland Restoration: Wetlands mitigate carbon emissions and improve water quality and biodiversity.
- **Forest Restoration:** Activities such as reforestation and afforestation impact the watersheds by restoring balance; they also promote retention of water and capture of carbon.
- **Sustainable Watershed Management:** Integrated watershed management has the potential to protect water resources, minimize erosion, and improve carbon sequestration.
- **Blue Carbon:** Coastal Ecosystems: Mangroves, salt marshes, and seagrass beds are coastal ecosystems that, if protected and restored, can serve to sequester larger amounts of carbon. These ecosystems also serve as fisheries and act as coast line protectors as well.

Challenges and Opportunities

- **There are some challenges, however, that need to be overcome:** Water-related projects have a number of strengths with regard to participation in carbon markets:
- **Standardized Methodologies:** One of the priorities is to develop practical, comprehensive, and comparable methodologies for measurement and register of carbon emissions reductions and sequested emissions from water-related activities.
- **Data Availability and Quality:** There is a need to have credible information on water abstraction, water quality, and the status of ecosystems for good measuring of carbon emissions and imports, as well as some monitoring of the projects undertaken.

Conclusion

Water and climate change are two sides of the same coin. Improving access to water facilities and harnessing the carbon market presents an opportunity to address the challenge of water and environmental challenges while aiding in the fight against global warming. With an emphasis on water-related initiatives, restoration of the ecology, and efficiency in water use, people can ensure a better future.

Simplifying Carbon Accounting for Small and Medium Enterprises (SMEs)

Dr. Rimika Kapoor, Founder, GreenLoop CleanTech

Introduction

As the global urgency to address climate change intensifies, organizations across industries are being pushed to adopt more sustainable practices. Carbon accounting, a method for quantifying the greenhouse gas (GHG) emissions associated with business activities, plays a pivotal role in enabling companies to track, reduce, and report their carbon footprints. While large corporations have the resources to invest in sophisticated carbon accounting systems, small and medium-sized enterprises (SMEs) often face barriers due to their limited financial and technical capacity. However, the role of SMEs in mitigating climate change is critical, as they form the backbone of most economies and contribute significantly to global emissions. Simplifying carbon accounting for SMEs, therefore, becomes essential to ensure their participation in sustainability efforts.

This article explores the challenges SMEs face with carbon accounting, the benefits of engaging in the process, and practical steps to make it more accessible for these enterprises.

The Importance of Carbon Accounting for SMEs

SMEs play a crucial role in the global economy. According to the World Bank, SMEs represent about 90% of businesses and more than 50% of employment worldwide. Their contribution to carbon emissions is also significant, although it often goes unmeasured due to the informal or decentralized nature of many SME operations. As environmental regulations become stricter, investors and customers increasingly demand transparency regarding a company's environmental impact. Carbon accounting offers a structured way for SMEs to:

1. Identify emission sources: Understanding where emissions originate (Scope 1, 2, or 3) allows SMEs to target areas for reduction.
2. Improve operational efficiency: By monitoring energy use and emissions, businesses can find ways to reduce waste and save on energy costs.
3. Enhance market competitiveness: SMEs that report and reduce their carbon footprints may attract eco-conscious customers and investors, improving their brand image and opening new market opportunities.
4. Prepare for future regulations: As more countries introduce mandatory carbon reporting requirements, starting carbon accounting now will help SMEs remain compliant in the future.

Challenges for SMEs in Carbon Accounting

While the benefits of carbon accounting are clear, SMEs face unique challenges that make the process daunting:

1. Lack of Resources: SMEs often operate on tight budgets, with limited access to the specialized staff or technology needed for accurate carbon accounting. Investing in dedicated software or hiring sustainability experts is often unaffordable for smaller companies.
2. Complexity of Frameworks: Many carbon accounting frameworks, such as the Greenhouse Gas (GHG) Protocol, require

technical expertise and involve complex calculations. For SMEs without in-house sustainability teams, navigating these frameworks can be overwhelming.

3. Data Availability and Accuracy: SMEs may lack the tools or systems to collect accurate emissions data. This is especially true for Scope 3 emissions, which encompass indirect emissions from the supply chain, making the process time-consuming and prone to inaccuracies.

4. Lack of Awareness: Many SMEs, particularly in developing markets, may not be fully aware of the significance of carbon accounting or how it can benefit their business in the long term.

Simplifying Carbon Accounting for SMEs

To overcome these challenges, SMEs need a streamlined and cost-effective approach to carbon accounting. Simplification can be achieved through several strategies, including adopting user-friendly tools, building awareness, and leveraging external support.

1. Adopt Simple, Cost-Effective Tools

One of the most effective ways to simplify carbon accounting for SMEs is through digital tools that automate data collection and calculation. Several platforms and software solutions now offer carbon accounting tailored to smaller businesses. These tools simplify the reporting process by:

- Providing pre-built templates based on industry standards like the GHG Protocol.
- Automating emissions calculations by integrating with existing business systems (e.g., energy management systems or financial records).
- Offering scalability, allowing SMEs to start with a basic version and expand as their reporting needs grow.

Many of these platforms come at an affordable cost or even offer free tiers for small enterprises, making carbon accounting accessible to a wider range of businesses.

2. Use a Step-by-Step Approach

SMEs can ease into carbon accounting by adopting a phased approach. Rather than attempting to calculate and report on all emissions (Scope 1, 2, and 3) at once, SMEs can start with the easier aspects, such as Scope 1 (direct emissions) and Scope 2 (indirect emissions from purchased energy). Scope 3 emissions, which involve upstream and downstream supply chain activities, can be incorporated later as the company grows more comfortable with carbon accounting.

By breaking down the process into manageable steps, SMEs can avoid feeling overwhelmed and ensure more accurate reporting. For instance:

- Step 1: Measure and report energy consumption from utilities (Scope 2).
- Step 2: Track fuel consumption from company-owned vehicles (Scope 1).
- Step 3: Gradually begin assessing emissions from suppliers, product transportation, and waste management (Scope 3).

3. Leverage Industry Support and Collaboration

SMEs can also benefit from partnerships and collaborations within their industries. Industry associations, local government bodies, and sustainability organizations often offer training programs, toolkits, and resources specifically designed for small businesses. These can help SMEs navigate the complexities of carbon accounting without needing to invest heavily in consultants or proprietary tools.

For example, Greenloop CleanTech and other clean tech organizations provide resources that assist SMEs in understanding carbon accounting and its benefits. Networking within such forums can expose SMEs to best practices, allowing them to benchmark their progress against similar-sized businesses.

4. Develop Internal Awareness and Skills

Building internal capacity is crucial for the long-term success of carbon accounting within SMEs. While many smaller enterprises may not have dedicated sustainability officers, training existing staff to understand the basics of carbon

accounting can create a more sustainable company culture. Simple training on topics such as energy efficiency, waste management, and data collection techniques can empower employees to contribute to the company's carbon reduction goals.

In many cases, government agencies or environmental NGOs offer free or subsidized training programs that can help SMEs build these internal capabilities without significant cost.

Benefits of Simplifying Carbon Accounting for SMEs

By simplifying carbon accounting, SMEs can unlock several long-term benefits:

- Cost Savings: Energy efficiency and waste reduction often lead to direct cost savings, especially in industries where energy consumption is high.
- Risk Mitigation: Early adoption of carbon accounting helps SMEs stay ahead of regulatory changes, reducing the risk of non-compliance fines and operational disruptions.
- Improved Business Reputation: As customers and investors increasingly prioritize sustainability, SMEs that engage in carbon accounting can enhance their brand's reputation and attract new business opportunities.
- Access to New Markets: Many larger corporations are now requiring carbon reporting from their suppliers. SMEs that are prepared with accurate carbon accounting may find it easier to enter new supply chains and markets.
- Contribution to Global Climate Goals: SMEs collectively contribute significantly to global emissions. By engaging in carbon accounting, SMEs play a vital role in global efforts to reduce emissions and combat climate change.

Conclusion

Simplifying carbon accounting for SMEs is essential to ensuring their participation in the global sustainability movement. While the process can seem complex and resource-intensive, leveraging simple tools, industry support, and phased approaches can make carbon accounting accessible and manageable for smaller businesses. By adopting these practices, SMEs can not only contribute to global climate goals but also improve their operational efficiency, reputation, and competitiveness in a market increasingly focused on sustainability. As more SMEs engage in carbon accounting, their collective impact can help drive meaningful progress toward a low-carbon economy.

CBAM: How It Impacts Indian Iron and Steel Sector

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Nilesh Bhattad
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The Indian Iron and Steel industry is undergoing some significant changes due to evolving EU Carbon Border Adjustment Mechanism (CBAM) reporting rules and its impact on the trade patterns. Some primary reasons for the CBAM impact on the Indian Iron and Steel industry is that it is the second largest producer in the world, besides being high carbon-intensive. We are currently in the Transitional Phase 1 (October 2023 to December 2025). During this phase, only submitting the quarterly report is mandatory. However, most of the CBAM reporting requirements, including accurate data collection, timely submission, EU-accredited report auditing, and cross-verification will become mandatory from 2026 when the Definitive Regime starts. Moreover, the penalty for inaccurate report submission will only be applicable from 2026 and CBAM certificate submissions are compulsory from 2027, as per the updated rules under the Omnibus Package.

The primary purpose of the transitional period is for impacted sectors and companies to use the given period as a pilot learning phase to be fully prepared and equipped to adapt to the CBAM ecosystem.

In this blog, we will dissect how Carbon Border Adjustment Mechanism is affecting Indian Iron and Steel and its financial pressures on the MSMEs.

Why is the Indian Iron and Steel sector highly vulnerable to CBAM reporting?

The European Union's Carbon Border Adjustment Mechanism (CBAM) represents a significant shift in global trade regulations, especially for India's secondary steel sector, which constitutes 40% of the nation's steel production. With iron and steel being India's largest CBAM-covered exports to the EU, the financial impact of this regulation is substantial, potentially adding up to 25% in additional costs. This challenge is particularly critical for India's MSMEs in the secondary steel sector, which are already facing barriers like low awareness and gaps in emissions data collection. However, CBAM also presents an opportunity to innovate and adopt low carbon technologies, helping the sector remain competitive and align with India's Net Zero aspirations. The potential impact of CBAM will be felt on India's steel exports even after the Omnibus package, focusing on the secondary steel sector, largely composed of micro, small, and medium enterprises (MSMEs). The total contribution of MSMEs to the GDP is 38%, which indicates the steel sector economic powerhouse that will witness major ripples. Close examination of this data indicates that close to half of India's GDP will be under impact due to CBAM, causing significant impact on India's economy, trade, and business.

India's Steel Exports to the EU: In FY 2022-23, India's iron and steel exports to the EU represented 23.5% of its total steel exports, valued at over $13 billion.

Financial Implications: CBAM could impose an additional 25% carbon tax on Indian CBAM-covered goods exports to the EU, including steel, significantly raising costs and reducing competitiveness, as per the Centre for Science and Environment.

Secondary Steel Sector Vulnerability: The secondary steel sector, using energy intensive methods like Direct Reduction Electric Arc Furnace (DRI-EAF), produces higher emissions and faces greater risk from CBAM's carbon tariffs.

How does CBAM impact the Indian steel sector?

There are approximately 333 DRI plants, 55 EAFs, 1103 IFs, and 1313 Steel rolling mills in different parts of the nation. Hence, most of these could be under immense impact of CBAM regulations. Steel producers in India are at the most risk from

Europe's new carbon tax, as per Goldman Sachs Group Inc report. There could be an additional $102 to $190 a ton of tax charges on imports of Indian steel over the next decade owing to the high embedded carbon emissions in Indian steel.

A major challenge to India becoming a fully green production hub is systematic and accurate carbon emissions data collection. Additionally, the massive amount of data needs to be managed and processed digitally for efficient outcomes. CBAM could also affect India-EU trade relations in terms of continuity of trade.

How does CBAM change steel exports?

EU CBAM is poised to leave a massive impact on the Indian steel sector and it is going to be critical for small sector players as their economic outcomes will depend on it. The CABM rules will result in major changes as India is the second largest crude steel producer in the world, showing a capacity to produce 179.5 million tones of crude steel in the Financial Year 2023-24, as per the Ministry of Steel report.

Moreover, SMEs constitute 33-35 per cent of India's crude steel capacity. With this scale of the steel industry under direct impact, international trade will also witness changes. For instance, India's iron and steel export to the European Union stands at 23.5%, as per the latest World Bank Data.

In 2023, India ranked 2nd in global steel production with an output of 140.8 million tones, as per the World Steel in Figures 2024 report. Furthermore, India exported over $13 billion worth of iron and steel in fiscal year 2023, as per the Steel Export data. India's position as the second-largest steel producer and a major exporter, highlights its global trade integration and business significance. The introduction of

CBAM poses compliance challenges for Indian steel exports, especially to the EU, pushing the industry to adopt sustainable practices to stay competitive, profitable and relevant globally.

India's domestic steel production and greenhouse gas emissions

India's steel industry contributes to around 2% of the GDP, and the production of finished steel in India increased by 49% to reach 122.3 million tonnes over the previous year. India's emission intensity of steel production is at 2.54 T CO2/T Crude Steel (tCO2/TCS), which is significantly higher than the global average of 1.91, as per the Ministry of Steel report. These figures are only set to witness a sharp spike in coming years due to rising India's domestic demand and global requirements.

If we look at the emission levels that the Indian steel industry is responsible for, credible data indicates that the steel industry of India accounts for 10-12% of India's total emissions. India's historical contribution to the accumulation of GHGs is about 4% despite being home to 17% of the world population. Hence, it is critical to decarbonize the Indian steel industry amid the rapidly changing global economy, which is witnessing the development of a stronger climate-conscious mindset.

Major CBAM challenges for Iron and Steel companies

The challenges associated with CBAM compliance are multifaceted, requiring the implementation of comprehensive systems and processes to meet regulatory obligations and make businesses CBAM-proof. Here are five key challenges organizations face in preparing CBAM reports:

1. **Limited Market Readiness & Regulatory Familiarity**

   Despite CBAM's phased rollout, there is a significant knowledge gap among stakeholders regarding its operational nuances, especially around emissions boundaries, embedded carbon calculation, product-level attribution, and quarterly reporting formats. A lack of iron and steel sector-specific training and institutional guidance continues to hinder preparedness.

2. **Precision in Emissions Calculation**

   CBAM compliance requires detailed, process-level emissions quantification, aligned with EU methodologies. Current practices often lack the granularity and accuracy needed for product-wise embedded emissions tracking, particularly in plants with integrated or indirect emissions sources.

3. **Data Integrity and Audit-Readiness**

   Generating traceable, auditable emissions data remains a major barrier. EU regulators demand verifiable, digitized reporting backed by documentation and third-party validation. Manual or fragmented data capture systems in Indian MSMEs compromise both auditability and compliance assurance.

4. **Shipment-Level Carbon Traceability**

   CBAM mandates shipment-wise emissions disclosures, including invoice-linked carbon values. The lack of real-time tracking, ERP integration, and lifecycle data consolidation creates compliance risks and delays in quarterly reporting cycles.

5. **Technology and Infrastructure Gaps**

   A significant share of Indian steel exporters, particularly in the secondary sector, lack the necessary MRV (Monitoring, Reporting, and Verification) infrastructure and digital capabilities. As the Definitive Regime restricts the use of default values from 2026, real-time emissions tracking tools, carbon accounting platforms, and automated reporting systems will be critical.

Conclusion

CBAM is a challenge but also an opportunity for business expansion if the right technology is used. It can drive innovation, clean tech adoption, and better global trade alignment. For India's steel industry, the time to prepare is now if it doesn't want to be impacted by double whammy in the coming years. CBAM is not the only challenge that the Indian iron and steel sector is faced with. It is also feeling the increasing pressure from the Green Steel Taxonomy introduced by the Ministry of Steel. These regulations coupled with the practical setbacks including lack of adequate infrastructure, high carbon intensity in the Indian iron and steel sector and the right technology is adding to the crisis. It is critical to focus on investment in the right technology to not just defeat the double whammy but also use CBAM as an opportunity for more business expansions and economic gains.

Exploring The Impact of Technology on Sustainability Practices and Its Role in Shaping Diplomatic Relations

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Introduction

In the modern interconnected world, technology remains key to the development of innovative ways through which concerned stakeholders approach sustainability in their practices. Sustainable technologies are those that aim at the preservation of natural resources while minimizing harm to the environment, having in mind the balance of economic and social benefits at large. From providing practical answers to pressing global issues of climate change, resource depletion, and pollution through new renewable energy applications and IoT-driven smart cities, to improving energy efficiency using artificial intelligence, technological advancement changes sustainability practices across the globe. Equally significant, technology shapes diplomatic relations through fostering international cooperation based on climate goals, enabling transparency in environmental undertakings, and creating new forms of global partnerships. As countries and companies use new technological tools to meet more ambitious targets of sustainability, understanding the interplay between technology, sustainability, and diplomacy is an indispensable necessity if proper policies are to be pursued to foster a sustainable global future for the coming generation.

The Role of Technology and Innovation in Sustainability Practices

At the heart of driving sustainability are technological advancements, especially in renewable energies, AI, IoT, and blockchain, which transform how environmental objectives are met. The renewable technologies of solar, wind, and bioenergy directly cut emissions by providing alternatives to fossil fuels. AI optimizes energy use and resource management; IoT monitors environmental contributions in real time for efficiency; and blockchain underpins transparent, trusted carbon markets and certification.

These technologies and innovations enhance resource efficiency, cut emissions, and support Sustainable Development Goals by promoting clean energy, sustainable cities, and responsible consumption for the corporate sector. For instance, smart grids powered by AI and IoT reduce energy waste and costs; blockchain platforms guarantee carbon credit integrity to combat fraud and help in climate commitments. Patented technologies related to blockchain-enabled carbon markets and carbon accounting that indicate availability for commercialization across different countries such as CNT Carbon Stablecoin (MVGX) from Singapore, Satellite MRV for carbon emissions from China, dMRV multi-activity credit generation (CERO) from Canada, NFT Carbon Credit Tracking from USA which help the world by making carbon markets more trustworthy, cheaper to operate, faster to scale, and more equitable.

However, there are still several challenges with the adoption and scale-up of such technologies around the world: the high upfront costs with longer returns discourage investment, particularly in developing nations. Awareness and misinformation gaps decrease acceptance. Infrastructure deficits, such as limited renewable grids or EV charging

stations, impose practical barriers. Behavioral resistance, organizational inertia, integration issues, regulatory inconsistencies, and complex sustainable supply chains will also hamper uptake. Coordinated policies, international cooperation, capacity building, and innovative finance will be required to unlock technology's full sustainability potential worldwide.

Technology as a Catalyst in Diplomatic Relations

Technology now anchors international sustainability cooperation through shared data, common tools, and joint frameworks for climate action across borders.

Green technology transfer is central to the UNFCCC and Paris Agreement, which call for enhanced development and transfer through the Technology Mechanism and its Article 10 technology framework. May every country come forward to take initiative to drive the rule and regulations by obtaining the green tech in their system.

Green technology shapes world trade, opening new markets for sustainable products but also changing trade patterns due to environment-inspired policies and regulations.. Yet diffusion is constrained by TRIPS intellectual property rules that promote innovation but impede access in developing countries, though recognized flexibilities could ease climate-relevant transfers.

Harmonization of standards and policy, and patent-sharing initiatives like the Eco-Patent Commons, illustrate how even with frictions in the approach to access, IP and collaboration can catalyze cooperative climate action.

In other words, technology forms the rules, incentives, and partnerships of climate diplomacy and is thus a lever for both progress and negotiation in global sustainability governance.

Geopolitical and Economic Implications of Sustainable Technologies

It follows that technological competitiveness in sustainable technologies is important for the global position, economic growth, and geopolitical strategy of a nation. The countries leading in green technology, such as renewable energy equipment, energy storage, and environmental monitoring, receive export advantages, attract investment, create jobs, and influence international standards on sustainability.

However, unequal access to these technologies creates geopolitical challenges, deepening inequalities between developed and developing countries, besides complicating diplomatic relations. Issues like intellectual property, varied regulations, and competition for resources heighten tensions. International cooperation, policies of technology transfer, and inclusive frameworks are required to balance equity with the incentive to innovate.

This interplay sets the stage for exploring emerging digital green diplomacy in which digital tools and frameworks of cooperation will set guidelines for technology-driven sustainability governance.

Emerging Trends: Digital Green Diplomacy

Digital green diplomacy turns climate diplomacy into a dynamic and transparent collaborative environment, deploying data-sharing platforms, remote sensing satellites, and blockchain in carbon markets. These technologies allow for accurate environmental monitoring, verification of emissions, and more transparency, therefore fostering trust and reducing information gaps in international cooperation on climate issues.

This form of diplomacy enables multilateral and polylateral cooperation via virtual platforms, which speed up decision-making and involve smaller states and non-governmental actors more deeply. The European Union is the frontrunner in these policies, incorporating into the Green Deal digital solutions to advance sustainable data practices and green technology standards. Other countries, such as Japan and South Korea, apply digital monitoring to reinforce climate partnerships, while in areas like California and the European Union, blockchain-enabled carbon markets build trust and efficiencies into carbon credit trading.

Overall, digital green diplomacy merges technology with international relations for enhanced cooperation, accountability, and

innovation-in sum, laying the foundation for more agile, data-driven diplomatic strategies necessary to navigate the complexities of sustainable development in the 21st century. There is need for open platform for sharing the technologies in a correlated manner with all the connected stakeholders.

Challenges and Future Directions

There are challenges at the intersection of technological innovation with sustainability and diplomacy that involve balancing the IP protection of innovation and wide access to green technologies. While intellectual property rights encourage inventors through protection, they often restrict technology transfer, particularly to developing countries with limited resources. This tension complicates international cooperation, wherein countries negotiate between safeguarding national interests and fulfilling global climate commitments.

The other factor that also hampers collaboration is the trust deficit. Geopolitical rivalries, strategic distrust, regulatory differences, and a lack of global green technology standards cause fragmentation, ultimately reducing interoperability and scaling of sustainable solutions.

These challenges can be overcome through frameworks that foster open innovation with respect for IP, stronger international dialogue and trust to create harmonized standards, and financial instruments such as green bonds and climate funds that provide incentives for technology diffusion and capacity building.

Equitable models of technology sharing that balance considerations of fair compensation with access, the potential use of digital tools to improve the transparency of diplomacy, and the development of harmonized metrics on sustainability-all are areas where future research is needed. Policy makers should promote adaptive rules and incentives that can support collaborative innovation ecosystems, enabling inclusive and effective sustainable development.

Navigating IP rights, geopolitics, and technological change demands integrated global governance-a balance between competition and cooperation-to meet the scale of sustainability challenges in front of us.

Conclusion

Technology has indeed changed the way sustainability is practised and the nature of diplomatic relations, acting as a strong catalyst in linking environmental objectives with international cooperation. New tools, such as AI, IoT, blockchain, and renewable energy technologies, have opened up new avenues for resource efficiency, reduced emissions, and sustainable development. At the same time, technology has reshaped diplomacy by providing platforms for collaboration, transparency, and trust-building in international climate action for the better world.

Yet, none of these will suffice to tackle global sustainability challenges; what is needed, rather, is coordinated technological cooperation between countries. It is here that a proper balance of intellectual property rights with equitable access, bridging the trust deficits, and harmonization of technological standards become critical to inclusive and effective collaboration. The future of sustainability and diplomacy depends on nurturing integrative frameworks that unite national interests with shared global responsibilities at large.

In light of emerging trends in digital green diplomacy, among other areas, a concerted research and policy innovation agenda that harnesses the full potential of technology in service of sustainable development is an imperative. Only in this way will the international community rise to the scale and urgency of the environmental challenges to ensure a resilient and equitable future for all.

Views are Personal

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Carbon Market Readiness: How Carbon Accounting Standards Are Shaping Indian Companies

Dr. Rachana Malviya, Founder, GreenLoop CleanTech

As the world intensifies its efforts to mitigate climate change, carbon accounting and reporting have emerged as pivotal elements in managing emissions and promoting sustainability. For businesses in India, aligning with globally recognized carbon accounting standards is not just a regulatory requirement but also a strategic move toward participating in the growing global carbon market. As governments and organizations work to reduce their carbon footprints, the ability to accurately measure and report greenhouse gas (GHG) emissions opens up opportunities for companies to trade carbon credits, offset emissions, and demonstrate their commitment to environmental stewardship.

This article delves into the importance of carbon accounting standards, their role in preparing Indian companies for the global carbon market, and the benefits of adopting these frameworks.

The Importance of Carbon Accounting Standards

Carbon accounting refers to the process of measuring, recording, and reporting a company's carbon emissions, specifically the volume of greenhouse gases (GHGs) released into the atmosphere due to business activities. The accuracy and transparency of this process are critical because it forms the basis of many sustainability strategies, from regulatory compliance to carbon trading and offsetting initiatives.

Globally accepted standards such as the Greenhouse Gas (GHG) Protocol, ISO 14064, and the Carbon Disclosure Project (CDP) provide organizations with comprehensive frameworks to measure and manage their carbon footprints. These standards ensure uniformity in reporting and offer methodologies for calculating Scope 1 (direct emissions), Scope 2 (indirect emissions from energy consumption), and Scope 3 (other indirect emissions across the value chain) emissions.

For Indian companies, aligning with these standards ensures credibility in the global market. It demonstrates accountability and transparency in reporting, making them reliable partners in sustainability-focused industries. Moreover, as India continues to play a significant role in international climate negotiations, meeting global standards is crucial for businesses aiming to engage in the burgeoning carbon market.

The Role of Carbon Accounting in the Global Carbon Market

The global carbon market is growing rapidly as more countries adopt mechanisms like carbon pricing, emissions trading systems (ETS), and carbon offsetting schemes to reduce their GHG emissions. In these markets, businesses and governments trade carbon credits representing a reduction or removal of emissions with the goal of offsetting their carbon footprints. Participation in these markets requires companies to measure their emissions accurately, making carbon accounting an essential foundation for engaging in carbon trading.

India, with its growing industrial base and significant carbon footprint, has a crucial role to play in the global carbon market. Indian companies, especially those in energy-intensive sectors like manufacturing, cement, and steel, can benefit from participating in these markets by selling carbon credits or offsetting their own

emissions. However, to do so, they must adopt standardized carbon accounting practices that are recognized globally.

Carbon Pricing and Its Impact on Indian Enterprises

Carbon pricing refers to the financial valuation of carbon emissions, typically through carbon taxes or emissions trading systems. Governments and regulatory bodies impose carbon pricing to encourage businesses to reduce their GHG emissions. Companies with lower emissions can sell carbon credits to those struggling to meet their targets. For Indian companies, this creates a significant opportunity to monetize their sustainability efforts by trading carbon credits, both domestically and internationally.

However, participation in these markets requires adherence to global carbon accounting standards. Without reliable, standardized emissions data, companies may struggle to verify their carbon credits or face difficulties in complying with market regulations. This makes carbon accounting standards critical for Indian enterprises that want to be competitive in the global carbon economy.

Key Carbon Accounting Standards

1. The Greenhouse Gas (GHG) Protocol

   The GHG Protocol is the most widely used carbon accounting framework globally. It provides detailed guidelines for companies to measure and report their GHG emissions across Scopes 1, 2, and 3. The protocol emphasizes transparency, accuracy, and consistency in reporting, making it a cornerstone for companies looking to participate in carbon trading. For Indian businesses, adopting the GHG Protocol ensures that their carbon accounting practices align with global expectations, opening up opportunities for international partnerships and participation in carbon markets.

2. ISO 14064

   The ISO 14064 standard provides tools for quantifying, monitoring, and verifying GHG emissions at the organizational level. It is part of the broader ISO 14000 family of environmental management standards. ISO 14064 focuses on standardizing the process of carbon accounting, making it easier for companies to measure and report their emissions consistently. For Indian companies, obtaining ISO 14064 certification can enhance credibility and facilitate access to international markets, where regulatory bodies and investors increasingly demand standardized reporting.

3. Carbon Disclosure Project (CDP)

   The CDP is a global disclosure system that encourages companies to measure and report their environmental impacts, including carbon emissions. Through the CDP, companies disclose their climate risks, strategies, and emissions data, which are then made available to investors and stakeholders. Indian companies that participate in the CDP can enhance their reputation and gain access to global capital markets by demonstrating their commitment to sustainability and transparency.

4. Science-Based Targets initiative (SBTi)

   The Science-Based Targets initiative helps companies set emission reduction targets that align with the Paris Agreement's goal of limiting global warming to well below 2°C. By setting science-based targets, companies demonstrate a commitment to reducing emissions in line with scientific recommendations. For Indian companies, adopting SBTi standards can signal leadership in climate action, attract environmentally conscious investors, and improve competitiveness in global markets.

Benefits for Indian Companies

1. Access to Global Markets and Investments

   Companies that align with international carbon accounting standards gain credibility in global markets. Investors, customers, and regulatory bodies increasingly favor businesses with transparent and standardized carbon accounting practices. Indian companies that meet these standards

can attract international investments, form partnerships with global corporations, and participate in international carbon trading platforms.

2. Regulatory Compliance and Risk Mitigation

   As India strengthens its climate policies, companies are expected to comply with both national and international environmental regulations. Adopting global carbon accounting standards helps businesses stay ahead of regulatory changes and avoid penalties related to non-compliance. Additionally, companies that proactively measure and reduce their emissions are better equipped to mitigate financial and reputational risks associated with climate change.

3. Improved Operational Efficiency and Cost Savings

   Accurate carbon accounting allows companies to identify inefficiencies in their operations that contribute to higher emissions. By pinpointing these areas, businesses can implement changes to reduce energy consumption and emissions, leading to cost savings. Over time, companies that integrate carbon accounting into their sustainability strategies can improve operational efficiency and enhance long-term profitability.

4. Reputation and Brand Value

   Sustainability is increasingly becoming a key factor in consumer decision-making. Companies that demonstrate a commitment to reducing their carbon footprint through standardized accounting practices can enhance their brand value and appeal to environmentally conscious consumers. This not only strengthens a company's reputation but also contributes to customer loyalty and market differentiation.

Challenges and the Path Forward

While the benefits of adopting carbon accounting standards are clear, Indian companies may face several challenges in implementing these frameworks. Limited access to reliable emissions data, lack of expertise in carbon accounting, and the costs associated with implementing new systems can hinder progress. However, with the growing importance of sustainability in global business, it is imperative for Indian companies to invest in carbon accounting tools and training to remain competitive.

Government initiatives, such as India's commitment to achieving net-zero emissions by 2070, can provide further impetus for companies to adopt these standards. Collaborating with industry associations, leveraging technological advancements, and participating in capacity-building programs can help businesses overcome these challenges and fully integrate carbon accounting into their operations.

Conclusion

For Indian companies, carbon accounting standards are no longer optional but essential for thriving in the global carbon market. By adopting frameworks like the GHG Protocol, ISO 14064, and participating in the CDP, businesses can ensure compliance with emerging regulations and unlock opportunities for growth in the carbon trading space.

In this context, GreenLoop CleanTech is organizing the "1st GreenLoop CleanTech & PHDCCI Sustainability Summit 2024: ESG and Carbon Accounting for a Greener Future." The conference will focus on the theme: "Driving ESG Excellence and Precision Carbon Accounting in India's Evolving Landscape," featuring a masterclass session on carbon accounting. As India continues its journey toward a sustainable future, companies that invest in accurate carbon accounting will be well-positioned to lead in both domestic and international markets.

Empowering Climate Action through Gender-Responsive Solutions

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As the world continues to face the compounding effects of climate change, the need for affordable, innovative and inclusive solutions has never been more urgent. Tackling climate change is not just limited to reducing emissions, mitigating disasters and adapting to environmental shifts but it is also dependent on addressing the disproportionate impacts of climate change on vulnerable and marginalised communities. It also requires ensuring that every person, regardless of their gender, has the necessary means, resources, decision making power and agency is at the centre of the solution. In particular, the focus needs to be on integrating gender equity into climate resilience strategies, empowering women and marginalized communities to be an integral part of the design and implementation of climate response actions.

The Gender-Climate Nexus

As our planet's surface temperature rises and is on the verge of crossing the tipping point of 1.5 degree celsius, marginalized communities, particularly women are at a heightened risk. Women, especially in low-income, tribal and rural areas, are disproportionately impacted by climate change due to pre-existing gender inequality. These structural vulnerabilities are worsened as climate change disrupts livelihoods, agriculture, and access to basic resources. Women's roles in caregiving and domestic labor place additional burdens on them during climate-related disasters, while limited access to land, financial resources, and decision-making power further hinders their ability to adapt. The consequences of climate change, such as health risks, displacement, and loss of livelihood, deepen existing gender inequalities, pushing women further into poverty and marginalization. Addressing these challenges requires gender-sensitive policies that empower women and ensure their inclusion in climate adaptation and decision-making processes.

This is due to a range of factors, including entrenched social inequalities, limited access to resources, and lack of decision-making power. In India, for example, women are disproportionately affected by extreme weather events like floods, droughts, and heatwaves, yet they are also leading efforts to combat these challenges.

On the international climate policy stage, the positive impact women can have on their environment and on sustainable development goals has generated widespread demand for more inclusive climate action and gender-sensitive financing channels. Women play crucial roles in community-based adaptation and mitigation efforts, driving resilience through sustainable practices in agriculture, natural resource management, and energy as well. However, despite their central role in climate resilience, women's contributions and needs are often overlooked in the planning and implementation of climate policies and programs at the local levels.

Why it matters: Importance of Gender-Responsive Climate Action

Gender-responsive climate action can unlock significant benefits:

- Increased Effectiveness of Climate Solutions: By understanding and addressing the differences in the experiences of various

genders, we can create more effective climate solutions that meet the needs of all. Women's knowledge, especially in areas like agriculture, natural resource management, and healthcare, is crucial for developing resilient and sustainable solutions.

- Economic Empowerment: Addressing gender inequalities in climate resilience offers a unique opportunity to create economic opportunities for women. By promoting women's leadership in sectors like clean energy, sustainable agriculture, and climate- resilient livelihoods, we help build an inclusive economy that supports sustainable development and reduces poverty.

- Social Justice and Equity: Climate change is a social justice issue. The impacts of climate change disproportionately affect those who have the least capacity to adapt, including women, indigenous groups, and the poor. Our firm's work focuses on creating equitable climate resilience strategies that lift up the most vulnerable, ensuring that everyone has the chance to thrive in a changing world.

- Empowering Women as Leaders of Change: Women have proven themselves to be powerful agents of change in climate resilience. From leading grassroots initiatives to advocating for policy reforms, women are at the forefront of climate action. Our consulting services support women's leadership by providing them with the tools, resources, and education they need to lead effective climate resilience initiatives. This is not just about addressing women's vulnerabilities; it's about recognizing and amplifying their roles as change-makers.

Our Approach: Gender-Responsive Climate Resilience

Our vision is to support the creation of gender-transformative climate actions that include interventions which recognize the gendered impacts of climate change, heat, air pollution, disasters, and food insecurity; and that while addressing these challenges ensure that gender considerations are woven into every aspect of climate action. At the heart of our advisory services is a commitment to promote gender equity in climate resilience. Our approach is built around three key pillars:

1. Gender-Responsive Risk Assessments: We offer comprehensive gender-responsive climate risk assessments that identify the specific vulnerabilities and capacities of women and other marginalized groups in the face of climate change. By recognizing the different experiences and needs of these groups, we help organizations design more targeted and effective climate resilience strategies that address the root causes of inequality and build on the strengths and knowledge of local communities.

2. Inclusive Action Plans: Developing inclusive, gender-responsive action plans is essential for ensuring that climate interventions benefit everyone, not just the most privileged. We work closely with stakeholders to co-create action plans that integrate gender equity, taking into account local contexts, traditional knowledge, and gendered power dynamics. These plans are designed to ensure that women and men have equal access to resources, decision- making opportunities, and benefits from climate resilience initiatives. Other interventions focus on strengthening women's and men's adaptive capacities and promote participatory, locally led adaption that supports communities to survive and thrive in a changing climate. Including women in decision-making spaces and harnessing the opportunities offered by the green transformation and the digital transformation are key elements to an inclusive green transition.

3. Guidance on Integrating Gender into Climate Finance: One of the key barriers to advancing gender equity in climate action is the lack of gender-sensitive climate finance. We aim to provides strategic advice to organizations and financial institutions on how to integrate gender considerations into climate finance frameworks, ensuring that funding flows to initiatives that empower women and address gender-based vulnerabilities. We help design funding mechanisms that support gender-equitable climate

solutions, ensuring that women are not only beneficiaries but also decision-makers in the climate finance space.

At Pristine Planet, our vision is to create a world where nature-based solutions restore environmental balance, enhance climate resilience, and drive sustainable, inclusive development for all. We believe nature offers solutions to global environmental challenges, enhancing the resilience of ecosystems while providing climate change mitigation and adaptation services. And we understand that addressing climate change is not a one-size-fits-all endeavour. As the impacts of climate change vary greatly across regions, cultures, and communities, and so must the solutions. Our effort is to tailor all our deliverables to the unique contexts and needs of each partner. By fostering partnerships with organizations that share our commitment to gender equity and climate resilience, we aim to create a lasting impact that goes beyond just implementing projects; it is about shifting paradigms and transforming the way we think about climate change and gender.

Reconciling Materiality to Transform the Energy System Successfully to Achieve Net Zero

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As the world transitions towards a low-carbon economy, achieving net-zero emissions has become a critical imperative. However, this transformation requires a fundamental shift in the way we produce, consume, and think about energy. To successfully navigate this transition, it is essential to reconcile materiality $_2$ the significance of environmental, social, and governance (ESG) issues $_2$ with the need to transform the energy system.

"Reconciling Materiality" refers to balancing the crucial physical and practical constraints (the "materiality" of the energy transition) with the ambitious goals of achieving net zero emissions. This involves addressing the tangible challenges such as securing critical material resources, managing infrastructure, ensuring affordability and reliability, and implementing a circular economy to make the energy transformation successful. The core challenge is that the transition to a net-zero economy is incredibly metal-intensive

Key Considerations:

Materiality Assessment: Conduct a thorough materiality assessment to identify the most significant ESG issues impacting the energy system, including climate change, water scarcity, and human rights.

Stakeholder Engagement: Engage with stakeholders, including investors, customers, and civil society, to understand their expectations and priorities for the energy transition.

Net-Zero Strategy: Develop a comprehensive net-zero strategy that integrates materiality considerations, including reducing greenhouse gas emissions, promoting sustainable land use, and ensuring responsible supply chain practices.

Innovation and Technology: Leverage innovation and technology to drive the energy transition, including the development of new energy sources, energy storage, and grid modernization.

Policy and Regulation: Advocate for policies and regulations that support the energy transition, including carbon pricing, tax incentives, and grid integration.

Benefits of Reconciling Materiality:

Reduced Risk: By addressing material ESG issues, companies can reduce the risk of stranded assets, regulatory non-compliance, and reputational damage.

Increased Investment: A clear net-zero strategy and materiality assessment can attract investors and stakeholders who prioritize sustainability and ESG considerations.

Improved Efficiency: By optimizing energy systems and reducing waste, companies can improve operational efficiency and reduce costs.

Enhanced Reputation: Companies that prioritize materiality and net-zero emissions can enhance their reputation and build trust with stakeholders.

By reconciling materiality with the need to transform the energy system, companies can unlock the benefits of the energy transition while minimizing the risks. This requires a coordinated effort from governments, businesses, and civil society to achieve a net-zero future.

Addressing Material Constraints

Critical Mineral Supply Chains: The shift to renewable energy and electric vehicles requires significant amounts of critical minerals like lithium, cobalt, and nickel for batteries and other components. Reconciling materiality involves diversifying supply chains and promoting circular economy principles (recycling and reuse) to secure a stable and sustainable supply of these materials.

Infrastructure and Technology Gaps: Existing energy grids were not designed for the intermittent nature of many renewables (solar and wind). A key material challenge is modernizing infrastructure, developing advanced energy storage solutions, and scaling up new technologies like green hydrogen and carbon capture and storage (CCS).

Embodied Carbon: The production of essential industrial materials like steel, cement, and plastics accounts for a significant portion of global emissions (almost a quarter). Reconciling materiality requires a "materials transition" to lower-impact production methods and incorporating circularity to reduce the embodied carbon of the physical goods needed for the energy system.

Balancing Competing Objectives

A successful net-zero transition must balance four interdependent objectives:

Emissions Reduction: The primary goal of cutting greenhouse gas emissions to as close to zero as possible.

Affordability: Ensuring that the transition does not make energy and materials prohibitively expensive for consumers and industries, which could compromise economic empowerment and social equity.

Reliability and Security: Maintaining a secure and resilient energy supply during the phase-out of traditional energy sources and integration of new ones (e.g., using nuclear energy as a baseload supply where appropriate).

Industrial Competitiveness: Guiding countries and companies to leverage their comparative advantages in new clean technologies and materials to maintain economic strength.

Strategic Implementation

Successfully achieving net-zero requires a multi-pronged approach to reconcile these material realities:

Policy and Financial Support: Governments need to establish clear policy frameworks, provide fiscal support (e.g., green bonds, incentives), and encourage private sector participation to help overcome high upfront costs and technology barriers.

Innovation and R&D: Investing in research and development can help drive down the costs of expensive clean solutions and address technological limitations.

Holistic Planning: Strategies should consider the entire value chain and life cycle of materials and energy systems to avoid simply shifting emissions or environmental burdens from one area to another.

Just Transition: Addressing the social and economic impacts on communities and workers currently dependent on fossil fuel industries is a crucial, material aspect of the transition that must be managed to ensure equity and broad support.

Conclusion

The reconciliation of materiality balancing the physical constraints and resource demands of the energy transition with the ambitious goals of achieving net-zero emissions is central to a successful and sustainable transformation of the global energy system.

This approach requires simultaneously addressing tangible challenges, such as securing vast amounts of critical minerals, modernizing infrastructure, and managing the embodied carbon of industrial materials, while balancing the interdependent objectives of emissions reduction, affordability, reliability, and industrial competitiveness.

By integrating robust materiality assessments and ESG considerations into core strategy, companies and governments can leverage innovation, supportive policy, and circular

economy principles to mitigate risks, attract necessary investment, and ensure a resilient, secure, and equitable energy future. Ultimately, a successful net-zero transformation demands a coordinated, holistic plan that manages both the energy transition and the associated materials transition to avoid merely shifting environmental or social burdens.

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- Impact Assessment of CSR Projects
- Environment Social Governance (ESG)
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- Alliance for Water Stewardship (AWS)
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